APPLICATION OF CONTINGENT VALUATION METHOD IN SANITATION QUALITY IMPROVEMENT EFFORTS AT CIKAPUNDUNG RIVERS IN BANDUNG CITY

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Abstract : Currently experiencing a sub-watershed Cikapundung waste pollution is very high. To remedy the situation must involve people's desire to keep their environment to keep them clean. Public interest can we know the contingent valuation method (CVM). The research was conducted in October 2012 to November 2012 in Bandung City. Every week Sub-watershed Cikapundung produce 3018.4 m3, while polling stations in the area to accommodate the sub-watershed Cikapundung only 22 Solid Waste Management Facility (TPS) with a total capacity of 2768.4 m^3/weeks thus remaining 9.03% or 250 m^3/weeks (1000 m3/month), TPS incoming junk that could potentially contaminate the river entrance Cikapundung. The study says the 56.7% (208 respondents) still throw garbage into the river, there is a 567 m^3/month the incoming stream. If we assume all the waste has entered the stream processing cost of Rp 119,550,45.-. If added to the waste to Rp 1,092,452,979.-. In fact CVM shows the total cost willingly donated by people in Sub-watershed Cikapundung Rp 527,905,500. -. With the availability of such costs, the government still had to Rp 564,547,479. - to be able to cover the shortfall in the cost of waste management sub-watershed Cikapundung. In addition, 97% of the public favor a counseling program so that people do not throw garbage into the river, and is estimated to cost Rp 335,195,000.- per month. Total government had set aside Rp 899,742,479.- every month to improve waste management systems and community mental Cikapundung Rivers Bank.

Keywords : Waste Pollution, Desire Society, Contingent Valuation Method

INTRODUCTION

Cikapundung River is the river that divides The Bandung City from the north to the south. Watershed (DAS) Cikapundung is one part of the sub Citarum and a river that serves as the main drainage in downtown Bandung.

Pollution problems arise from the behavior of the people living in the river basin Cikapundung who likes to throw garbage into the river. The change of the society alone can be the key to improving sanitation in the river changes. But changing people's behavior that have been formed over the years is not easy, especially related to waste management, which has always in the care of the government, but the government can no longer cope with the problems of garbage alone, efforts must be made also of the community to reduce waste and keep the environment as a form of society will value its environment. In such cases, the assessment of environmental services offer an alternative to align the interests of both parties (government and public) and assist policy makers in making changes (Jiang, 2010). Value of the services that will be measured through the method of Contingent Valuation Method (CVM). CVM typically use survey techniques to obtain the individual's willingness to pay (WTP) for providing a good environment or willingness to accept compensation (WTA) for a loss. Thus, these values are

taken to represent the economic benefits of the proposed changes and approvals in terms of cost-benefit for the social benefit of public policy typically increases social welfare (Salazar, 2009). Economic assessment of the use of some water resources (which in this case is Cikapundung River) is a relatively new, although it is very important that water policy to be inclusive and efficient (Zander, 2010).

CVM is also more accurate when compared to the shadow price method (shadow prize), when we try to estimate the total economic value which is the only technique that is theoretically capable of estimating the value of both the use and non-use (Senate, 2010). The purpose of CVM itself capable of emphasizing the use of economic principles to support decision making, flexible and integrated management, assessment of benefits, plan design, alternative evaluation, financial and institutional design (Harou, 2009).

METHODOLOGY

The research will be conducted in Watershed Cikapundung Bandung region in September-November 2012. The study discusses the behavior of the watershed Cikapundung, in this case the Willingness to Pay, Willingness to Accept and Willingness to Support for the program keep Cikapundung Clean River. Contingent Valuation Method (CVM) that could result in getting a reference implementation of the program has been designed in structuring and improving hygiene Cikapundung river bank, especially in the city of Bandung.

Mapping

Mapping was conducted to determine the sub-watershed Cikapundung to make the study area. Mapping the region aims to create a picture of the areas of research such as river pollution, pre-distribution facilities and sanitation, population distribution, and more. The mapping is made to facilitate the analysis of this study.

Observation Field

Field observations Imagery Drainage is important. Aiming to see and observe the condition of drainage contaminated by waste. Dirtiness index level draws on research Frisellya (2009) (**Figure 1**). This standard makes it possible to calculate the percentage of waste in surface area. In this study not only calculate the surface, but researchers add value t to be calculated percentage of the volume of waste.

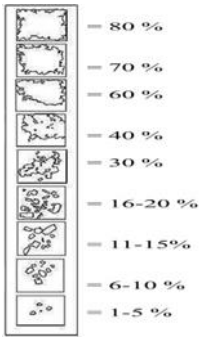


Figure 1. Frisellya's Dirtiness Index Level (2009)

Questionnaire

The initial phase of this research is to perform preliminary data processing is a condition of existing research data research area. In this stage, will be analyzed more in depth on the correlation between the social aspects of the demography, perceptions, fears of pollution, sources of pollution, the pollution, and the desire cleanliness Cikapundung River. For the formula of Slovin sample using the formula for being fit and can be used to calculate the population of Sub-watershed Cikapundung.

$$n = \frac{N}{1+Ne^2} \quad \text{.....(*1)}$$

where, : n = sample size
: N = population size
: e = persen error

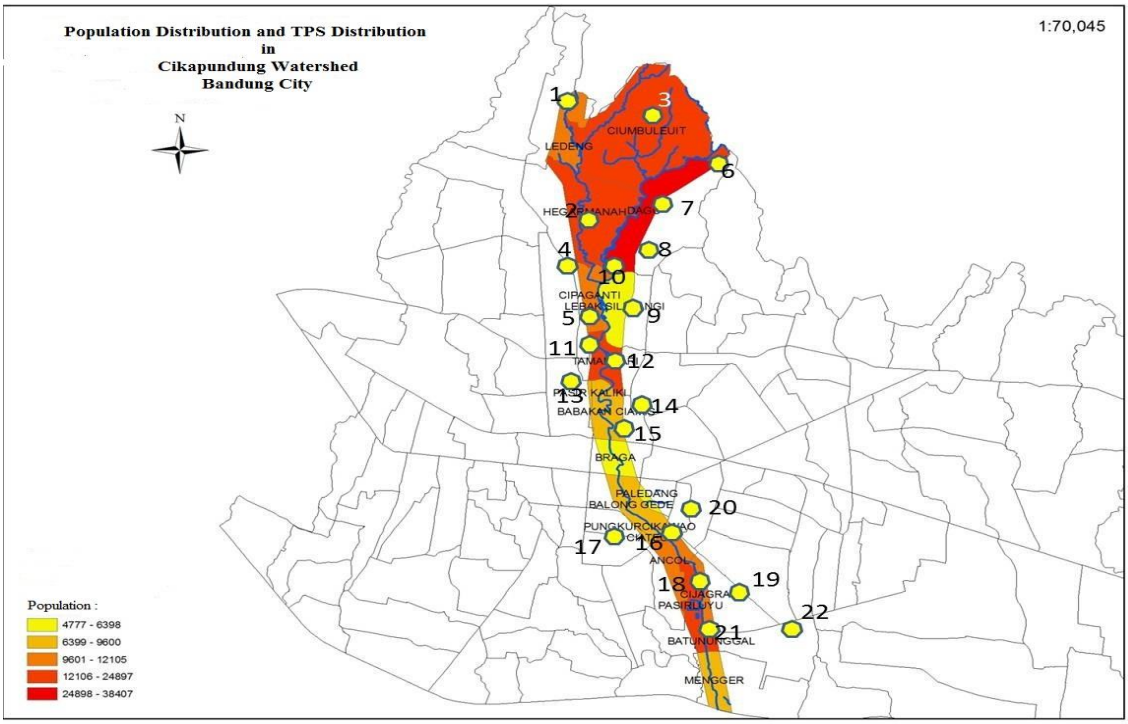
*1 : Slovin's Formula on Barlet, 2001

Efforts to get the discussion will be conducted by direct interview, to gather information about the condition of the existing waste management, particularly identifying locations prone to dumping into the river, conducted the interview as a qualitative research method. In the process of selecting informants, researchers used purposive sampling method, is choosing the people or parties who are considered to be clear about the problem being investigated (Faisal, 1990).

RESULT AND DISCUSSION

Research Area Existing Conditions

Initial research began by mapping the study area. It is made to determine the existing condition also limits the study area. Mapping created using ArcGIS 9.3 software with map material way the earth from the Ministry of Forestry in West Java in 2005. Existing conditions will be more clearly illustrated in **Figure 2.**



Description

1. TPS Ledeng
2. TPS Bungur
3. TPS Punclut
4. TPS Sukajadi
5. TPS Jembatan Layang
6. TPS Kebon Binatang
7. TPS Sangkuriang
8. TPS Terminal Dago
9. TPS Komunal Darrul Hikam
10. TPS Simpang
11. TPS Cibeunying
12. TPS Pasar Bunga
13. TPS Cicendo
14. TPS Braga
15. TPS Patrakomala
16. TPS Pasar Karapitan
17. TPS Tegalega
18. TPS Pasirluyu
19. TPS Putraco
20. TPS Bintara
21. TPS Batununggal
22. TPSSekelimus

Figure 2. Map of Population Distribution and TPS Distribution Sub-watershed of Cikapundung

This study determined the region into 20 districts, which overlaps with Sub-watershed Cikapundung. Depicted in **Figure 2** the population distribution is also the distribution of population Disposal While (TPS) in each region. From the field observations, the known total TPS in Sub-watershed Cikapundung TPS is 22 with a total capacity of 2768.4 m^3/weeks.

Total waste calculations, calculated from actual TPS capacity in the field and combined with the estimated waste generated per day. According to the Department of Housing West Java, 2011 is also under study Yusfi (2012) values for the solid waste sub-watershed Cikapundung was 1.7 l / person / day. Thus, the total waste generated each month is 3018.4 m^3, and are not transported and did not go to the polls is 9% of the total waste generated by the human population in the sub-watershed of 250 m^3/weeks Cikapundung. The rest of the waste has the potential to pollute the river Cikapundung.

If we count the total waste per month, the total is 1000 m^3/month. If we assume all the garbage in the river Cikapundung, then according to the waste management system in PD Cleanliness Bandung will cost Rp. 119,550,455, - for the garbage that is not accommodated. Meanwhile, for the garbage that has accommodated itself to cost Rp. 972,902,523, -. This is calculated from the cost of sewage treatment is Rp 237,479, - / t, also calculated per volume of Rp. 59,369, -/m3 and for landfill tipping fee of Rp. 33,500, -/ton.

In addition to the calculation according to the actual mapping TPS above, also calculated according to the waste drainage image obtained from multiple sampling areas, the results can be seen in **Table 1**

Table 1. *Image Drainage*

Area	Volume Avarage (m^3)	Weight Avarage (Kg)
Dago	0.92	100.64
Ciumbuleuit	2.23	205.45
Tamansari	27.74	5704.23
Cipaganti	13.20	2931.56

This result could be a reference to the area Cikapundung Atas (Hegarmanah, Ledeng, Cipaganti, Ciumbuleuit, Lebak Siliwangi, Dago, Tamansari) for each channel drainage in this area relate Cikapundung Tengah and Bawah into the Castle. Total waste entering the drainage is 44.09 m3. When compared with the total solid waste does not enter the polling station in the area is 443.7 m3. This means that 9.94% ≈ 10% of the residual waste that is not accommodated TPS into the drainage channel.

Image drainage can be used to estimate the volume of waste entering drains in other parts, such as parts of the Middle and Lower Pollutant Sources to the benchmark value of the Cikapundung Top. Pollutant Sources value is the average percentage of the value of the "I am who throw garbage into the river", "people who throw garbage into the river," and "junk mail". Value for Cikapundung Pollutant Sources Above is "951". A value of "951" indicates the percentage "agree" and "strongly agree" of the total value of 2100 (maximum value 300/Area), shows how people's behavior on the level of their own waste. This translates to 45.3% Above Cikapundung community behavior could potentially be a source of contaminants. **Table 2** will describe the estimation of waste into drains or water bodies in two other areas.

Table 2. *Image Drainage* per Area

Region	Area	Value Percentage of Pollutant Sources[1]	Estimation of Waste Sign in Drainage (m^3)[2]	Remaining Volume Waste Not Logged in TPS (m^3)[3]	Percentage of Waste Sign in Drainase[4]
Atas	Hegarmanah, Ledeng, Cipaganti, Ciumbuleuit, Lebak Siliwangi, Dago, Tamansari	951	44.3	443.7	10
Tengah	Pasirkaliki, Braga, Babakan Ciamis, Ancol, Balong Gede, Ciateul, Pungkur,	862	40.2	0	Tidak ada
Bawah	Pasirluyu, Cijagra, Cikawao, Mengger, Batununggal	719	33.5	111.2	30.1

Description:
1: Taken from the percentage of questionnaires "agree" and "strongly agree" to the "source polluters"
2: Taken from the amount of the average volume in **Table 1**
3: The power calculation tamping tps in the field
4: Comparison of estimates of waste in drainage and waste outside TPS

The results showed that the Cikapundung Top and Bottom Cikapundung, drainage channels accounted for a total of 33.5 m^3 of waste during the study. These results are only estimates of the benchmark is just garbage Sub-watershed drainage Cikapundung.

Value of 40.2 m^3 from Cikapundung Tengah's section but can not find trash in the drainage indicates that people in this section do not throw garbage into drains but throw garbage directly into the river Cikapundung. Because the distribution of waste management in The Cikapundung Tengah has been good, but for the riparian areas of dense population, no field observations or the provision of waste management infrastructure. So these figures we can conclude from the community are right on the banks of the River Cikapundung.

Profile of Respondents

Total population in Sub-watershed Cikapundung was 253,645 inhabitants. The population is spread out in 20 wards. To take a sample of the formula used Slovin. The results obtained were 208 respondents to the 93% confidence level. Respondents consisted of diverse backgrounds, but still fit the criteria for purposive sampling method used in this study, namely the people who live along the river that have a distance <250 m, and the general public living in the sub-watershed within Cikapundung > 250 m to the limit Cikapundung Sub-watershed. The diversity of the differences of these variables strongly influence the perception of each

respondent to lead to the determination of Willingness to Pay (WTP) for improved hygiene Cikapundung River. These variables can be seen in **Table 3.**

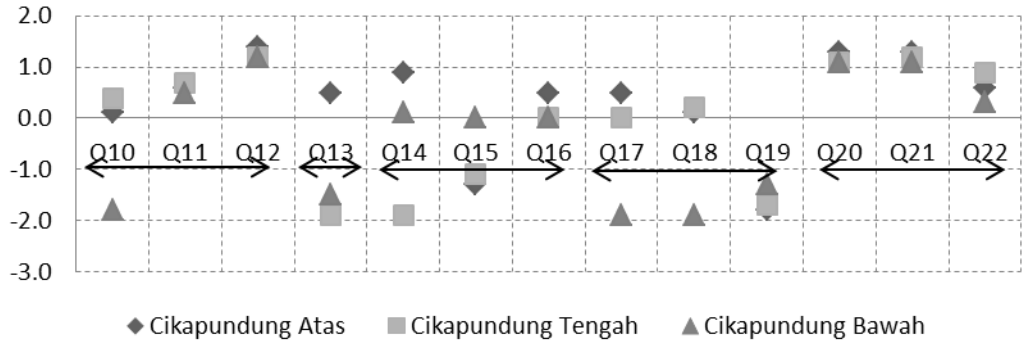
Table 3. Different Test and Test Correlation Public Attitudes Sub-watershed Cikapundung the WTP

Attributes of Respondent	Different Test		Correlation Test		
	Sig.	Information	Correlations Coefficient	Sig.	Information
Profile					
Sex	0.008	Different	0.320	0.008	Weakness Relationship
Age	0.223	Not Different	0.382	0.223	Not Significant
Education	0.000	Different	0.437	0.000	Weakness Relationship
Job	0.000	Different	0.824	0.000	Weakness Relationship
Income	0.000	Different	0.616	0.000	Weakness Relationship
Expenditure	0.000	Different	0.616	0.000	Weakness Relationship
Family Members	0.415	Not Different	0.574	0.415	Not Significant
Length of Stay	0.008	Different	0.448	0.008	Weakness Relationship
Distance Home	0.006	Different	0.326	0.006	Weakness Relationship
Public Perception					
Usefulness River	0.000	Different	0.520	0.000	Weakness Relationship
Restribution Waste	0.000	Different	0.522	0.000	Weakness Relationship
Desire Cleanliness	0.602	Not Different	0.341	0.602	Not Significant
Perception Defilement					
Trash Disorders	0.000	Different	0.525	0.000	Weakness Relationship
Pollutant Sources					
Dispose of Waste into River	0.010	Different	0.484	0.010	Weakness Relationship
Other Discard Waste into River	0.000	Different	0.522	0.000	Weakness Relationship
Waste Posts	0.036	Not Different	0.465	0.036	Not Significant
Impact of Polluted					
Flood Disorders	0.003	Different	0.498	0.003	Weakness Relationship

Attributes of Respondent	Different Test		Correlation Test		
	Sig.	Information	Correlations Coefficient	Sig.	Information
Leisure Disorders	0.000	Different	0.541	0.000	Weakness Relationship
Health Problem	0.003	Different	0.501	0.003	Weakness Relationship
Action for Cleanliness					
Cleaned Together	0.000	Different	0.535	0.000	Weakness Relationship
Extension of Government	0.003	Different	0.458	0.003	Weakness Relationship
Participate	0.001	Different	0.516	0.001	Weakness Relationship

Table 3 presents some data that shows the fact that a lot of the things that make the difference in determining WTP. Only respondents age factor and the number of family members per residence is relatively the same. And the community's desire for cleanliness river is also a shared perception of waste shipments from other parts of the equation from the start of the Cikapundung Up until Cikapundung Down. Background of respondents also waste management system in each region is different. From the results above we can see in **Figure 3** that the relationship Cikapundung attitudes towards the river where the positive and negative values almost equal. This shows the difference in the perception of multiple variables Cikapundung views of the role of the river itself for each individual and each region.

Public Attitudes Toward Cikapundung River Relationships



Description :
1 : Strongly Disagree
2 : Disagree
3 : Undecided
4 : Agree
5 : Strongly Agree

Public Perception
Q10 : Uses the River
Q11 : Retribution for Waste
Q12 : Desire Cleanliness

Disorders Defilement
Q13 : Waste Disorders

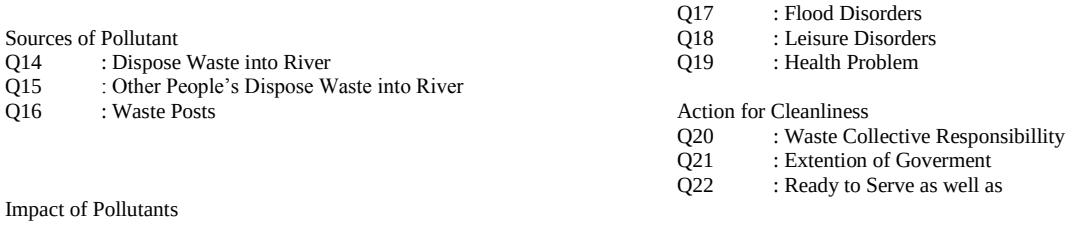


Figure 3. Graph results of Public Attitudes Toward Mapping Cikapundung River

Figure 3 shows the attitude of society towards a wide range of variables and their effects on river cleanliness Cikapundung. Figure 3 shows the difference, but not too significant. However, these variables will certainly becoming a material consideration in determining the attitude of society to the River Cleanliness Cikapundung mainly in the form of WTP.

The survey results get, 53% of the people who live along the river, as well as 47% of people living in Sub-watershed Cikapundung. Characteristics of the waste management system is almost the same for each group. For groups that have a residence <250 m tend not well-facilitated by the government in terms of waste management. With the field conditions and the narrow streets of densely populated, it is difficult for the janitor to haul trash to the nearest polling station. Besides cleanliness of facilities and infrastructure was not provided. Conditions such as these encourage people to throw garbage into the river. That is why there are only local Q14 Cikapundung Cikapundung Top and bottom which is positive, which means that people still throw garbage into the river.

This is different from people who have residence> 250 m to limit Cikapundung Sub-basin, where the settlement has a fairly wide streets and orderly settlement allowing facilitated by a local janitor. With these conditions in the trash can be controlled by a janitor though apparently there are still people who throw garbage directly into the river. That is because there are still many who live in the communities along the river, and the community is difficult to get the infrastructure adequate hygiene.

Yet according Faramita (2012) the success rate of collection of solid waste (garbage) is influenced by both technical and non-technical. in the technical aspects, the effect given by the variation patterns existing collection and the frequency of collection. While in the non-technical aspects, the effect is given by the level of dependency and the public perception of the main actors.

In addition, if viewed from the public perception of the usefulness of the river (Q10), Society Under Cikapundung likely to benefit, because they only accept the results of any waste shipment from the previous area (Q16). Almost each piece admits getting the junk mail from the previous area, and therefore lower Cikapundung may accumulate a total waste entering the river so that the river was Cikapundung no longer uses.

However, in the area under its own there is a difference that can be perceived differentiating variable. Variables such as distance and economic levels. For example, when comparing The Batununggal Village and Mengger Village where other side region to each other

and separated by the River Cikapundung only, but background Society Batununggal higher economic level and have good spatial settlement so that no one who throw garbage into the river, it is inversely proportional to the spatial Mengger where denser settlements and no sanitation facilities and infrastructure so that people tend to throw garbage into the river.

Things like that happen that cause differences in WTP of each urban area. In general, as many as 10.2% of respondents refused to pay and 45.8% refused to no increase in dues, but they replaced it with energy and services in terms of protecting the environment. Total afford to pay for the increase in dues (WTP) was 44%.

The total cost calculation that can be given by the public is Rp 527,905,500, - from WTP plus Rp 90,000,000, - from donated labor (Willingness to Support) are converted into dollars, while the WTA itself, 100% of people can receive all activities or programs with the goal of improving hygiene Cikapundung River for cleanliness each month.

The number is of course a lot of help from the total cost to be incurred in the management of the River Cikapundung Rp. 1,092,452,979, - The government still had to increase the number of deficiencies coupled with the allocation of funds to meet the wishes of 97% of respondents want to have counseling to people in the surrounding flood plains is estimated to cost Rp. 335,195,000, - per month. Total government had set aside Rp. 899,742,479, -.

When compared with studies Jiang (2011), in which WTP drawn to reduce agricultural pollution in the River Min, China, the situation is not much different Cikapundung River, where everyone was asked rise retribution (WTP form) with the intent and purpose of improving hygiene in the river of garbage Cikapundung . In China, especially the Min River, 57% liked the idea of retribution rise, with an average rate increase CNY 0.5 or equivalent to Rp 750, -.

Cikapundung River could pay as much as 44% increase in sanitation rates to free Cikapundung River of Waste, with an average increase of Rp 2.500, -. In fact if traced from upstream, the river was equally Cikapundung polluted agricultural waste from West Bandung regency. With a larger rate increase should the government can take advantage of this opportunity to design waste management systems in Sub-watershed Cikapundung even better.

CONCLUSIONS

The Conclusion is Cikapundung in critical condition in the case of river pollution by garbage, the Estimate was 567 m^3 of waste entering the river each month, whereas Willingness to Accept the Sub-watershed Cikapundung to accept the government's program to clean up the river for 97%, and the level of willingness to Support and Willingness to Pay for cleaning Cikapundung River was 89.8% in the form of pay, personnel, establish, maintain and preserve the environment Cikapundung River of garbage. Improving hygiene Cikapundung River is a shared responsibility, but poor waste management system of government should be immediately repaired to the potential that exists in the community can be maximized for cleanliness Cikapundung River.

Suggestion, there should be further research on pollution estimates Imagery Drainage and waste into the river Cikapundung associated with time, population growth, or at the age of disposable goods and services.

References

Barlett, James. 2001. *Organizational Research Determining Appropiate Sample Size in Survey Research, Information Technology, Learning, and Performance Journal Vol.19 No. 1. 43-50.*USA

Faisal, Sanafiah. 1990. *Penelitian Kualitatif: Dasar-dasar dan Aplikasi*. Yayasan Asih Asah Asuh. Malang. Indonesia.

Faramita, Nadia., Rahardyan, Benno. 2012. *Analysis on The Implementation of Scheduled Solid Waste Collection Program in Regional Scale*. Environmental Engineering Seminar's Graduate Programme. Institut Teknologi Bandung. Bandung. Indonesia

Frisellya, Priska. 2009. *Measurement Method Developing of Dirtiness Level Caused by Garbage Using Perception and Image Variables for Supporting Road Sweeping Activity (Case Study : Bandung City)*. Bachelor Programme. Institut Teknologi Bandung. Bandung. Indonesia

Harou , Julien J., Manuel P.V., David E.R., Josue M.A., Jay R.L, Richard E.H. 2009. *Hydro-economics Models : Concepts, Design, Applications, and Future Prospects, Journal of Hydrology 375. 627-643*. California. USA.

Jiang, Yi., Leshan Jin., Tun Lin . 2010. *Higher Water Tariffs for Less River Polution-Evidance from The Min River and Fuzhou City in China, China Economic Review 22. 183-195.* Beijing. China

Salazar, Salvador Del., Francesc Hernandez S., Ramon S.G,.. 2009. *The Social Benefits of Restoring Water Quality in Context of The Water Framework Directive : A Comparison of Willingness to Pay and Willingness to Accept, Science of The Total Environmental 407. 4574-4583.* Valencia. Spain

Senate, Maria M., Francesc Hernandez S., Ramon S.G. 2010. *Economic Feasibilty Study for Wastewater Treatment : A Cost-benefit Analysis, Science of The Total Environmental 408. 4396-4402.* Valencia. Spain.

Yusfi, Rosi N. 2012. *Study The Characteristics of Waste And Alternative Waste Management Systems Along The Cikapundung River*. Bachelor Programme. Institut Teknologi Bandung. Bandung. Indonesia.

Zander, Kerstin K., Stephen T.G., Anna Straton. 2010. *Trade-offs Between Development, Culture and Conservation-Willingness to Pay for Tropical River Management among Urban Australians, Journal of Environmental Management 91. 2519-2528.* Darwin. Australia.

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CONTENT OF HEAVY METALS IN THE WATER AND WATER HYACINTH (*Eichhornia crassipes*) IN WATER BODIES RECEIVING WASTEWATER FROM TEXTILE INDUSTRY (Case study: Cikacembang River, Majalaya Districts, Bandung Regency)

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Abstract: Cikacembang River is including the worst water quality, from a total of 56 industries in the District Majalaya, 22 textile industry throw waste into the Cikacembang River with an average daily discharge 66,058 m^3/day (BPLHD Bandung regency, 2012). Effluents from textile industry contains high amounts of metal, especially cadmium, chromium, copper, and leadthat are harmful to living things. Utilization of aquatic plants for wastewater treatment is an economical method of wastewater treatment contaminated by heavy metals. Therefore, to reduce the content of heavy metal in the Cikacembang River, it isdone phytoremediation by using the water hyacinth (*Eichhornia crassipes*) with two different methods, namely continuous system (field) and continuous system (laboratory). The content of heavy metals Cd, Cr, Cu, and Pb in the water and the water hyacinth (*Eichhornia crassipes*) were measured using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). The result showed that the metal content in the water and the water hyacinth (*Eichhornia crassipes*) in batch and continuous systemsis different, the effectiveness of the water hyacinth plant (*Eichhornia crassipes*) to absorb metal in a batch system is better than continuous system because the batch system can reduce Cd metal, Cr, Cu, and Pb respectively 1.19%, 57.95%, 88.18%, and 0.29%. In the continuous system, the water hyacinth plant (*Eichhornia crassipes*) can only reduce about Cd 74.68% and Cu 46.41%, while Pb and Cr increased -138.69% and -28.90%.

Keywords: Cikacembang River, phytoremediation, water hyacinth (*Eichhornia crassipes*), batch system, continuous system

INTRODUCTION

Based on the monitoring results by the Ministry of Environment (MOE) and Environment Monitoring Agency (BPLHD) West Java, along in 2009, 2010 and 2011 status Citarum heavily polluted river water. Iriany and Rachmatiah research (2014) showed that an increase in pollution from upstream to downstream in Upstream Segment Citarum shown by an increase in toxicity in Onion (*Allium cepa*) and a decrease in diversity makrozoobenthos.Citarum River has tributaries which one of them is Cikacembang River which is located on Citarum River Upstream. Based on data from BPLHDs Regency Bandung (2012), the river Cikacembang is including the worst river water quality, from a total of 56 industries in the District Majalaya as many as 22 pieces of textile industry Cikacembang throw waste into the river with an average daily discharge 66,058 m^3/day. Based on Puslitbang research (2010), Cikacembang River upstream side have the quality status of being contaminated, whereas Cikacembang River downstream has heavily polluted the quality status. Textile industry effluent contains high amounts of metal, especially chromium, copper, and cadmium that are harmful to living things (Deepali and Gangwar, 2010).

Textile industrieswhich throw waste into Cikacembang River have done treatment of physics, chemistry, and biology before disposing of waste, but the condition is still toxic Cikacembang River so that the necessary efforts to further processing (Maulani and Rachmatiah, 2014). This is because the textile industry effluent contains high amounts of metal, especially chromium, copper, and cadmium that are harmful to living things (Deepali and Gangwar, 2010). Cikacembang River water is toxic even though no cause of death in Nile Tilapia (*Oreochromis niloticus*), but change the overall parameters of the blood, increasing the number of erythrocyte abnormalities and cause abnormalities in the secondary lamela gills (Azlia and Rachmatiah, 2015).

Utilization of aquatic plants for wastewater treatment which is contaminated by heavy metals is an economical method (Rai, 2010). The response of plants is absorbing metal directly through the roots at a rate absorption of the metal which may reach 90-95% depending on the species, the concentration of the metal, and environmental factors such as pH, temperature, and other (Chakraborty and Mukherjee, 2012). The use of plants to remove, move, stabilize, or destroy contaminants called phytoremediation (Dhahiyat, 2011). The strengths of phytoremediation is environmentally friendly, low cost, sewage treatment aesthetically pleasing, and is especially suitable for developing countries. Plants used in phytoremediation should have a large enough capacity in metal uptake, accumulation, and the ability to process in a short time (Singh *et al.*, 2012).

Some aquatic plants that can be used as phytoremediation plants are kiapu (*Pistia stratiotes L.*), kiambang (*Salvinia molesta*), and water hyacinth (*Eichhornia crassipes*) (Dhahiyat, 2011). *Eichhornia crassipes* can be used to reduce the content of heavy metals Cd, Cr, Cu, Pb, Zn, and Ni (Singh et al, 2012; Yapoga et al, 2013; Komy et al, 2012; Gaherwar and Kulkarni, 2012). In this study, the water hyacinth (*Eichhornia crassipes*) is used to reduce heavy metals in Cikacembang River with continuous system and batch systems in the laboratory. The analysis was conducted to determine the concentration of metals Cd, Cr, Cu, and Pb in water and plants by using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) is compared with the content of water quality standards under Regulation 82 of 2001 Class II, namely 0.01 mg/L, 0.05 mg/L, 0.02 mg/L, and 0.03 mg/L for each of the metals Cd, Cr, Cu, and Pb and quality standards at the plant recommended by WHO 0.02 mg/kg, 1.30 mg/kg, 10 mg/kg and 2 mg/kg for each of the metals Cd, Cr, Cu, and Pb (Nazir *et al.*, 2015). BCF calculation and reduction of metals in water calculated to determine the absorption of metals Cd, Cr, Cu, and Pb in water hyacinth (*Eichhornia crassipes*). Ability of the metal bioaccumulation can be estimated from the classification of bioaccumulation is low (0-100 L / kg), medium (100-1000 L / kg), and high (> 1,000 L / kg) (Van Eszh, 1997 in Amriani et al, 2011). The purposes of this study are knowing the reduction of heavy metals in the river water Cikacembang and accumulation as well as differences in the absorption of heavy metals Cd, Cr, Cu, and Pb by water hyacinth (*Eichhornia crassipes*) in phytoremediation process Cikacembang River using batch and continuous systems.

METHODOLOGY

Continuous Systems Research (Field)

Continuous system research starting from July 2014 through December 2014 with details of a field survey (May 9, 2014), sampling baseline (July 3, 2014 and August 11, 2014), installation trial of the plant net (7 and October 11, 2014), continuous system research in Cikacembang River (November 2014), extraction of metals in Industrial Hygiene Laboratory, Environmental Engineering Institute of Technology Bandung (ITB) (November and December 2014), and testingof heavy metal by using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) in laboratory Service Center for Basic Science, University of Padjadjaran (PPBS-UNPAD) (March, 2015). Equipment used in the continuous system is anet of 2 x 1 x 1.5 m with a mesh size of 5 mm, bamboo, tarpaulin size of 3 x 4 m, 250 ml plastic bottles, plastic zip, shovels, buckets, cool box , blue ice, cameras, DO meter, pH meter and conductivity meter. Water hyacinth (*Eichhornia crassipes*), which is used in a continuous system from Ciparay areas which has a large and small size with an averagewet weight of each size is 71.78 and 24.29 grams. Research continuous system was carried out for 4 weeks, but it will only be explained for 1 week to compare with the batch system. Sampling (water and plants) done on days 0, 3, 5, and 7.

With reference to the SNI 6989.57-2008 water sampling in all the points were done in 0.5 x depth of the surface due to river discharge an average of less than 5 m^3/sec. Samples of water and then put in a plastic bottle of HDPE (High Density Polyethylene) measuring 250 mL. Water hyacinth (*Eichhornia crassipes*)samples were taken by 2 pieces large and small, and put them in a zip plastic. Samples were stored in a cool box to keep cool at 4 ° C.

Batch Systems Research (Laboratory)

Batch systems research and metal extraction were done at the Laboratory of Industrial Hygiene, Environmental Engineering Institute of Technology (ITB) in November and December 2014, and the measurement of the concentration of metals using the tool Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) was done in laboratory Service Center for Basic Science University Padjadjaran (PPBS-UNPAD) in March 2015. The object of the research is the water hyacinth (*Eichhornia crassipes*) obtained from rice fields in the area of Ciparaywhich has smaller size than in continuous systems with an average wet weight of 13.47 grams. The equipment used in batch systems research are glass beaker 50 ml, 250 ml Erlenmeyer flasks, flasks of 50 ml and 25 ml, funnel glass, watch glass, spatula, analytical balance, an electric stove, a water bath (water bath), refrigerator, oven, vaporizer cup, plastic zip, glass bottles, plastic bottles of 30 ml and 60 ml, papers, camera, and filter paper whatmann number 42 with a diameter of 90 mm. Materials used in batch systems research were HNO_3, HNO_3 10%, concentrated HCl, concentrated H_2SO_4, H_2O_2 10%, and aquabidest.During the research, plants were stored in racks in the aquatic laboratorywhich provided by the artificial lighting system (TL lamps 40 W, light intensity 900-1200 lux) to replace the function of sunlight. Sampling (water and plants) was done on days 0, 3, 5, and 7.

Extraction of heavy metals in water is based on Standard Methods, 5th edition (2001) following the research conducted by Nurfitri (2010) is by concentrating the 250 mL water

sample with 10 ml of HNO_3. Subsequently, the sample was heated to less than 50 mL volume. After that, the sample was diluted with distilled water until reaching the volume of 50 mL. Based on Amalia research (2012), extraction of heavy metals in plants is based on SNI-06-2464-1991 were weighed wet weight of the whole plant samples using an analytical balance. After that, the sample was separated between the leaves and roots. Further samples were chopped and mashed. The sample was then dried in an oven at 105°C for 2 hours. The oven wasused for the research is Precision Oven Economy models. Furthermore, the dry weight of the sample was weighed. Aquaregia (mixture of HCl: HNO_3 with a ratio of 3: 1) of 10 ml for every 1 gram dry weight of the sample is then given to the sample. Samples were heated in a water bath Boekel series models 020 070 1494RS-2 during a day and night. The sample then was filtered and diluted up to 50 mL volume.

Testing and Data Analysis

Testing of content of metals in water samples first of all was done by extracting the metal content in the water and plants. The content of metals in the samples were analyzed using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) brand Agilent Technologies type 700. ICP is a common tool used to detect various kinds of metals in the different samples. The main principle in determining element ICP is the injection of fluid and then element atomization, this technique is based on the spontaneous emission of photons from atoms and ions that have excitation in radio frequencies (Hou and Jones, 2000). The data obtained should be converted to the suitability of the data by the weight of samples using **Equation 1** until**Equation 6**.

$$\text{Concentration of heavy metals in water}\left(\frac{\text{mg}}{\text{kg}}\right) = \frac{\text{ICP Result (ppm) x 50 mL}}{\text{250 mL}} \quad \textbf{(Equation1)}$$

$$\text{Concentration of heavy metals in the roots}\left(\frac{\text{mg}}{\text{kg}}\right) = \frac{\text{ICPResult (ppm) x 25 m}}{\text{Weight of dry sample (g)}} \quad \textbf{(Equation2)}$$

$$\text{The concentration of heavy metals in the shoots}\left(\frac{\text{mg}}{\text{kg}}\right) = \frac{\text{ICP Result(ppm) x 25 m}}{\text{Weight of dry sample (g)}} \quad \textbf{(Equation3)}$$

$$\text{Efficiency of metal reduction} = \left(\frac{\text{Co}-\text{Cx}}{\text{Co}}\right) \text{ x } 100\% \quad \textbf{(Equation4)}$$

Where Co = Concentration of metal on day 0

Cx = metal concentrations on day 7

Bioconcentration factor (BCF) can be determined using the following equation (Soemirat, 2005):

$$\text{BCF (L/kg)} = \frac{\text{concentration of metals in plants}\left(\frac{\text{mg}}{\text{kg}}\right)}{\text{concentration of metals in water}\left(\frac{\text{mg}}{\text{L}}\right)} \quad \textbf{(Equation5)}$$

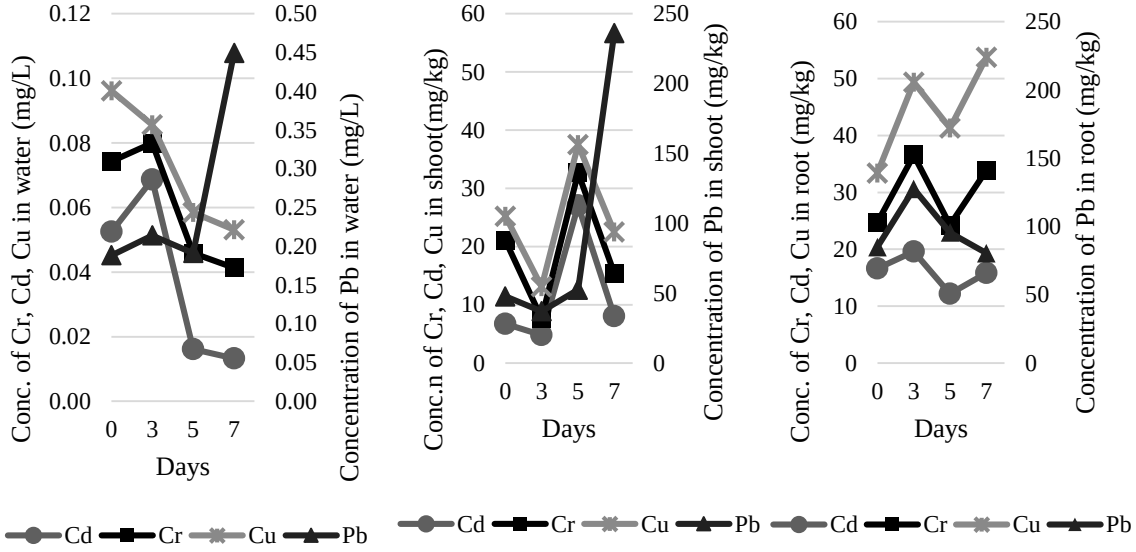
RESULTS AND DISCUSSION

Results of Continuous Systems Research (Field)

Metal content in the water and the plants in continuous system were fluctuated within 7 days because of the activity of the textile industry which dispose of wastewater into the river. Fluctuation of water metal content in Cikacembang River can be seen in **Figure 1**.

a. Cadmium (Cd)

Content of Cd in the water exceeded the quality standard (0.01 mg/L) which is between 0.01 to 0.07 mg/L. According to Siantiningsih (2005), Cd binds with small minerals so it's easily lifted from the bottom to the river. Cd uptake by roots and shoots will increase with increasing of metal concentration in the media. Cd concentrations in



a) Water b) Shoot c) Root

Figure 1. Content of Cd, Cr, Cu, and Pb in Continuous System Research

the shoots increases and decreases in the range 6.70 to 27 mg/kg, while the roots in different ranges which are not too far away that is from 12.1 to 19.6 mg/kg. Water hyacinth (*Eichhornia crassipes*) reduced Cd metal in water by 74.68%. Mobility and Cd metal solubility in water is high (Delcorso, 2008). Bioaccumulation of metals Cd in shoots were moderate that is 606.81 L/kg and in the root were high bioaccumulation with a value of 1190.91 BCF L/kg.

b. Chromium (Cr)

Chromium is used in the textile industry as a mordant which has resistance to fade so resistant to water, light, and sweat (Kozlowski, 2012). Range of Cr content in water is 0.01 to 0.03 mg/L, which still fulfills the quality standard (0.05 mg/L). Cr concentration in the roots continue to increase from 8.10 mg/kg to 18 mg/kg, while in the shoots decreased from 14.3

mg/kg (day 0) reaches the lowest point of 2.83 mg/kg (day 3) and increased again. Absorption of Cr in water depends on pH, oxidative Cr and concentration, salinity, and the presence of dissolved salts (Singh *et al.*,2012). There is no Cr reduction by plants due to the concentration in the water increases, so the percentage of Cr reduction is -28.90%. Cr metal accumulation levels in leaves on day 7 is in the amount of 262.19 L/kg and in the root of 643.12 L/kg, both of them are including moderate bioaccumulation.

c. Copper (Cu)

Cu contained in the dyes used by the textile industry, each dye is containing Cu as an internal part of the molecular structure of the chromophore (Andarani, 2009). Cu concentrations in water between 0.01- 0.02 mg/L is still in accordance with the quality standards supposed to (0.02 mg/L). Percentage of reduction of Cu by the plants is 46.41%. Cu concentration at shoots increased from 4.20 mg/kg to 7.06 mg/kg and at the root increased from 8.66 mg/kg to 19.08 mg/kg. The rate of accumulation of Cu in the shootsof 601.42 L/kg is including moderate bioaccumulation and at the root of 1691.74 L/kg including high bioaccumulation.

d. Lead (Pb)

Pb metal content range in water is 0.19 to 0.45 mg/L. The high concentration of Pb is because Pb compound is used as a pigment, including white lead (lead carbonate and sulfate), red lead (lead oxide), a variety of lead chromate and lead cyanamide (Eagleson, 1993). Pb concentrations in the roots were in the range 75.67 to 127.59 mg/kg and concentrations in the leaves between 37.04 to 236.17 mg/kg. BCF values of Pb in leaves and roots still relatively moderate bioaccumulation that is 525.32 L/kg in the shoot and 178.88 L/kg at the root. There is no reduction of metal, the concentration of Pb increased by 138.69% from the initial concentration, so the percentage of reduction is -138.69%.

Reduction of Cd, Cr, Cu, and Pb in the continuous system can be seen in Figure 2. It can be concluded that the water hyacinth (Eichhornia crassipes) can absorb the metal content of Cd and Cr for continuous systems research.

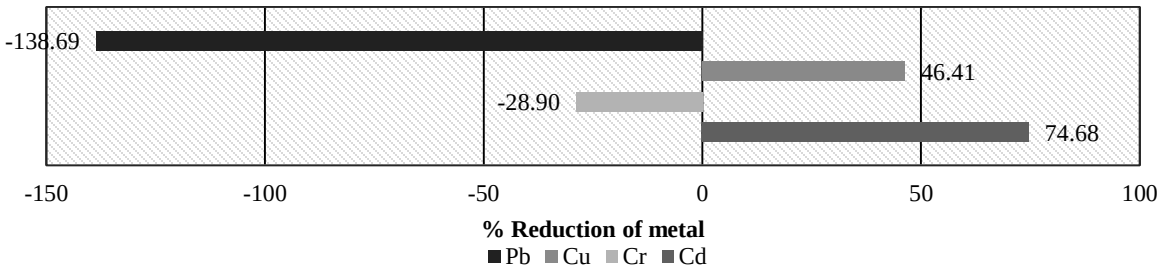


Figure 2. Reduction of Cd, Cr, Cu, and Pb in Continuous System Research

Results of Batch Systems Research (Laboratory)

Metal content in water of Cikacembang river in batch system can be seen in **Figure 3**.

a. Cadmium (Cd)

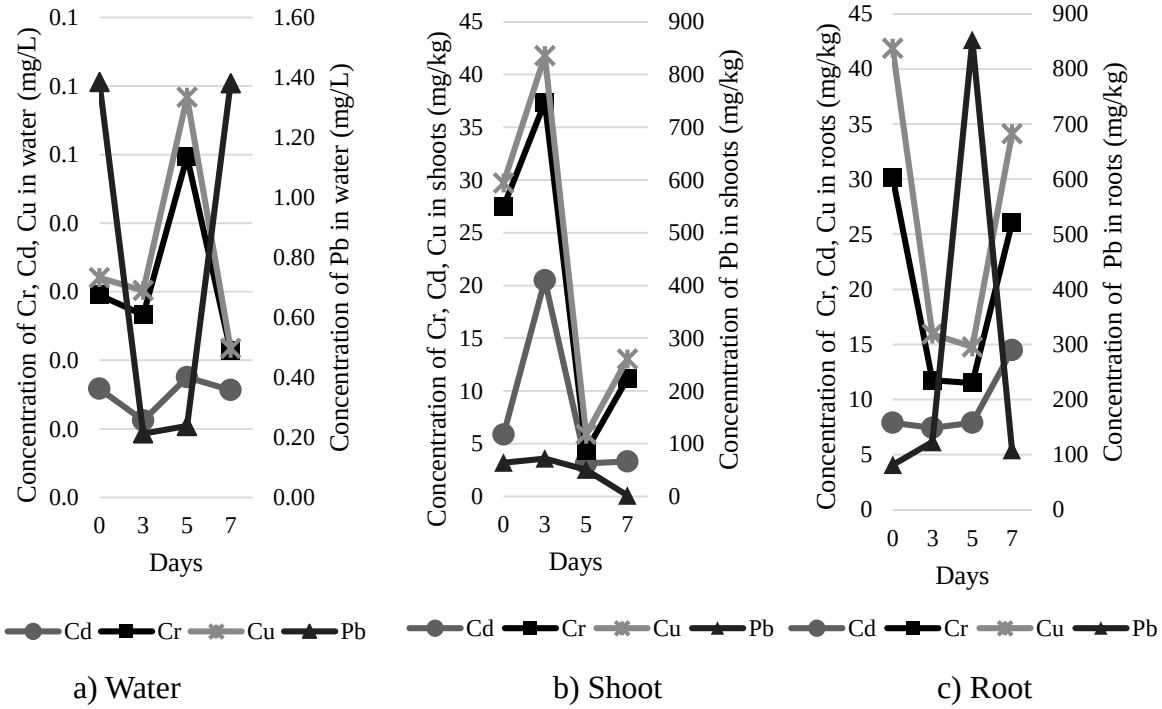
Cd metal concentrations in water that fulfill the quality standard (0.01 mg/L) is on the 3rd day, while the other days exceeded the quality standard which is 0.02 mg/L. Cd concentration in shoots between 0.02 to 5.88 mg/L, and the roots between 7.91 to 10.7 mg/L. It is estimated that the water hyacinth (*Eichhornia crassipes*) which are used already contains metals Cd, so after 3 days Cd metal diffusion was out of the plant. Percentage of reduction Cd metal in water is 1.19%. Cd mobility in the water is high enough, low content of Cd in the water showed uptake by plants. Levels of Cd accumulation in shoots and roots were moderate which is 211.67 L/kg and 924.70 L/kg.

b. Chromium (Cr)

All of Cr concentration in water does not exceed the quality standard (0.05 mg/L), it's only in the range of 0.01 to 0.03 mg / L. Initial concentration of Cr in shoots and roots is high that are 21.6 mg/kg and 22.2 mg/kg. Cr concentration decreases to be contained by 2.76 mg/kg in shoots and 5.02 mg/kg in the roots. Cr concentrations in roots is higher than Cr concentration in shoots, because the mobility of Cr from the root to the shoots is low, the concentration of Cr is dominant in the root (Shanker, 2005). Cr metal accumulation levels in leaves and roots is high which are 1,365.21 L/kg and 2,008.05 L/kg. Water hyacinth (*Eichhornia crassipes*) can reduce Cr in the water as much as 57.95%.

c. Copper (Cu)

Cu concentration in water is very low, of 0 - 0.01 mg/L, it did not exceed the quality standard (0.02 mg/L). Cu concentrations in the shoots ranges of 1.70 to 2.63 mg/kg and in the roots of 6.22 to 11.7 mg/kg. Cu concentrations that higher in roots than in the leaves is one of the mechanisms of plant tolerance to Cu metal. This is done to avoid the accumulation of toxic concentration by stopping excess of Cu in the root, so it does not enter the interior of the leaf (Yruela, 2009). Cr metal accumulation in shoots 6273.99 L/kg and the root 27455.39 L/kg including high bioaccumulation. This demonstrates the high demand for Cu in plants for photosynthesis. The location of Cu metal accumulation in plants is chloroplasts, Cu metal is needed for photosynthesis (Maksymiec, 1997). The need of Cu needs that are high on the water hyacinth (*Eichhornia crassipes*) is also shown on the Cu metal removal percentage is highest among the other metals is 88.18%.



a) Water b) Shoot c) Root

Figure 3. Content of Cd, Cr, Cu, and Pb in Batch System Research

d. Lead (Pb)

Pb concentration in water is much higher than the concentrations of Cr, Cd, and Cu. Pb concentration in water is between 0.21 to 1.38 mg/L exceeded the quality standard (0.03 mg/L). Absorption of Pb by the water hyacinth is higher than absorption of metals Cd, Cr, and Cu. Pb concentration in shoots is between 61.2 to 67.1 mg/kg and in the roots of 81.52 to 118 mg/kg. High Pb concentrations in water damage barrier function of plasmalemma so Pb gets into the cells in large numbers (Sharma and Dubey, 2005). However, if calculated bioaccumulation of Pb in the leaves and roots are low ehich are 1.48 L/kg and 78.57 L/kg. It was because of high differences between metal content in the water and in plants. Pb metal absorption by plants were classified as very low at 0.29%.

The results of the percentage reduction of heavy metals in the water due to metal uptake by plants existing batch systems can be seen in Figure 4.

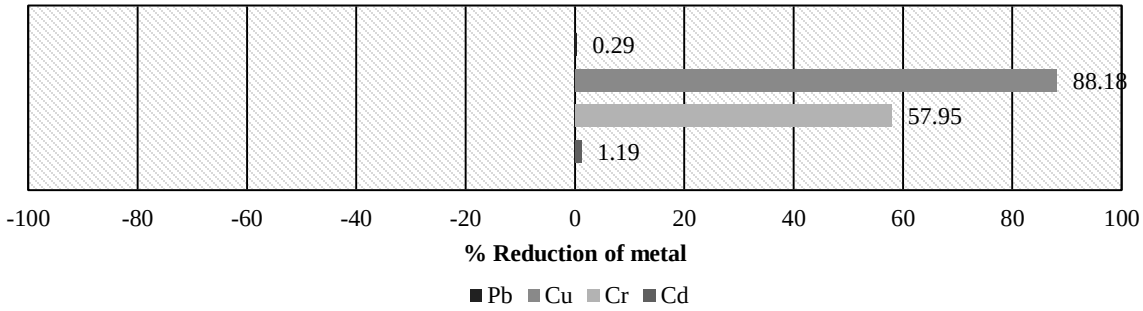


Figure 4. Reduction of Cd, Cr, Cu, and Pb in Batch System Research

Comparison of Batch and Continuous System

Content of heavy metals in the water and plant were different. Content of heavy metals in water less than inshoots and roots of the water hyacinth (*Eichhornia crassipes*). Although the metal content in water less, but many parameters Cd, Cr, Cu, and Pb were exceeded the quality standards that are harmful to living things. The trend of increase and decrease of Pb in water and plants on both systems is inversely proportional to the metal Cd, Cr, Cu. Lead availability is also affected by the presence of other heavy metals. Orronoa *et al*. (2012) in Fahr *et al*.(2014) reported that Pb availability was reduced when it was supplied with five heavy metals (Cd, Cr, Cu, Zn, and Ni) that have an antagonist effect. When Pb supplied alone or in ternary combination (with Zn and Cu), its availability increased due to the antagonistic interaction between Cu and Zn, which made Pb more available for plant uptake (Fahr *et al*, 2014).

In the continuous system, water hyacinth (*Eichhornia crassipes*) can eliminate most major metal that is Cd as much as 74.68% and Cu as much as 46.41%. However, Pb and Cr did not decrease but rather an increase in the concentration of each metal which is added as much as -138.69% and -28.90%. The reduction of Cd and Cu that were good by the water hyacinth (*Eichhornia crassipes*) is evidenced by the high bioconcentration factor at the root. Thus obtained that in the continuous system, water hyacinth (*Eichhornia crassipes*) is a good hyperaccuumulator for metals Cd and Cu. However, bioaccumulation of metals in the shoots is still relatively moderate, this is due to fluctuations in river water makes metal content in water varies so that the plant is unable to absorb metal maximum. BCF generated was compared with research by Swain *et al*.(2014), which gave exposure to the metal for 25 days, BCF for the Cd concentration of 0.27 mg/L were medium, which is 653 L/kg and at a concentration of 0.35 mg /L Cu which is 1,230 L / kg. Provided that metal exposure within 7 days of the study is very highalmost the same as research of Swain (2014), due to the routine of the textile industry effluent dispose of waste into water bodies.

Water hyacinth (*Eichhornia crassipes*) in a batch system can reduce metal content. Although metals Cd and Pb are relatively low at 1.19% and 0.29%, Cr and Cu are high, namely 57.95% and 88.18% , Water hyacinth (Eichhornia crassipes) is able to absorb large amounts of metal in accordance with the research Prasad (1983) that the water hyacinth can reduce Cr 60-80% within 8-16 days and in research Scheider (1995) which stated that for 30 minutes at 5.5 pH conditions as much as 2 g / L of roots and shoots of water hyacinth (*Eichhornia crassipes*) can be designated respectively 100% and 97%. The high eduction of Cr and Cu in water can be seen by

high BCF values in shoots and roots. Different with continuous system where high accumulation is only on the root. Thus obtained that the water hyacinth plant (*Eichhornia crassipes*) is an excellent hyperaccumulator for Cr and Cu. When compared with the Odjegba and Fasidi research (2007), the BCF value generated in the exposure of 0,3 mM of heavy metals in the water hyacinth (*Eichhornia crassipes*) for 3 weeks (21 days) produced BCF values which included in high bioaccumulation, BCF values for metals Cd exposure is 2093.80 L/kg, Cr metal is 1515.67 L/kg , Cu is 1298.20 L/kg, and Pb is 1048.20 L/kg. Cr and Cu metal content during the 7 days is very high so the BCF value is high as in research by Odjegba and Fasidi for 3 weeks

Cu was absorbed by the water hyacinth (*Eichhornia crassipes*) in batch and continuous system. Increasing concentrations of this Cu continues to happen because Cu is needed by plants in various tissues. Since the plants needit constantly then the roots and shoots of the plant was continuously absorbing Cu into the network. Yruela (2009) stated that plants need Cu for normal growth and development, when these ions are not available, the plant experienced certain symptoms of deficiency, which mainly affect the leaves and reproductive organs. On the other hand, the redox properties that make Cu as essential elements also contribute to toxicity, in which the redox reaction between Cu^{2+} and Cu^{+} can catalyze the production of hydroxyl radicals which are highly toxic which can cause cell damage in lipid levels, membranes, nucleic acids, proteins and other biomolecules.

CONCLUSION

Metal content in the water and the water hyacinth (*Eichhornia crassipes*) in batch systems is influenced by the flow of water, while the metal content in the batch system is more stable the absorption will be maximum. The highest reduction of metal occurs in a batch system is of 88.18% Cu.Water hyacinth (*Eichhornia crassipes*) is an excellent hiperakumulator for Cu compared to metals Cd, Cr, and Pb in the batch and continuous system which is viewed by high value BCF.

REFERENCES

Amriani, Hendranto, B., and Hadiyarto, A. (2011):Bioakumulasi Logam Berat Timbal (Pb) dan Seng (Zn) pada Kerang Darah (Anadara granosa L.) dan Kerang Bakau (Polymesoda bengalensis L.) di Perairan Telur Kendari.*Jurnal Ilmu Lingkungan*,**9** (2), 45-50.

Andarani, Pertiwi. (2009):*Profil Pencemaran Logam Berat (Cu, Cr, dan Zn) pada Air Permukaan dan Sedimen di Sekitar Industri Tekstil PT. X (Sungai Cikijing)*. Tugas Akhir. Bandung: Program Studi Teknik Lingkungan FTSL-ITB.

BPLHD. (2012):*Laporan Tahun 2012*. Badan Pengendalian Lingkungan Hidup Daerah (BPLHD) Kab.Bandung.

Chakraborty, Rupa., and Mukherjee, Somnath. (2012):Bioadsorptive Removal of Chromium and Lead by Aquatic Macrophyte. *Journal of the Institution of Public Heath, India*, **13**(2), 43-48. Available at: www.ipheindia.org.

DalCorso, Giovanni., Farinati, Silvia., Maistri, Silvia., and Furini, Antonella. (2008): How Plants Cope With Cadmium: Staking All on Metabolism and Gece Expression.Journal of Integrative Plant Biology,**50** (10), 1268–1280.

Deepali, K., and Gangwar, K. (2010):Metals Concentration in Textile and Tannery effluents, Associated Soils and Ground Water.*New York Science Journal*,**3**(4), 82-89. Available at: www.sciencepub.net/newyork.

Eagleson, Mary. (1993):*Concise Encyclopedia Chemistry*. Berlin: Walter de Gruyter & CO.

Fahr, Mouna., Laplaze, Laurent., Bendaou, Najib., Hocher, Valerie., El Mzibri, Mohamed., Bogusz, Didier., and Smouni, Abdelaziz. (2013): Effect pf Lead on Roor Growth. *Frontiers in Plant Science*, **4**, 108-113. Available at: www.frontiersin.org.

Gaherwar, Sujata., and Kulkani, Pragya. (2012):Studies on Removal of Toxic Heavy Metals from Water byEichhornia crassipes. Indian J.Sci.Res **3**(2): 99-103.

Hou, Xiandeng., and Jones Bradley T. (2000):*Inductively Coupled Plasma/Optical Emission Spectrometry in Encyclopedia of Analytical Chemistry R.A. Meyers (Ed.)*. Chichester: John Wiley & Sons Ltd.

Kozlowski, Ryszard M. (2012):*Handbook of Natural Fibres Volume 2: Processing and Applications*. UK: Woodhead Publishing Limited.

Maksymiec, W. (1997):Effect of Copper on Cellular Processes in Higher Plants. Photosynthetica, **34** (3): 321-342.

Mohanty, Kaustubha., Jha, Mousam., Meikap, B.C., and Biswas, M.N. (2006):Biosorption of Cr (VI) from Aqueous Solutions by Eichhornia crassipes. *Chemical Engineering Journal*, **117**, 71 – 77. Available at: www.elsevier.com

Nazir, Ruqia., Khan, Muslim., Masab, Muhammad., Ur Rehman, Hameed., Ur Rauf Naveed., Shahab, Surrya., Ameer, Nosheen., Sajed, Muhammad., Ullah, Mohib., Rafeeq, Muhammad., and Shaheen, Zeenat. (2015): Accumulation of Heavy Metals (Ni, Cu, Cd, Cr, Pb, Zn, Fe) in The Soil, Water, and Plants and Analysis of Physico-chemical Parameters of Soil and Water Collected from Tanda Dam Kohat. *Journal of Pharmaceutical Science and Research*, 7(3), 89-97. Available at: www.jpsr.pharmainfo.in

Odjegba, Victor J., and Fasidi, Ishola O. (2007): Phytoremediation of Heavy Metals byEichhornia crassipes. *Environmentalist*, **27**, 349-355. Springer.

Puslitbang SDA. (2010):*Status Mutu Air Sungai (Studi Kasus S. Citarum)*. Balai Lingkungan Keairan: Pusat Litbang SDA.

Rai, Prabhat Kumar. (2010):Phytoremediation of Heavy Metals in a Tropical Impoundment of Industrial Region. *Environ Monit Assess*, **165**, 529-537.

Schneider, I.A.H., Rubio, J., Misra, M., and Smith, R.W. (1995): Eichhornia crassipes as Biosorbent for Heavy Metals Ions. *Minerals Engineering*, **8** (9), 979-988.

Shanker, Arun K., Cervantes, Carlos., Loza-Tavera, Herminia., andAvudainayagam, S. (2005):Chromium Toxicity In Plants. *Environmental International*, **31**, 739 – 753.

Sharma, Pallavi., and Dubey, Rama Shanker. (2005):Lead Toxicity in Plants. *Braz. J. Plant Physiol.*, **17** (1), 35-52**.**.

Siantiningsih, Ari. (2005):*Pendugaan Sebaran Spasial Logam Berat Pb, Cd, Cu, Zn, dan Ni dalam Air dan Sedimen di Perairan Teluk Jakarta*. Skripsi. Bogor: Institut Pertanian Bogor.

Singh, Divya., Tiwari, Archana., and Gupta, Richa. (2012):Phytoremediation of Lead from Wastewater Using Aquatic Plants. *Journal of Agricultural Technology*, **8**(1), 1-11. Available at: www.ijat-aatsea.com.

Soemirat, Juli. (2005):*Toksikologi Lingkungan*. Yogyakarta: Gajah Mada University Press.

Swain, Gomati., Adhikari, S., and Mohanty, P. (2014): Phytoremediation of Copper and Cadmium from Water Using Water Hyacint, Eichhornia crassipes. International *Journal of Agricultural Science and Technology*, **2** (1), 1-7.

Yapoga, Seka., Ossey, Yapo B., and Kouame, Victor. (2013):Phytoremediation of Zinc, Cadmium, Copper, and Chrome from Industrial Wastewater by Eichhornia crassipes. *International Journal of Conservation Science*,**4**(1), 81-86. Available at: www.ijcs.uaic.ro.

Yruela, Inmaculada. (2009):Copper In Plants: Acquisition, Transport, and Interactions.*Functional Plant Biology*, **36**(5), 409–430.

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NITRIFICATION KINETICS IN AQUACULTURE WASTEWATER TREATMENT USING BATCH REACTOR

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Abstract: Accumulation of aquaculture wastewater in pond that contains ammonium can disturb the metabolism of the body and cause death in freshwater prawns. Therefore, ammonium should be removed through nitrification on the suspended growth bioreactor such as batch reactor. The objective of this study was to evaluate the removal efficiencies of ammonium, to determine kinetics of biomassa growth, and to determine nitrification rate through kinetic constant and reaction order. Five laboratory scale batch reactor with working volume of each reactor 12,5 L were fed with synthetic wastewater that already contains mixed culture bacteria. This research was carried out with different ammonia nitrogen concentration : 1, 2, 3, 4 and 5 mg NH_3-N/l. The parameter observed during the process were temperature, pH, DO (Dissolved Oxygen), COD (Chemical Oxygen Demand), VSS (Volatile Suspended Solids),TAN (Total Ammonia Nitrogen), nitrite, and nitrate. The results showed that ammonia nitrogenremoval only occured on the first four days of operation reactor with the greatest removal efficiencyin R2(2 mgNH_3-N/l) wasabout 25.74%. Nitrite accumulation did not occur during reactoroperation. In addition, from this research obtained μ_m was 0.038 day^{-1} and Ks was 0.189 mg/l.
keywords: aquaculture wastewater, ammonium, nitrification, batch reactor, kinetics

INTRODUCTION

Fish farming(aquaculture) is a food production system whose development is fastest in the world. Such activities are not only performed by the system cages, floating net and embankment., but can also be done with the pond system. Based on statistical data of marine and fisheries (2013), the result of an aquaculture production in Indonesia in 2012 reached1,433,820 tons. The production has increased 27.2% compared with production in 2011, was1,127,127tons.One of the freshwater fishery commodities with the potential to be cultivated commercially is prawns, known as the giant fresh water prawn.

Prawns (*Macrobrachium rosenbergii*) including freshwater shrimp native to Indonesia because there are19 species of the genus Macrobrachium. Prawns are the most popular freshwater shrimp because of its large size and has a high economic value in both the domestic and overseas markets. Water quality is very important forprawns rearing. In Indonesia, many prawns rearing using static systems (rearing without water exchange). One of the problems on static system is a decrease water quality. It is due to aqua culture wastes derived from metabolic processes excretedthrough the gills in the form of ammonium ion(NH_4^+) (Salim and Sadafule, 2013). In addition, ammonium is generated through organic matter decomposition by microorganisms in the water (Fernandes etal., 2010). Research carried out by Gunawan(2007), showed that the rearing of prawns on a static system having an ammonium concentration

between0.56 to 3.03mg/L, while the recirculation system between0.07 to 0.38mg/L. Prawns can tolerate ammonium levels of up to1mg/L. Ammonium levels above 1mg/L can disrupt the body's metabolism and cause death in prawn(Barajas et al., 2006). Therefore, ammonium removal from aqua culture wastewater is necessary to improve water quality.

One of the alternatives for ammonium removal is biological treatment. The treatment is environmentally friendly, economical, effective, and efficient and has the potential for wide applications. Ammonium removal can be achieved through nitrification. Nitrification is the process of converting ammonium into nitrate by microbes (Bitton, 2011). Nitrification can held on the suspended growth reactor, the microorganisms that are responsible for wastewater treatment is maintained in a suspended condition in a liquid such as in a batch reactor.

Batch reactorisassumed to be perfectlymixedso that the entire reactor content is homogenous at any given time. Based on research that has been carried out by Escobaretal (2002), a batch reactor can be used for ammonium removal in waste milk with ammonium initial concentration of 11.7mg/L and the final concentration of ammonium is 0mg/L. Batch reactor is often used to estimate the kinetic parameters because it required operating time is relatively short (Jih et al., 2008). However, information on the value of kinetic parameters for aqua culture wastewater treatment with batch systems have not been found. Based on this, it is necessary to research about aqua culture wastewater treatment using a batch reactor so that ammonia nitrogen can be remove through nitrification and treated wastewater can be used for aquaculture.

RESEARCH METHODOLOGY

This research was conducted in several stages beginning with problem identification and study of literature so that the research can be designed in appropriate action base on literature.In this research, there are 5 units batch reactors and each reactor was used for every variation of concentration. That reactor was a laboratory-scale with 15 liter total volume and 12.5 liter working volume. Batch reactor made of polypropylene (PP), which has a size of 23x23x33.8cm. Air supplycomes froman aquarium pump that supplied through air diffusers tone located at the bottom of the reactor thus enabling stirring. During operation, dissolved oxygen (DO) was maintained above 2mg/l. Schematic diagram of bacth reactor used in this research is shown in **Figure1**.

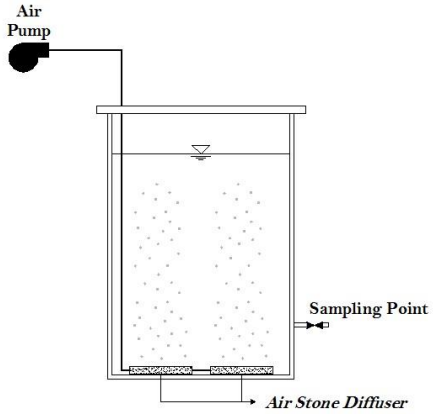


Figure1. Schematicdiagram of bacth reactor

Furthermore, synthetic wastewater used in this experiment to avoid fluctuations in influent concentration and ensure the availability of wastewater to be treated. The composition ofthe synthetic wastewater refers to Harwanto et al(2011) which consists of glucose, ammonium sulfate, sodium bicarbonate, sodium phosphate, and manganese(II) sulfate whereas concentration refers to Hai et al (2015). All the ingredients are mixed with aquadest as a solvent. In this research, synthetic wastewater for ammonia nitrogen concentration of 5 mg NH_3-N/l requires chemicals with certain mass is shown in **Table1**.

Table1. Composition of synthetic wastewater

Composition	Mass (gram)
$C_6H_{12}O_6$	0.0055
$(NH_4)_2SO_4$	0.041
$NaHCO_3$	0.0704
Na_2HPO_4	0.0045
$MnSO_4$	0.0006

Each reactor filled with 8 liters of bacterial culture with a biomass concentration of 3603 mg/l was settling for 2 hours so it will separated between the supernatant and sludge.Then, the supernatant was discarded and synthetic wastewater with various concentrations of ammonia nitrogen (TAN), which is 1, 2, 3, 4and5mgNH_3-N/L was fed into each reactor so that the volume to 12.5liters. The reactor was operated in aerobic conditions to keep the dissolved oxygen(DO) above 2mg/l. At this stage, samples were taken every day with grab sampling method until it reaches a steady state and that samples were analyzed for TAN, nitrite, nitrate etc. The parameters and methods of analysis used in this research is shown in **Table2**.

Table 2. Procedure and analysis methode

Parameter	Procedure	Analysis Methode
Temperature	SMEWW-2550	Termometer
pH	SMEWW-4500-H^+B	Electrometric Method
DO	SMEWW-4500-O-G	Membrane elektrode method
COD	SMEWW-5220-C	Closed reflux
VSS	SMEWW-2540-E	Gravimetri
TAN	SMEWW-4500-NH_3-F	Phenate method
Nitrite	SMEWW-4500-NO_2-B	Colorimetric method
Nitrate	SMEWW-4500-NO_3-B	Brucine method

RESULTS AND DISCUSSION

Effect of Ammonia Nitrogen Concentration Variation on Temperature

Temperature is an important factor influencing the growth of bacteria because bacteria can live at certain temperatures. The results of temperature measurements during reactor operation is shown in **Figure2**.

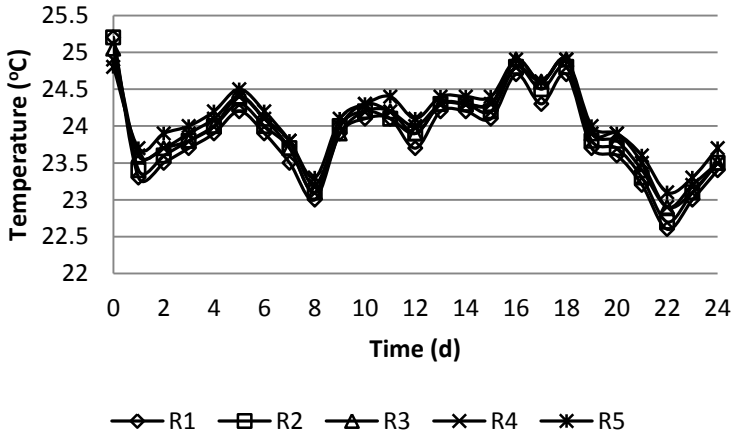


Figure 2. Temperature conditions in batch reactors

Based on **Figure2**,shows that the value of the temperature fluctuated during the24 days of running. This can be caused temperature during reactor operation did not control so water temperature will change according to air temperature. Temperature values range between 22.6-25,2˚CinR1; 22.7-25,2˚CinR2; 22.9-25,1˚CinR3; 22.9-24,9˚CinR4; and23.1-24,8˚CinR5. Optimum temperature for nitrification bacteria growth is15-30˚C(WEF, 2008). The value of the temperature during reactor operation was still in the range of15-30˚C. This indicated that the temperature inside the reactor support nitrification.

Effect of Ammonia Nitrogen Concentration Variation on pH

The degree of acidity(pH) defined as hydrogen ions(H^+) concentration in water. In biological treatment unit, pH is environmental parameters that influence bacteria activities in the substrate utilization. The results of pH measurements during reactor operation is shown in **Figure3**.

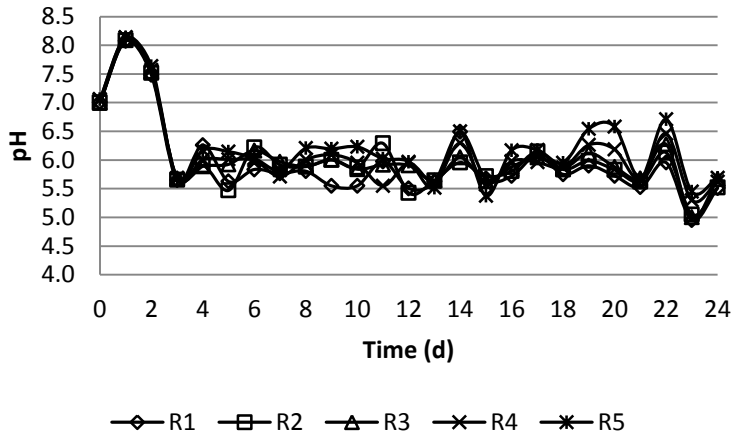


Figure 3.pH conditions in batch reactors

Based on **Figure3**, shows that the pH value in each reactor has decreased on the second day. This was due to the presence of organic matter (glucose) derived from bacterial cultures and synthetic wastewater. Glucose is a carbon source for the bacteria that very easily biodegradable. Metabolism occurred during reactor operation that causes glucose is oxidized to carbon dioxide(CO_2).Then, carbon dioxide(CO_2) reacts with water to form carbonic acid.In addition, ammonium derived from synthetic wastewater. Nitrification causes oxidation of ammonium to nitrateand generated hydrogen ions(H^+).

The presence of carbonic acid(H_2CO_3) and hydrogen ions(H^+) in water cancauses decreased ofpH values that resulted in acidic water. This can lead to inhibition nitrification in

reactor such as the oxidation of ammonia nitrogen. According to Fumasoli et al(2015), the oxidation of ammonia nitrogenusually stops when the pH value drops below pH 6.

Effect of Ammonia Nitrogen Concentration Variation on Dissolved Oxygen (DO)

Dissolved oxygen needed by bacteria for aerobic respiration (Metcalf and Eddy, 2003). The results of dissolved oxygen(DO) measurements during reactor operation is shown in **Figure4**.

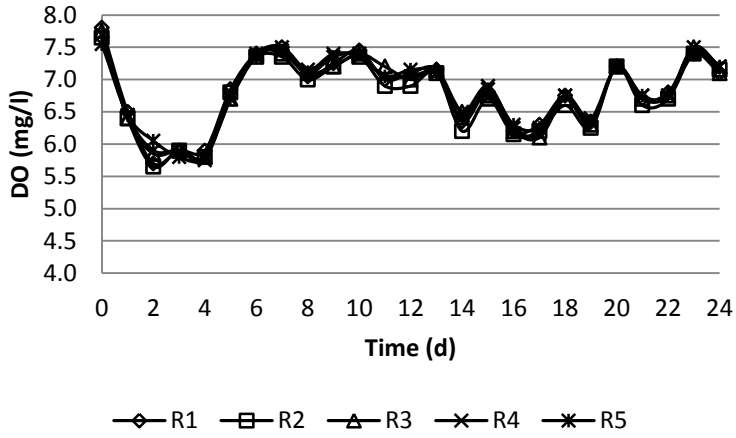
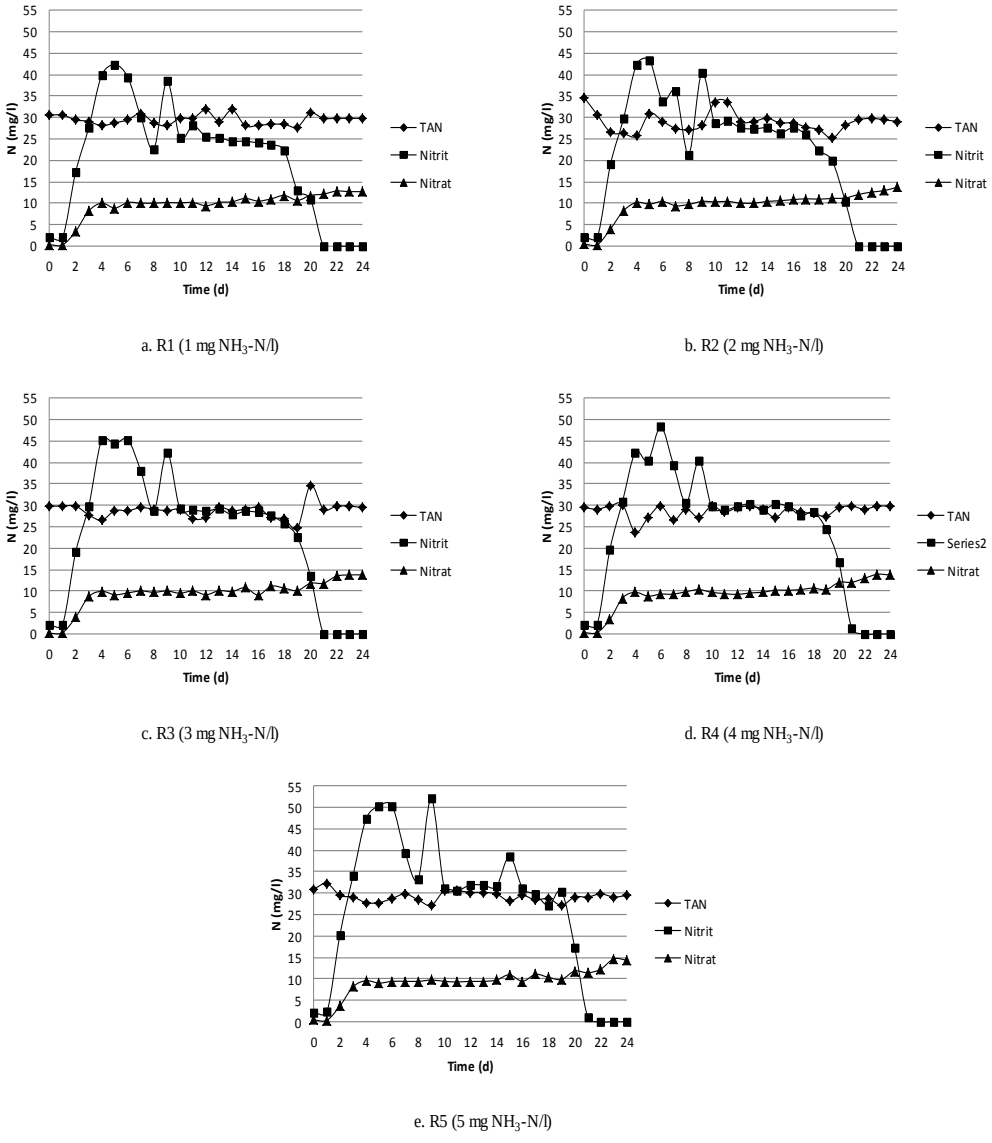


Figure 4. Dissolved oxygen (DO) conditions in batch reactors

Based on **Figure4**, it was known that the concentration of dissolved oxygeninR1, R2, R3, R4, andR5 in sequence, range between5.7 to 7.8mg/l; 5.6 to 7.7mg/l; 5.8 to 7.8mg/l; 5.7 to 7.8mg/l; and5.8 to 7.6mg/l. Then, dissolved oxygen concentration decreased until a second day in each reactor. On the 3rd day until the 8th day, dissolved oxygen concentration has increased an dissolved oxygen concentration tends to be stable on the 8th day to 24thday. Decreased of dissolved oxygen concentration caused due toon aerobic biological treatment, bacteriause oxygen for oxidation organic and ammonia nitrogen resulting decreased of dissolved oxygen concentration. Increased of dissolved oxygen concentration that occurred on the 3rd day until the 8th day because most organic and ammonia nitrogen was oxidized on the previous day so that the organic compounds and ammonia nitrogen that was oxidized on the 3rd day until the 8thhave lower concentration that causedecreased oxygen required by bacteriafor oxidized organic and ammonia nitrogen. Although there has been decreased dissolved oxygen concentration during reactor operation, but it was not below 2mg/l. Thus, oxygenwas not a limiting factor in oxidation of organic and ammonia nitrogen.

Effect of Ammonia Nitrogen Concentration Variation on TAN, Nitrite, and Nitrate

The pH value of each reactor has decreased below pH 7 during reactor operation. According to Murti et al(2013), ammonia nitrogen at pH5-7 is in the form of ammonium ion($NH4^+$). The results of ammonia nitrogen, nitrite, and nitrate measurements during reactor operation is shown in **Figure5**.



a. R1 (1 mg NH_3-N/l)

b. R2 (2 mg NH_3-N/l)

c. R3 (3 mg NH_3-N/l)

d. R4 (4 mg NH_3-N/l)

e. R5 (5 mg NH_3-N/l)

Figure 5. Inorganic nitrogen concentration in batch reactors

Based on **Figure5**, it can be seen that ammonia nitrogen concentration decreased until the 4th day was 8.19% in R1; 25.74% in R2; 10.97% in R3; 19.68% in R4; and10.36% in R5. Then, ammonia nitrogen concentration tend to fluctuated until the 20th day and tend to stable on21thday to 24thday. Decreased of ammonia nitrogen concentration can be caused by oxidation of ammonia nitrogen to nitrite. This indicated that nitrification occurred in reactor. From Figure5, shows that ammonia nitrogen concentration of each reactoron the 5thday to the 24thday still high which indicated that oxidation of ammonia nitrogen was inhibited. This was due to the decreased of pH value below pH 6 on the 3rd day. According to Fumasoli et al(2015), the oxidation of ammonia nitrogen usually stops when the pH value drops below pH 6.

Increased of nitrite concentrations began on the 2nd day was 88.21% in R1; 88.66% in R2; 88.31% in R3; 88.65% in R4; and 88.53% in R5. This indicated that ammonia nitrogen was oxidized to nitrite. In each reactor, nitrite concentration began to decreased on the 6thday. Decreased of nitrite concentration followed by increased nitrate concentration because nitrite will be oxidized to nitrate. Based on **Figure5**, it was known that there is no accumulation of nitrite during reactor operation. This was due dissolved oxygen concentration in the reactor more than 2mg/l so that oxidation of nitrite to nitrate run well.

Nitrate concentration increased on the 2ndday was90.61% inR1; 90.26% in R2; 91.24% in R3; 89.43% inR4; and89.93% inR5. This indicated that nitrification occured in the reactor because the end product from nitrification was nitrate which is formed as a result from nitrite oxidation.

In autotrophic nitrification, *Nitrobacter* play a role in oxidation of nitrite to nitrate. According to the EPA(2002), the optimum pH for *Nitrobacter* growth is7.5-8. However, oxidation of nitrite to nitraterun well despite the pH values was decreased. This indicated that oxidation of nitrite to nitrate in the reactor did not involve autotrophic bacteria (*Nitrobacter*), but it involved heterotrophic bacteria. According to Zhang et al(2015), heterotrophic nitrification play apredominant role in nitrate production. In addition, heterotrophic nitrification is carried out by bacteria that tolerant to acid (Allison and Prosser, 1993). So, mixed culture used in this researchwasheterotrophic bacteria.

Effect of Ammonia Nitrogen Concentration Variationon COD

COD(Chemical Oxygen Demand) defined as amount of oxygen required to oxidize organic compounds. The results of COD measurements during reactor operation is shown in **Figure6**.

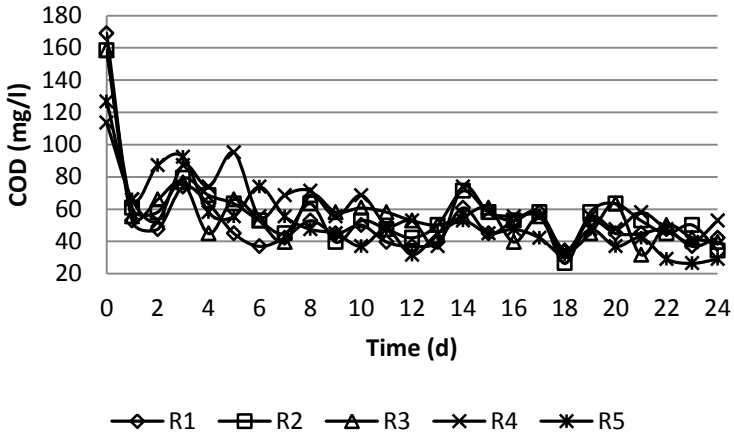


Figure 6.COD concentrationin batch reactors

Based on **Figure 6**, shows that organic compounds concentration measured as COD decreased until 24thday was 75% in R1; 78.33% in R2; 75% inR3; 53.49% inR4; and77.08% inR5. This indicated, bacteria utilized organic compounds(glucose) as a substratethat occured oxidation of organic compounds and result indecreased organic compounds concentrations. Concentration of substrate was the less that lead to bacteria death. According to Mulyani et al (2012), the death of bacteria can increase soluble COD concentration.

When reactor operation from the 1stday to 24thday, organic compounds in each reactor concentration, range between 31.68 to 79.2 mg/l inR1; 21.12 to 79.2 mg/l in R2; 26.4 to 79.2mg/l in R3; 31.68 to 100.32mg/l in R4; and 21.12 to 95.04 mg/l in R5. COD concentration greater than 60mg/l will influence nitrification (Celenza, 2000). However, the process that occurred in the reactor was heterotrophic nitrification. Research conducted by Zhao et al (2012), showed that conditions with glucose and NH_4^+as an organic carbon source and nitrogen source cause the growth of *Alcaligenesfaecalis* (heterotrophic nitrifier). While the condition absence of an organic carbon source or in the presence of carbonate as the sole carbon source cause failed and no nitrite or nitrate could be detected. Thus, the presence of organic compounds required in heterotrophic nitrification.

Effect of Ammonia Nitrogen Concentration Variation on VSS

Biomass concentration during reactor operation can be measured by VSS (Volatile Suspended Solid). That parameter defined as many organic compounds that suspended in water. The results of VSS measurements during reactor operation is shown in **Figure7**.

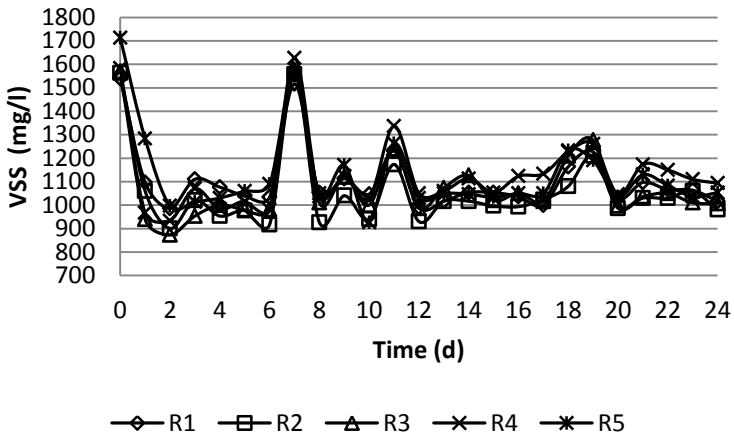


Figure 7.VSS concentrationin batch reactors

VSS concentration at the beginning was 1540mg/l inR1, 1563mg/l in R2, 1570mg/l in R3, 1583mg/l in R4, 1713mg/l inR5. According to Bitton (2011), nitrification will perform optimally when biomass concentration between1200 to 2500mg/l. VSS concentration at the beginning of reactor operation support nitrification, but during reactor operation VSS concentration tend to fluctuated. Based on **Figure7**, it can be seen that VSS concentration decreaseduntil the 2nd day was 35.93% in R1; 42,43% in R2; 44.37% in R3; 41.05% in R4; and41.83% in R5. This can be caused bacteria did not get enough substrate to support of bacteria growth and resulted death of bacteria then bacteria cells lysis. According to Sudol et al(2010), lysis of bacterial cells can increase soluble COD. Furthermore, VSS concentration of each reactor increased on the 7th, 9th, 11th, 18th, and 21th day.This was due to bacteria utilized organic compounds so that the growth of bacteria measured as VSS has increased while the concentration of organic compounds measured as COD has decreased on the 7th, 9th, 11th, 18th, and 21th day. Although VSS concentration during reactor operation had been below 1200mg/l, but nitrification can be accomplished

Bacterial Growth Kinetic

Kinetics of bacterial grow this determined by observing bacteria growth versus time on a log phase. Analysis of bacterial growth kinetic in batch system was described by Monod model is shown in **Figure8**.

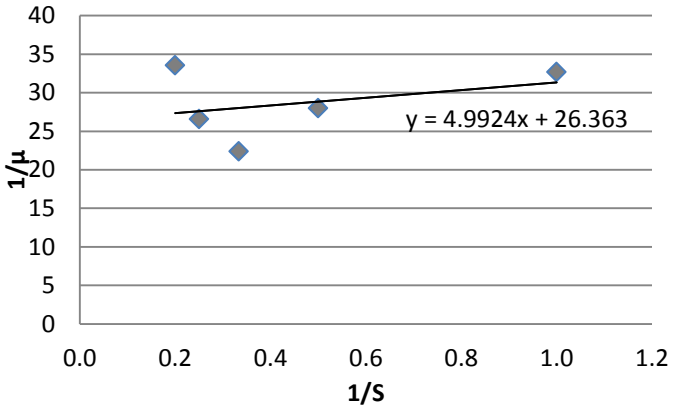


Figure 8. Lineweaver-Burk plot for determination of $\mu_m$and Ks

Based on **Figure8**, the value of the maximum specific growth rate (μ_m) was 0.038day^{-1}and a half-saturation constant value(Ks) was 0.189mg/l. According toward et al(2011),the maximum specific growth rate(μ_m) for nitrification bacteria is 0.62 to 0.92day^{-1}. The $\mu_m$value was smaller and indicated that the maximum growth rate of bacteriawas slow. This can be caused oxidize ammonia nitrogen required a long time. According Bitton (1998), the value of $\mu_m$is influenced by the type of bacteria and environmental conditions of growth such as pH. In addition, the value of Kswas 0.189mg/l. Ks value showed an affinity of bacteria to substrate. According to Bejarano(2005), the Ks value for nitrification range between0.15 to 2mg/l. The results showed that the value of Kswas in the range0.15 to 2mg/l.

CONCLUSION

Ammonia nitrogen removal only occured during four dayswiththe greatest removal efficiency in R2(2 mgNH_3-N/l) was25.74%. This was due to the decreased of pH value below pH 6 on the 3rd day so that the oxidation of ammonia nitrogen to nitrite can be stopped. In addition, nitrite accumulation did not occurduring reactor operation. Nitrification occured within the reactor involves heterotrophic bacteria. Furthermore, the value of the maximum specific growth rate (μ_m) was 0.038day^{-1}and a half saturation constant (Ks) was 0.189mg/l. This indicated that bacteria can not utilize the substrate available because unfavorable environmental conditions(pH) so that the maximum growth rate of bacteria was slow.

REFERENCES

Allison, A.M and Prosser, J.I.(1993) : Ammonia Oxidation at Low pH by AttachedPopulations of Nitrifying Bacteria, *Soil Bid. Biochem*, 25(7), 935-941.

Barajas, F.M., Villegas, R.S., Clark, G.P., Mosqueda, J.G., and Moreno, B.L. (2006) : Daily Variation in Short-Term Static Toxicity of Unionized Ammonia in Litopenaeus Vannamei (Boone) Postlarvae, *Aquaculture Research*, **37**(13), 1406-1412.

Bejarano, J.R.C. 2005. *Effect of Operational Variables on Nitrogen Transformations in Duckweed Stabilization*

Ponds. UK : Taylor & Francis Group plc.
Bitton, G. 2011. *Wastewater Microbiology,4th edition*. New Jersey : John Wiley & Sons, Inc.
Bitton,G. 1998. *Formula Handbook for Environmental Engineers and Scientists*. New York : John Wiley & Sons, Inc.
EPA.2002. *Nitrification*. USA : AWWA with assistance from Economic and Engineering Services, Inc.
Fernandes, S.O., Kulkarni, S.S., Shirodkar, R.R., Karekar, S.V., Kumar, R.P., Sreepada, R.A., Vogelsang, C., and Bharathi, P.A.L.(2010) : Water Quality and Bacteriology in An Aquaculture Facility Equipped with A New Aeration System, *Environmental Monitoring and Assessment*, **164**(4), 81-92.
Fumasoli, A., Morgenroth, E., and Udert, K.M. (2015) : Modeling The Low pH Limit of *Nitrosomonas Eutropha* in High-Strength Nitrogen Wastewaters, *Water Research*, **83**, 161-170.
Gunawan, H. 2007. Penggunaan Sistem Resirkulasi untuk Pembesaran (*Grow-Out*) Udang Galah (*Macrobrachium rosenbergii*). Tesis Magister Biologi. Bandung : ITB.
Hai, N.T,. Lili, Y., Qigen, L., Liangjie, Z., Jun, L., and Hong, Z. (2015) : Assessment of water quality of giant freshwater prawn (*Macrobrachium rosenbergii*) in culture ponds in Zhejiang of China, *International Journal of Fisheries and Aquatic Studies*, **2**(3), 45-55.
Harwanto, D., Oh, S.Y., and Jo, J.Y. (2011) : Comparison of The Nitrification Efficiencies of Three Biofilter Media in A Freshwater System, *Fish Aquat Sci*, **14**(4), 363-369.
Jih, C.G., Huang, J.S., Lin, H.J., and Chou, H.H. (2008) : Comparative Kinetic Behavior of Nitrifiers with Different Growth Environments, *Biosource Technology*, **99**, 3484-3490.
Metcalf dan Eddy. 2003. *Wastewater Engineering Treatment : Treatment, Disposal, and Reuse*, *4th edition*. New York : McGraw-Hill, Inc.
Mulyani, H., Sasongko, S.B., and Soetrisnanto, D. (2012) : Pengaruh Preklorinasi terhadap Proses *Start Up* Pengolahan Limbah Cair Tapioka Sistem *Anaerobic Baffled Reactor, Momentum*,**8**(1), 21-27.
Murti, R.S., Purwanti, C.M.H., and Suyatini. (2013): Adsorpsi Amoni dari Limbah Cair Industri Penyamakan Kulit Menggunakan Abu Terbang Bagas, *Majalah Kulit, Karet, dan Plastik*, **29** (2), 85-90.
Oktafiani, M and Hermana, J. (2013) : Pengaruh Konsentrasi Nutrien dan Konsentrasi Bakteri pada Produksi Alga dalam Sistem Biorekator Proses Batch, *Jurnal Teknik Pomits*, **2**(2), 57-62.
Salim, S.S and Sadafule, N.A. (2013) : Potential for Ammonia and Nitrite Reducing Products for Shrimp Farms in Andhra Pradesh, *Discovery Agriculture*, **1**(1), 33-38.
Sudol, M.Z., Podedworna, J., Heidrich, Z., Krawezyk, P., and Szezygiel, J.2010. *Environmental Engineering III : Experiment Feasibility Study on Application of A Mechanical Cavitation Inducer for Disintegration of Wastewater Sludges*. USA : CRC Press.
Ward, B.B., Arp, D.J., and Klotz, M.G. 2011. *Nitrfication*. USA : ASM Press.
Zhang, J., Müller, C., and Cai, Z. (2015) : Heterotrophic Nitrification of Organic N and Its Contribution to Nitrous Oxide Emissions in Soils, *Soil Biology & Biochemistry*, **84**, 199-209.
Zhao, B., An, Q., He, Y.L., and Guo, J.S. (2012) : N_2O and N_2 Production during Heterotrophic Nitrification by *Alcaligenes faecalis* Strai

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MODIFICATION OF TRIPIKON-S WITH BIOBALL ADDITION IN ARTIFICIAL BLACK WATER TREATMENT FOR SWAMP AND COASTAL AREAS

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Abstract: Tripikon-S can be used as a septic tank or pit latrine households to areas of shallow groundwater, tidal areas and swamps, or on small plots of land area. Construction Tripikon-S consists of three concentric pipes with the working principles of the treatment process is similar to a conventional septic tank. This study is intended to treat black water on batch and continuous systems with tripikon-S reactor volume of 18 liters. The reactor used in the research are original Tripikon-S reactor (Tripikon-S Control) and Tripikon-S with the bioball addition (Tripikon bioball). Black water used is black water artificial. Organic load variation is 1500 mg COD/ l and 2000 mgCOD / l. The parameters analyzed were pH, DO, temperature, COD, total nitrogen (NTK) and total phosphate. In a batch system average COD removal efficiency in the reactor Tripikon-S and Tripikon-S bioball is 44.31% and 49,81%. In the continuous system with a residence time of 48 hours and a variety of organic load in 2000 is able to provide the best results in COD, NTK and total phosphate. COD removal efficiency, NTK and total phosphate in the reactor Tripikon-S was 63.04%, 25.20% and 26.53%. While Tripikon-S reactor bio-ball COD removal efficiency, NTK and total phosphate was 75.93%, 25.02% and 35.39%.
Keywords : Blackwater, Tripikon-S, Bioball, Septic tank

INTRODUCTION

At this time the condition of sanitation in Indonesia is still bad, where public access to sanitation facilities are lacking especially in areas that are difficult area such as coastal areas and marshes. Sanitation infrastructure needed to separate the waste from the environment to prevent the onset of disease (Flores et al, 2008; Setiawati et al, 2013) Sanitation in Indonesia only increased from 46% to 55% during 1994-2004. These circumstances make sanitation ranked Indonesia is below average for the Southeast Asian region and the world (Fatoni et.al, 2010). Improving sanitation needs to be done to reduced productivity and environmental degradation (Genser et al., 2008; Rutsein, 2000; Victroia et al., 1998; Katukiza et al, 2012). Inadequate sanitation can also cause a variety of infectious diseases(Lemonick, 2011; Thye et al, 2013).Coastal and swamp areas are the most difficult areas to improve sanitation. Various attempts were made in the improvement of sanitation in coastal and swamp areas one of which is the development of the septic tank was named Tripikon-S. Construction Tripikon-S consists of three concentric pipes with the working principles similar to a conventional septic tank that was applied to the coastal areas, swamps, rivers and places with a high groundwater level(Saraswati et al., 2009; Wijaya et al., 2010; Nurmandi, 2012; Putri et al, 2013).

The research that has been conducted by saraswati et al, 2009 showed that the performance of Tripikon-S is only able to reduce effluent BOD_5 to 40% so that the necessary be done to

improve the performance development Tripikon-S. This research will be modified with bioball addition. The addition of bioball is intended as a biofilter for embedding large amounts of bacteria with a very small risk of deadlock. Also called a biofilter for wastewater aeration contacts will come into contact with microorganisms attached to the surface of the media so as to improve the efficiency of decomposition of organic matter (Pohan, 2008). Thus allowing for wastewater treatment with a high concentration of load as well as the efficiency of processing large enough (Said, 2000). So, with a combination of the above techniques are expected to be applied to Tripkon-S in order to improve the performance Tripikon-S in black water treatment in coastal and swamp areas.

METHODOLOGY

This study focused on the performance Tripikon-S in treating black water. The stages of the research can be seen in **Figure 1**.

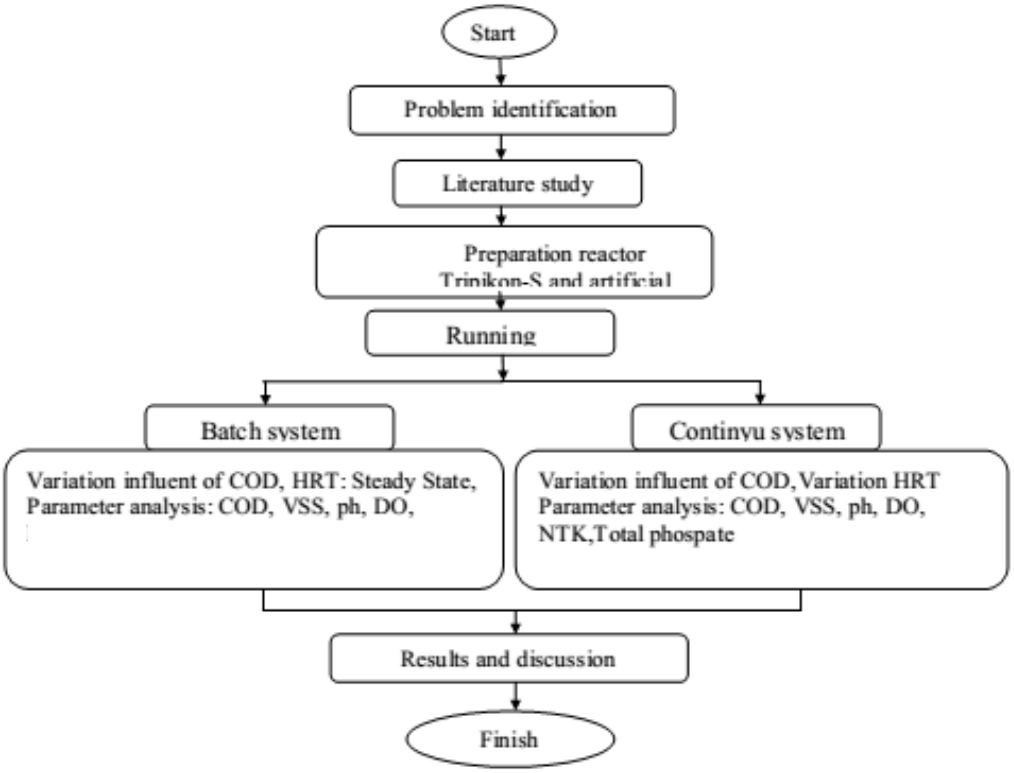


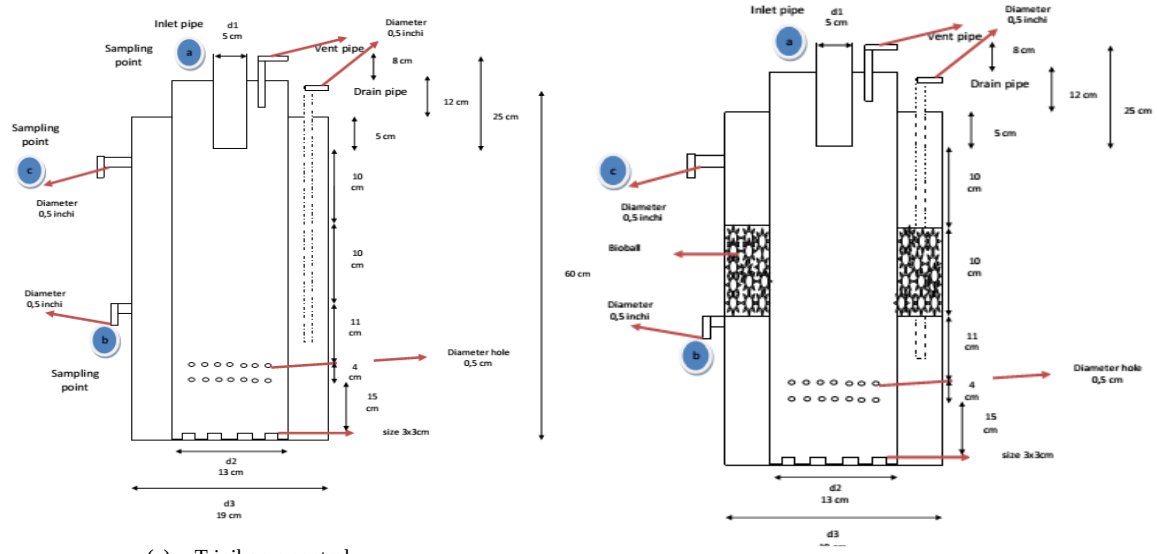
Figure 1. Flow diagram

Location and Time Research

Location research and preparation of artificial blackwater is done in Laboratory of Water Quality Environmental Engineering Institut Teknologi Bandung (ITB).

Research tools

This study uses two reactors Tripikon-S-shaped tube made of pipes made from PVC. Tripikon-S reactor without development (Tripikon-S Control) that is used has a medium volume of 18 liters. While the reactor with the addition bioball Tripikon- S (Tripikon bioball-S) has a volume of 14.6 liters media and cavity volume fraction of 3.6 liters. Schematic is shown in **Figure 2**.



(a) Tripikon-s control

(b) Tripikon-s bioball

Figure 2. Reactor scheme

Preparation Artificial Black Water

Black water artificially made using glucose, $(NH_2)_4SO_4$, $KH2PO_4$ and Kaolin

Preliminary Waste Characterization

Parameters measured include COD, total nitrogen (NTK), total phosphate, pH, temperature, and DO.

Laboratory analysis

Procedures performed sample collection and examinations based on the Indonesian National Standard (SNI). Methods of analysis parameters used are listed in **Table 1**.

Table 1. Method and frequency parameter analysis

No	Parameter	Method	Frequency
1.	COD	Refluks tertutup/COD Mikro	Everyday
2.	pH	pH meter	Everyday
3.	Temperatur	Termometer	Everyday
4.	Total Nitrogen (NTK)	Destruksi-Destilasi-Titrasi	Beginning and end
5.	Total Phospat	Spektrofotometri	Beginning and end
6.	TS		Everyday
7.	VSS		Everyday

Batch

Batch phase is the phase of the reactor start-up and acclimatization. Organic load variations are 1500 and 2000 mg COD / l. The parameters measured were pH, temperature, DO, COD, and VSS. At the end of the study the kinetics of the allowance is calculated using the model of Monod's kinetic.

Continuous

At this stage that is varied HRT (Hydraulic Retention Time). The parameters tested were COD, VSS, DO, pH, temperature, total nitrogen (NTK) and total phosphate.

RESULTS AND DISCUSSION

Initial characterization

Prior to the initial characterization, artificial black water was made. Options concentrations and characteristics of artificial black water is used as a reference based on the study of literature native black water effluent concentration. It is intended that the artficialblack water represent the characteristics of the original black water. Referenced waste characteristics are shown in **Table 3**.

Table 3. Composition of black water
(Palmquist and Haneus, 2005)

Parameters	unit	Average (Deviation standar)	Range
Q	$m^3 h^{-1}$	0.17 (0.01)	0.16 – 0.18
Total phospat	mg L^{-1}	42.7 (19)	21 - 58
Total Nitrogen	mg L^{-1}	150 (26)	130 - 180
BOD_5	mg L^{-1}	1037 (545)	410 - 1400
COD_{Cr}	mg L^{-1}	2260 (1268)	806 - 3138
Total solid	mg L^{-1}	3180 (2000)	920 - 4320
VS	mg L^{-1}	2560 (1900)	420 - 3660
pH	-	8.94 (0.1)	8.87 – 9.08

Results of characterization black water artificial can be shown in **Tabel 4**.

Table4. Data of charateristic black water artificial

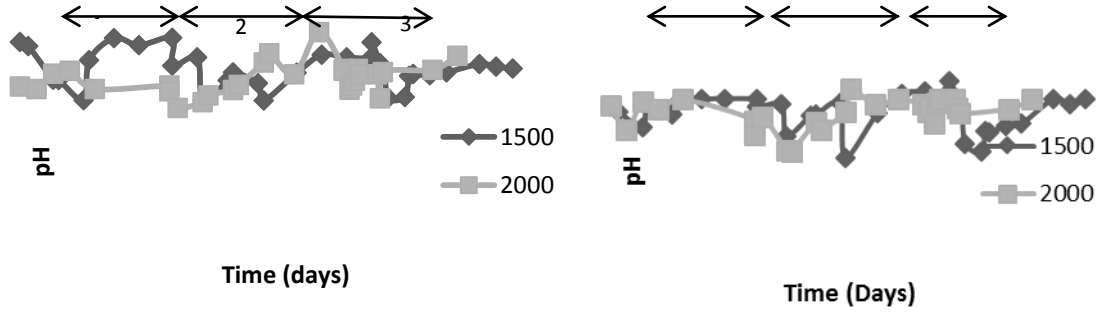
Parameters	Concentration (mg/l)
COD	2470
BOD	2120
TN	147
TP	43
pH	6.25

From the data of characterization shown that the waste contains high levels of organic compounds. This is indicated by the value of COD and BOD. Biological treatment is recommended as a viable treatment alternative treatment. BOD loadings exceeding 1000 mg / l to make decent use of anaerobic processes (Davis and Cornell, 1991 in Happy, 2010).

Batch System

pH

In **Fig3.** it can be seen that the measured pH values for both reactors are not much different. In Tripikon-S control for variations in organic load 1500 mg COD / l measured pH values were in the range 4.83 to 6.59. As for the variation of the organic load of 2000 mg COD / l measured pH values were in the range 4.6 to 6.89. Decrease in pH at the beginning of the batch process indicates rapid growth of bacteria that contribute acidogenesis elaborate monomer compleks hydrolysis of organic compounds into volatile fatty acids (Li.et al, 2007).



(a) Tripikon-s control

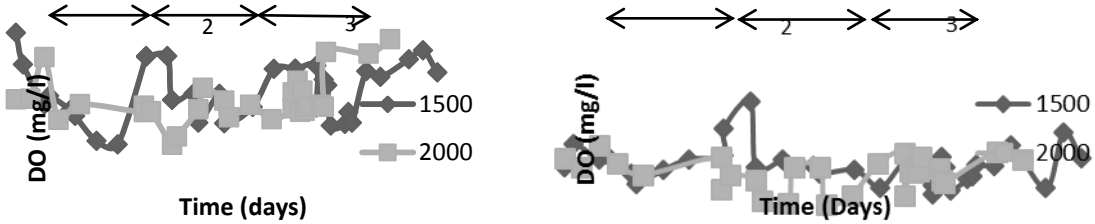
(b) Tripikon-s bioball

Figure 3.pH in the reactor

Dissolved Oxygen (DO)

Dissolved Oxygen (DO) is the amount of oxygen dissolved in the water. DO values measured in **Figure 4.** for Tripikon-S controlfor organic load 1500 and 2000 mg COD / l were in

the range 1.15 to 6.91. In Tripikon-S Bio-ball measured DO values were in the range 1.2 to 6.02. Average DO values for organic load variations 1500 mg COD / l is almost always higher than the value of DO for organic load variations COD 2000 mg / l. Rise and fall of the measured DO values indicate the activity of microorganisms. Microorganism activity would increase if the DO decreased. According to Gomez et al, 2002; Tait et al, 2013 Increasing DO concentration showed a decrease in the growth of biofilm and bacterial density in biofilm.

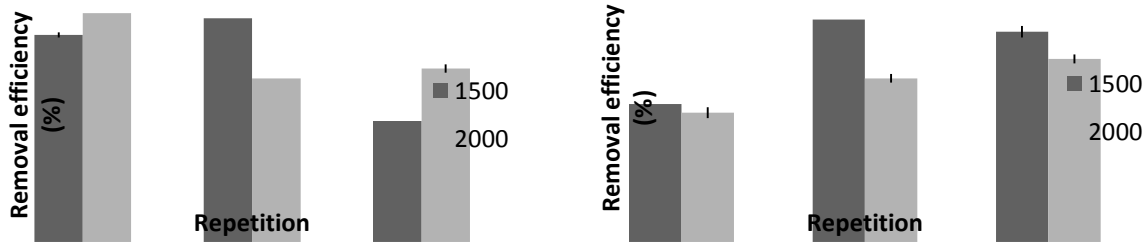


(a) Tripikon-s control (b) Tripikon-s bioball

Figure 4. Dissloved oxygen in the reactor

Removal of COD

In **Figure 5.** for Tripikon-S control when repetition 1st, removal efficiency reached 80% and 90% for load variations 1500 and 2000 mg COD / l. Then, during the 2nd repetition removal efficiency reached 90% and 62%. In the 3rd repetition removal efficiency decreased to 44% and 68% for load variations 1500 and 2000 mg COD / l. As for the Tripikon-S bioball when repetition 1st, removal efficiency reached 52% and 49% for load variations 1500 and 2000 mg COD / l. Then, during the 2nd repetition removal efficiency reached 83% and 62%. In the 3rd repetition removal efficiency decreased to 80% and 70% for load variations 1500 and 2000 mg COD / l. The increase in removal efficiency that occurs in the reactor Tripikon-S bioball showed that microorganisms present in the reactor and the media have been used to adapt the bioball incoming susbstrat.

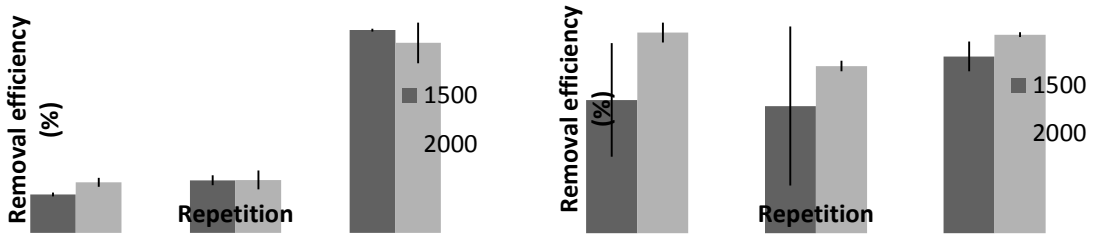


(a) Tripikon-s control (b) Tripikon-s bioball

Figure 5. Removal COD in the reactor

Removal of Nitrogen Total Kjehdal (NTK)

In Tripikon-S control (**Figure 6.)** on the organic load variations 1500 and 2000 mg COD / l NTK able to set aside up to 44.78% and 41.96% to 3th repetition. In Tripikon-S bioball (**Figure 6**) for the organic load variations 1500 and 2000 mg COD / l NTK capable of removing up to 35.62% and 39.66%

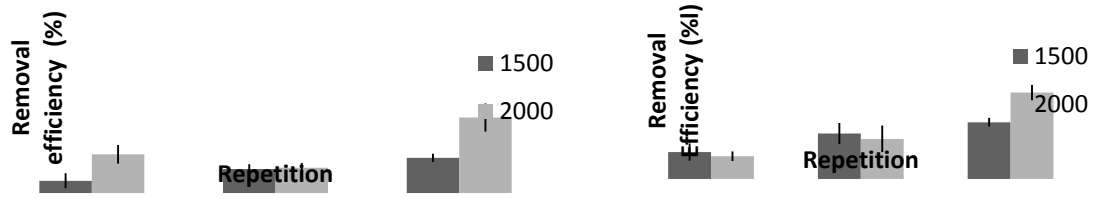


(a) Tripikon-s control (b) Tripikon-s bioball

Figure 6. Removal of nirogen total kjehdal in the reactor

Removal of Total Phospate

In the reactor Tripikon-S control removal efficiency for total phosphate with organic load variations 1500 and 2000 mg / l was 8.3% and 17.93% for 3th repetition. While the Tripikon-S bioball atotal phosphate removal efficiency for organic load variations 1500 and 2000 mg / l was 14.44% and 21.95%.



(a) Tripikon-s control (b) Tripikon-s bioball

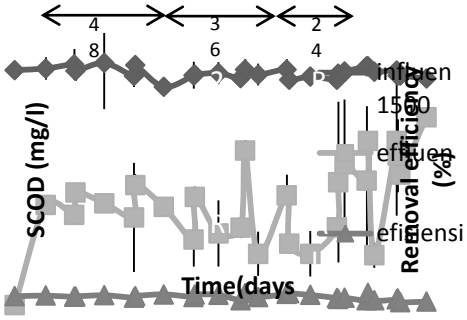
Figure 7. Removal of total phospate in the reactor

Continuous Systems

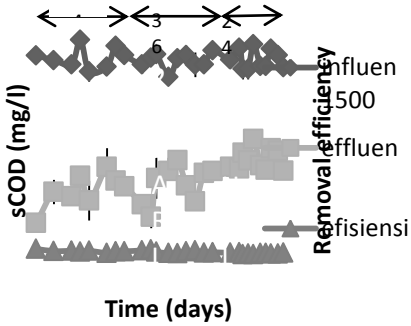
Removal of COD

In Tripikon-S control removal efficiency that occurs when the organic load variation 1500 mgCOD / l with a residence time of 48, 36 and 24 hours was 52.94%, 45.45% and 21.95%. As for the variation of the organic load of 2000 mg COD / l removal efficiency happens to a 24-hour stay was 48.36 and 63.04%, 42.62% and 17.24%. While the Tripikon-S bioball removal efficiency that occurs when the organic load variation 1500 mgCOD / l with a residence time of

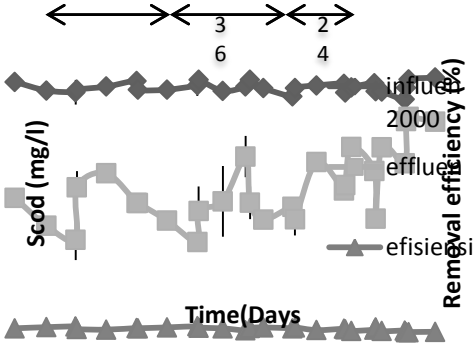
48, 36 and 24 hours was 71.36%, 53.46% and 53.69%. As for the variation of the organic load of 2000 mg / l removal efficiency happens to a 24-hour stay was 48.36 and 75.93%, 56.03% and 42.96%. From the above it can be seen that the best removal efficiency for Tripikon-S control is the residence time of 48 hours with a variety of organic load up to 2000 mg / l with a percentage of 63.04% allowance. For Tripikon-S bioball best removal efficiency given current residence time of 48 hours with a load variation to 2000 mg / l with a percentage allowance of 75.93% (**Figure 9**). This is consistent with reports Jing et al, 2002; Sakadevan and Bavor, 1999; Paulo et al, 2013 that with the longer residence time (HRT), the COD removal efficiency will be higher.



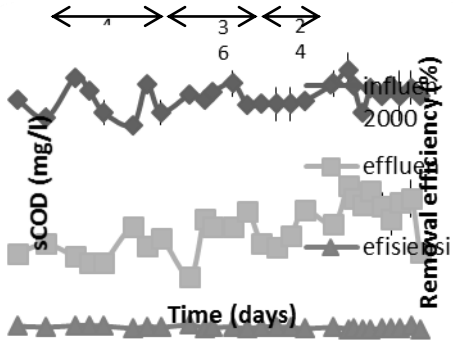
(a) Tripikon-s control



(b) Tripikon-s bioball



(a) Tripikon-s control

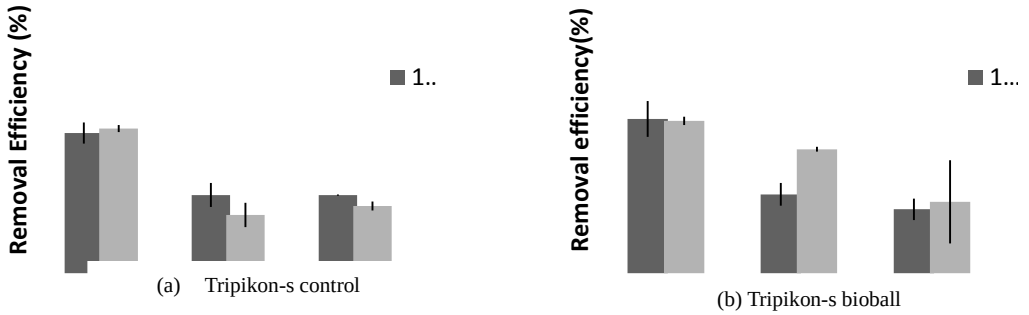


(b) Tripikon-s bioball

Figure 9. Removal of COD in the reactor

Removal of Nitrogen Total Kjehdal

The best removal (**Figure 9.)** efficiency for reactor control Tripikon-S is the residence time of 48 hours with a variety of organic load up to 2000 mg / l with a percentage of 25.20% allowance. For Tripikon-S bioball best removal efficiency given current residence time of 48 hours with a load variation to 2000 mg / l with a percentage allowance of 26.53%.

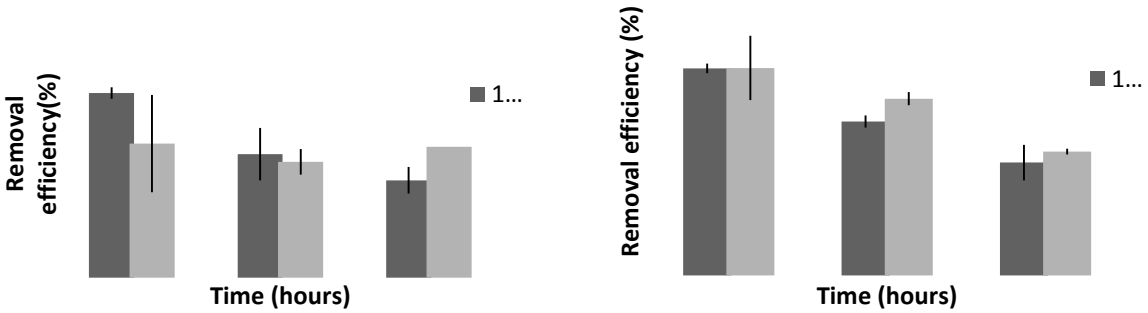


(a) Tripikon-s control (b) Tripikon-s bioball

Figure 9. Removal of nirogen total kjehdal in the reactor

Removal of Total Phosphate

The best removal efficiency of total phospat shown in **Figure 10**. for reactor control Tripikon-S is the residence time of 48 hours with an organic load variations 1500 mg / l with a percentage of 34.31% allowance. For Tripikon-S bioball best removal efficiency given current residence time of 48 hours with a load variation to 2000 mg / l with a percentage allowance of 35.99%

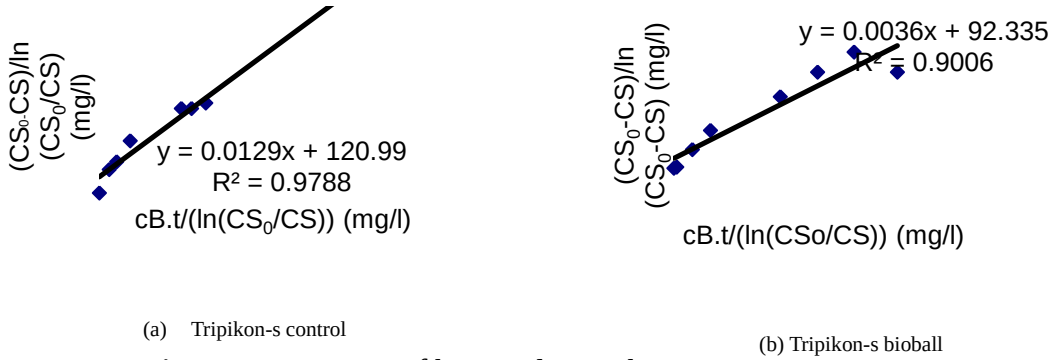


(a) Tripikon-s control (b) Tripikon-s bioball

Figure 10. Removal of total phospat in the reactor

Kinetics at Bacth System

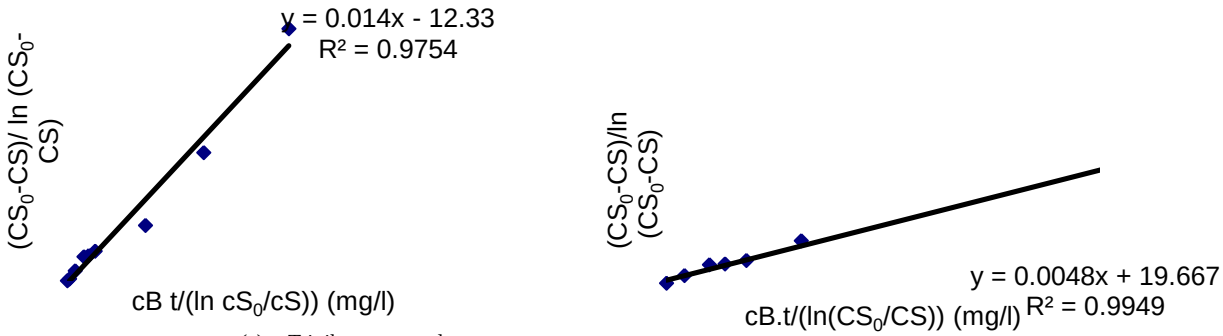
Kinetics were calculated on a batch system is the maximum bacterial growth kinetics. The kinetic model used to follow the Monod equation. In **Figure 11.**for Tripikon-S reactor load control with 1500 mg COD / l was obtained μmax and ks was 0.0129 and 120.99. While the on Tripikon-S bioball to load 1500 mg COD / l was obtained μmax and ks was 0.0036 and 92.335**.**



(a) Tripikon-s control (b) Tripikon-s bioball

Figure 11. Kinetics of bacterial growth maximum on the reactor

In **Figure 12**. it appears that the value of μmax and ks for Tripikon-S reactor control with load variation COD 2000 mg / l was 0.014 and 12.33. While the reactor Tripikon-S bioball with the same load obtained μmax and ks was 0.0048 and 19.667.



(a) Tripikon-s control (b) Tripikon-s bioball

Figure 12. Kinetics of bacterial growth maximum on the reactor

ACKNOWLEDGMENT

Bill & Melinda gates foundation in "Stimulation Local Innovation on Sanitation for Urban Poor in Sub Sahara Africa and South East Asia" research project.

CONCLUSION

In the batch reactor system Tripikon-S-S Control and Tripikon bioball capable of removing COD by 44% and 80% for load variation 1500 and 2000 As for the load variation of COD removal efficiency for the reactor Tripikon-S-S Control and Tripikon bioball is 68% and 70%.

For a continuous system best removal efficiency is given by the residence time of 48 hours

with a load variation 2000 mg COD / l. COD removal efficiency in the reactor Tripikon-S-S Control and Tripikon bioball is 63.04% and 75.93%. While the allowance for reactor Tripikon NTK-S-S Control and Tripikon bioball is 25.20% and 26.53%. Furthermore, the total elimination of phosphate efficiency in the reactor Tripikon-S-S Control and Tripikon bioball is 25.02% and 35.39%.

Based on the results of this study concluded that the reactor Tripikon-S bioball gives better results than the Tripikon-S Control on COD, NTK and total phosphate. Therefore, Tripikon-S bioball should be considered as an alternative to treat wastewater in the black water in coastal and swamp areas.

REFERENCES

Fatoni, zainal dan Stewart, donald. (2010) : Sanitation in an Emergency Situation : A Case Study of the Eruption Of Mt. Merapi, Indonesia, *International Journal of Environtmental Protection*, IJEP Vol.2 Iss.6 2012 PP.

Jamal,wafa and Mahmoud,nidal. (2009): Community onsite treatment of cold strong sewage in a UASB- septic tank, *Journal Biosource Technology 100 (2009) 1061-1068*.

Katukiza, A.,Ronteltap., Niwaga., Foppen., Kanssime dan Lens. (2012): Sustainable sanitation technology options for urban slums, *International Journal of Biotechnology Advances*, 30 (2012) 964-978.

Li, J., B. Li, G. Zhu, N. Ren, L. Bo and J. He (2007): Hydrogen Production From Diluted Molasses by Anaerobic Hydrogen Producing Bacteria in an ABR *International Journal ofHydrogen Energy* 32(1): 3274–3283.

Paulo, paula., Azevedo, caludia., Begosso, larissa., Calbiati, adriana, Boncz, marc. (2013): Natural systems treating greywater and blackwater on-site: integrating treatment, reuse and landscaping, *Journal of Ecological Engineering 50(2013) 95-100*.

Pohan, nurhasmawaty. (2008). *Pengolahan Limbah Cair Industri Tahu Dengan Proses Biofilter Aerobik*, Tesis magister, Universitas Sumatera Utara.

Putri, D.W.,Soewondo, P., Effendi, A.J.,Setiadi,T.(2013). Review of Applied Wastewater Treatment Technology for Floating and Flooded Communities, *International Water Association.*

Said, idaman nusa. (2000) : Teknologi Pengolahan Air Limbah Dengan Proses Biofilm Tercelup, *Jurnal Teknologi Lingkungan*, Vol.1, No.2, Januari 2000:101-113

Saraswati, sri.,Nizam.,Darmanto. 2009.*Penggunaan Tripikon-S untuk Pemukiman Kawasan Pesisir*

Setiawati,endang.,Notodarmojo,suprihanto.,Soewondo,prayatni.,Effendi,agus jatnika.,Widjanarko,otok. (2013) : Infrastructure development strategy for sustinable wastewater system by using SEM method (Case study Setiabudi and Tebet districts, South Jakarta, *Procedia environtmental sciences 17 (2013) 685-692*.

Thye, Y.P., Effendi, A.J.,Soewondo,P.,Setiadi (2013) : Lessons learned in appropriate post-disaster sanitation technologies from the 2004 tsunami. *International Water Asscociation Conferences*

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Institut Teknologi Bandung, Indonesia – November 25th, 2015

INFLUENCED FACTORS OF STRUCTURE FOR WASTEWATER TREATMENT SYSTEM IN CHALLENGING AREA, (CASE STUDY: PALEMBANG CITY, SOUTH SUMATERA PROVINCE, INDONESIA)

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Abstract: Provision of sanitation system in coastal settlement is a significant problem in Indonesia. Palembang is one of the low land which influenced by the Musi river. A quarter percentage from 1.4 million of population has live either in tidal condition or above the river. This condition was caused various problems in wastewater treatment system application determination. From Information, study literature, and survey, the dominant facilities which had built were still less efficient and ineconomical, and potentially harmful to the environment as well. Therefore, design modification was needed in order to develop the wastewater domestic management facilities. (1) the effect of soil properties indicates that soil is high of water saturated and clay. Using Plaxis 8.2 2D finite element analysis, it shows the reason of crack for the structure. (2) Tidal wave, which indicated the high and low points, 1.6 m and 1.1. m respectively lead the difference between waterlogged and dry condition. It causes the problem of fiberglass floatation. (3) Water quality describes that marsh condition which had experience of aerobic and anaerobic reaction can cause the corrosion of material. From the simulation shows that crack cause because the deformation mesh values is higher than safety factor, which is $25.24.10^3$ m higher than 0.016 m. the reduction of the values cause the collapse of the building.

Keywords : Domestic wastewater treatment: specific area: deformation

INTRODUCTION

Provision of sanitation systems problems in coastal areas were unresolved problems in Indonesia, including settlements located along the river (Ida, 2012). According Djonoputro, et al. (2010), the coastal area is classified as a specific region in the provision of sanitation infrastructure, particularly waste water infrastructure due to the different conditions of the region by land area, giving rise to particular challenges in the provision of infrastructure. So far, the problem is a major obstacle in the development of sanitation systems is the lack of maintenance of existing infrastructure and the lack of integration of system design and installation of wastewater treatment in the region (Lindbo, D.2005).

Palembang is the capital city of South Sumatra Province and fourth largest city in Indonesia with an area of 400.16 km^2. Palembang is generally a quite flat area with the characteristics of the region is heavily influenced by the presence of the Musi River which divides the city of Palembang from west to east. The existence of the Musi River caused 25% of the total population of 1.4 million inhabitants live in the city of Palembang in areas above the tidal marsh and river Musi (Djonoputro et al, 2010). The swamp area has unstable soil with a high water table and is influenced by tidal waters so we need a sanitation facility in accordance with the characteristics of the region of Palembang.

There are still many obstacles that hinder the government's ability to provide wastewater treatment systems as well as ongoing maintanance system. One of the failures

caused by factors of community acceptance. In addition, the problem posed is a discrepancy existing sanitation system design with regional characteristics of Palembang. Results of the study Djonoputro, et al., (2010) which states that the condition of the region of Palembang in the form of the marshland which cause a variety of problems in determining the application of the waste water treatment system of domestic waste.

Based on this, it needs a fursther research to defined the sanitation system in Palembang region. As for the factors that affect the infrastructure that were examined in this study are soil characteristics of the study area which is marshland, tidal river, and the river water quality affecting the design of treatment facilities sewerage system.

METHODOLOGIES

This research is focus with influenced factor of structure stability in domestic wastewater treatment. There are three stages of this research, which are; Research Preparation, Data Collection, and Data Analysis.

Research Preparation

In this phase is to determine the object of study, source of data, sampling techniques and analytical methods. Location of the study area is shown in **Figure 1** shows the location of the study area.

Palembang city was selected as a site of research. This location was chosen based on the condition of a residential community, which is a region of rivers and swamps in Indonesia. Palembang is the capital city of South Sumatra province and the fourth largest city in Indonesia. Palembang in general is an area with a sloping terrain that is geographically divided into two by the river Musi area and Seberang Ulu Seberang Ilir is a lowland region affected puddles (Siswanto, 2009). The presence of the river Musi cause 25% of the population living in the area of Palembang tidal marsh and over the river Musi (Djonoputro et al, 2010).

Foccused sites were in four district in Palembang city. These areas are as follows; Sub-District 1 Ulu, 2 ulu, 3-4 Ulu, and kelurahan Tuan Kentang. The region covers an area close to the banks of inland rivers and swamps (swamps, swampy), but the equation of state of this area is all the areas adjacent to the Musi River which children are affected by Tidal seawater.

Pengumpulan Data

The data collection was consisted of two types, namely primary data and secondary data. The secondary data in the form of public data (archives, libraries, reports, journals, technical instructions).

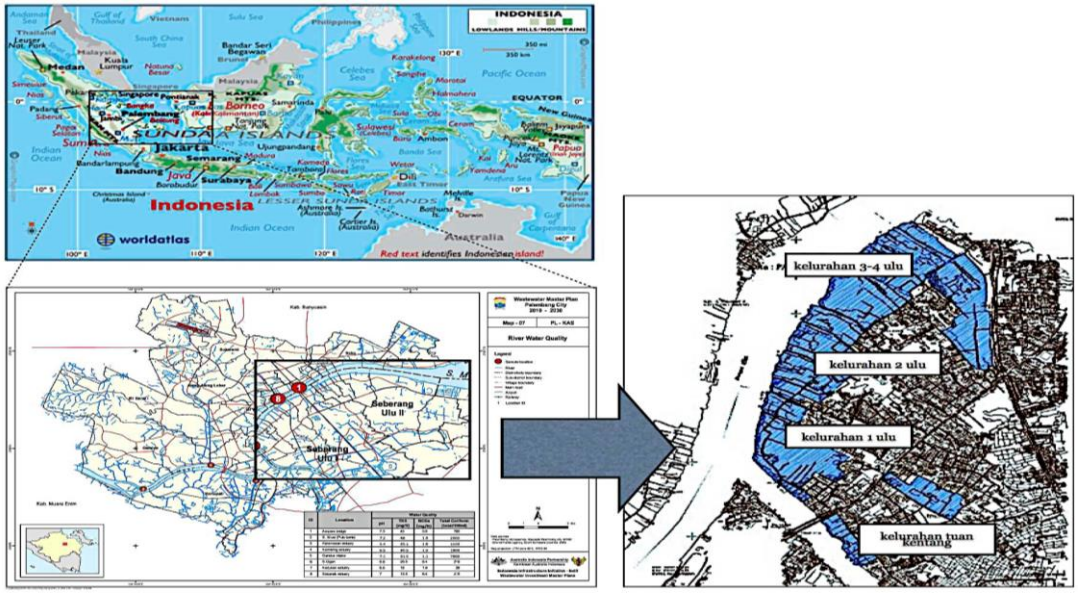


Figure 1. Research location**.**

For Primary Data, consists of field observations conducted in conjunction with ongoing research, graduate student of Faculty of Civil and Environmental Engineering, Bandung Institute of Technology, **Arti Indallah.** The first observations were made at the beginning of the study is that a sanitation inspection latrine facilities, means of disposal of domestic wastewater, and waste disposal proposition society, followed by a look at the desire of the community to sanitation facilities.

Field observations were carried out is to look at the condition of the existing infrastructure of existing effluent water in the study area. The next technical data collection is by sampling marshland sondir manner and boring logs. Soil sampling by boring logs, using the general method of ASTM D 4700 methods of augering, drilling & Site Investigation, This is done to obtain the data of physical and chemical properties of the soil. In the testing ground, the thing done is the determination of the location of the sampling by using purposive sampling method. Method of data collection is done by considering certain things that are considered to represent the observed region. So as to facilitate a team of surveyors to explore the situation of the study sites. Terms of soil testing itself must look at the characteristics of the soil in order to meet the region preventative area observed at each level of density level.

Data Analysis

Data analysis is the process of searching and compiling the systematic data obtained from interviews, field notes, and documentation (Sugiyono, 2008). By way of organizing the data into categories, lays into the units, synthesize, organize into a pattern, and then choose which ones are important and which will be studied, and make conclusions so easily understood by myself and others.

This research was carried out in abundance descriptive, that is an analysis that is based on data obtained inductively developed into a hypothesis. The data have been obtained later recapitulated by using Microsoft excel. It is focused on the research is only in its existing

state of sanitation in the study area. In parallel, a review of soil samples in the laboratory to see the characteristics of the soil.

Followed by simulating the model waste water facility with the character of the soil tested. The output of this software is to see how the study of land subsidence due to load upper load. Having obtained the results of further analysis of the problems that occur with domestic waste facility.

RESULTS AND DISCUSSION

Existing Condition of Domestic Wastewater Treatment Facility

Conditions of sanitation facilities especially wastewater treatment facilities should be studied to know the habits of the community in the study area as a material consideration in choosing sanitation technologies.

Knowing Existing Condition is very necessary to look at the toilet preferences used by the community **Figure 2.**

Figure 2. Type of used toilet (a) Hole in the floor (b) Fabricated toilet with broken flush (c) fabricated with good system.

Table 1. It can be seen that there are many people on both the type of home that inadequate infrastructure and technology. However it can be seen that the type of public house on stilts situation better than the people at home are still conventional floating. This is done because it is difficult to build adequate wastewater infrastructure over the water

Table 1. Toilet Condition and Treatment in community.

Variable	Semi-permanent House		Floating House	
	Frequency	%	Frequency	%
Type of Toilet				
Private Toilet WC	162	68.1	11	61.1
Sharing toilet	13	5.5	0	0.0
Public Toilet	48	20.2	1	5.6
River/drainage	15	6.3	6	33.3
Variable	**Semi-permanent House**		**Floating House**	
	Frequency	**%**	**Frequency**	**%**
Shape of Toilet				
Hole in the house floor	76	31.9	12	66.7
Seat Toilet	0	0.0	0	0.0
Squatting Toilet with broken flush	66	27.7	0	0.0
Fabricated Squating toilet	84	35.3	0	0.0
River	12	5.0	6	33.3

Wastewater Treatment				
Pit latrine	39	16.3	0	0
Drum in land floor	21	8.8	0	0
Direct pipe	10	4.2	0	0
Brick septic tank	27	11.3	0	0
Fabricated septic tank	21	8.8	0	0
Recharge into communal system	0	0.0	0	0
No treatment, no pipe	110	46.0	18	100
No treatment, pipe direct to the river	10	4.2	0	0

*) on going research

It can be seen from **table 1** Community in the study area still using squat toilet. It is important to note that different because society allows different preferences depending on the local culture and customs. This indicates the vulnerability of sewage contamination of the Musi river in the area itself, from field observations were carried out, the design of the septic tank itself also does not follow the standards that have been set Indonesian National Standard (SNI).

Failures that occur in domestic wastewater treatment facility

As mentioned before, Viewing from existing conditions that occur there are several types of existing treatment systems, directly in the exhaust system in the river, squat toilets manufactured with goose neck, squat toilets manufactured in olongi, toilet seat, and a hole in the floor house. However, almost all types of domestic septic tank waste management. Septic tank in this case is assumed to be a good system even though there is a system of communal and ABR to the biofilter tank in the area of research. Existing management systems will be references in the design of future innovation. Settlements in the study area is dominated by residential with type stage with some of them are floating homes on the flooded area (river area). In addition, there are areas of land reclamation on the type. In general, people use river water for daily needs. Wastewater facilities owned by communities dominated by pit latrines without management systems. Some people use local materials as waste shelters, such as PVC pipes, drums, with the form of columns made of brick or concrete. In addition to the individual facilities, there is also a public toilet facilities were built, both by the community and government. In the new residential area reclaimed in accordance with the government program, individual toilets are provided, including a simple exhaust system for the wastewater treatment facility. The conditions of settlement and sanitation facilities is shown in **Figure 3.**

Most of the application of the wastewater treatment system by the government or private parties is a facility that is commonly used in the area of land types. Of the many facilities that have been observed in this study, there are three problems that often occur, the cracks in domestic wastewater treatment, flotation of fiberglass on the bottom inside the protective wall construction, and pipe connections are broken.

Effect of Land Characteristics

From two points of soil sampling locations, indicate the location of the land in the area to take the characteristics of the soil samples showed that the soil is saturated with water and is classified as a medium plastic inorganic clays. Research sites have ground water elevation and is influenced by tidal sea level. Groundwater levels above 50 cm - 60 cm This indicates

that this region is quite high for flooded. Figure 4 shows that the greater the resistance value or qc states that land closer to the ground hard. In the following soil tests can be seen that the ground is still soft around the value of 5.4 m while to get to the hard ground around a depth of 6.6 m onwards

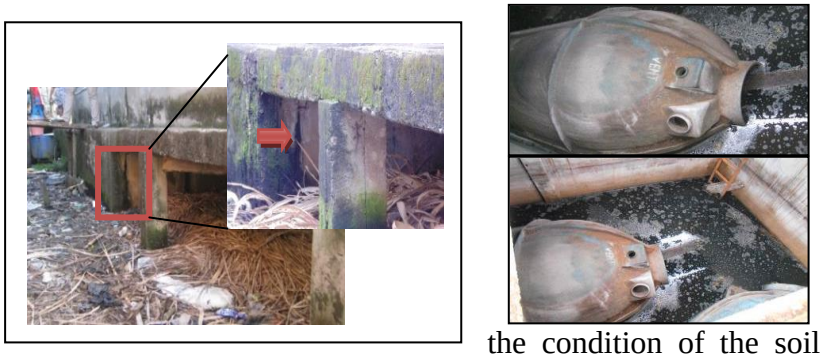
Seeing  the condition of the soil is relatively

Figure 3. a) Cracks in concrete material b) Flying Biofilter.

stagnant construction is required in accordance with the conditions of the soil itself. The rupture of sewage treatment and the frequent occurrence of a fault in the system piping may occur because of differences in the value of deformation of construction toilet with treatment system. Value of soil characteristics can be seen in **Table 2.**

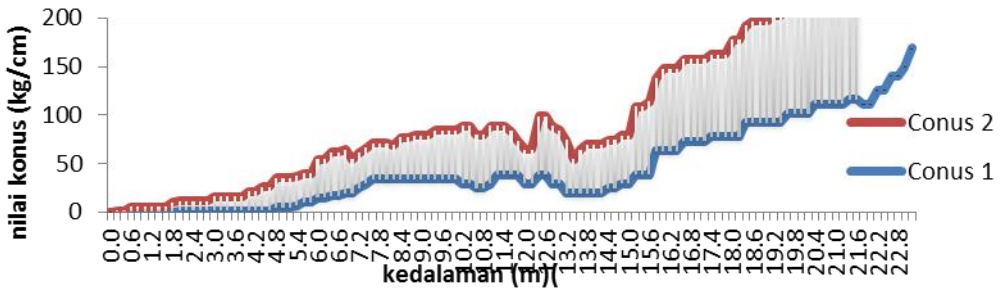


Figure 4. SPT graph.

The water content is almost close to the value of 100% indicates that the water content in soil is very high so do not be surprised if the ground is fairly soft. In general, for coarse-grained soil (coarse-grained), the nature and degree of the relative density of the particles is very important, consistency and plasticity of the tested soil showed that the soil including soft soil with the index value of the plastic is still in the value 7:23% and 15:50%.

Table 2. The characteristic of Soil in research site.

Tanah	Units	Tabung B1	Tabung B2
Berat Jenis tanah	gr/cm^2	1.42	1.42
Kadar Air (w)	%	170.29	93.84
Specific Gravity (Gs)		2.64	2.63
Batas *Atterberg*			
LL	%	50.10	59.70

Tanah	Units	Tabung B1	Tabung B2
PL	%	42.87	44.20
PI	%	7.23	15.50
Analisa saringan			
No. 3/8	%	100.00	100.00
No. 4	%	100.00	100.00
No. 10	%	99.71	100.00
No. 20	%	98.86	99.67
No. 40	%	98.43	99.00
No. 60	%	98.00	98.83
No. 100	%	97.71	98.17
No. 200	%	96.57	95.33
Pan	%	0.00	0.00
Konsolidasi			
Cc		0.52	0.51
Cv	Cm^2/min	0.00	0.00
Triaxial			
Φ		2.40	0.00
Cu	Cm^2/min	0.05	0.10

Cv values on soil properties provide information about the time required for a decrease (depression) were simulated using Plaxis. Simulations show that the time required for the overall decline is 100 times the emphasis by the load. This gave the need for preloading information requirements to achieve a certain reduction in order to reach stable ground. Cu values are under 0.25 tones / m so that the land is categorized as soft ground.

In this study, two modeling systems for the option selected, the watery pit latrine (Privy aqua) and Communal septic tank. The building structure is simulated using septic tanks and aqua Privy using concrete materials. It is assumed that the fiber material is much lighter than concrete. The capacity of each treatment was 5 people. From the results of the test with PLAXIS, deformation values issued by the Privy aqua and septic tanks are as follows 854.92 x 10-6m (Figure 6b) is 25,24x10-3m (Figure 6c). Previously conducted testing on the safe point with no load in it. Logically rift would not have been possible in a short time due to a considerable reduction of small value.. Then gradually with the addition of a load on the processing of domestic waste can affect the soil and decrease the load on the shear strength of the foundation itself. It is also the same as the pipe breakage in domestic wastewater treatment systems. This is because of differences in the toilet with a decrease in domestic wastewater treatment. .

Figure 6 shows a tendency toward collapse quite scattered. These conditions increase the probability of collapse of different directions in a structure that increases the likelihood of cracks. Information security factor (safety factor) obtained figures show 2.05 m which is very close to the standard values are allowed (2.0 m). Although it can be classified as safe, with a slight increase in weight of the structure can lead to excess deformation. In an effort to prevent this, the addition of an effective foundation needed (Ddarjanto, 2004)

In principle, if the load is excessive, failure usually occurs in the form of shear failure.

So in fact the main structural strength is a function of the shear strength. Soil shear strength in any direction is the maximum shear stress that can be deployed into the structure of the soil in that direction. At the time of reaching the maximum value of shear stress, the soil is considered to have failed, the shear strength mobilized telag entirely.

Shallow stabilization technique has limitations in the application of this technique is that it is not intended to eliminate the overall decline, but only serves as a far decrease (DPU 2005)

The presence of other causes of failure were not taken into account other than perhaps as a result of poor construction workmanship and details that less attention system. Detection of unexpected behavior during the excavation process can only be done by monitoring the performance of the process of beginning to end. An effective performance monitoring program should be included in the design for a variety of excavation in which the consequences of the predicted movement is significantly greater (Marr et al, 2007).

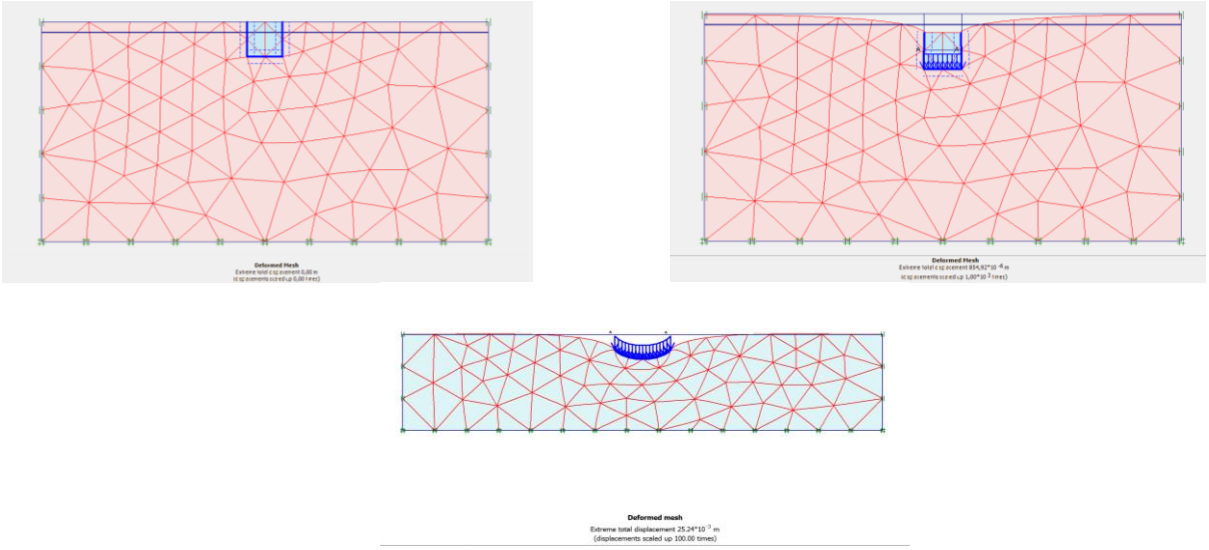


Figure 6. (a) *Deformation mesh in safety condition (b) deformation mesh* in *Aqua privy system; (c) deformation mesh communal septic tank system.*

Tidal Waves Effect

The study area is influenced by the tidal wave of water. Figure 7menunjukkan highest tidal elevation within one year occurred in January. In Figure 7, the level of water table changes with a high point occurs at the rate of 1.6 m above ground level, and the low point occurred at the rate of 1.1 m below ground level. This led to the residential areas have flooded periods and dry periods.

Stagnant periods and dry periods to explain the cause of the problem of fiberglass flotation of wastewater treatment systems. This is caused when the water reaches the water treatment system, Archimedes law applies (Sumidjan, 2012). According to the law of Archimedes, buoyant force balanced and opposite to the weight of displaced fluid (Lautrup, 2005). Wastewater treatment systems. If, waste water treatment system is made of very light material, the average density of the air in the fiberglass tank will be lower than the density of

water so that moving the system into a floating and detached from other supporting material. It is recommended to fill the fiberglass wastewater treatment system with water until full when placing the tank is empty, but still have to pay attention to the style of the riverbed processing system (or a layer of fiber glass construction below).

The quality of water contained in the marshland, Dealing with the effect of tidal wave river water which has been described previously, marshland aerobic and anaerobic reactions that explain the occurrence of corrosion in wastewater treatment systems (Figure 5). Corrosion problems caused material is slowly destroyed. Corrosively will also affect the strength of concrete (Sulistyoweni, et al., 2002). Immersion test shows the speed of corrosion of concrete (strength ST 37) are periodically soaked in water swamp (which comes from the swamp area of Jakarta) is 14,467 mpy (mille-inches per year). This value is three times higher than that of concrete continuously soaked with swamp water (5.098 mpy). Corrosion problems also contributed to the decrease in concrete strength also cause cracking problems in the water treatment facility with concrete materials. Ghani (2006) also mentions that the groundwater level changes also provide long-term impacts associated with a reduction in force or reduction in capacity.

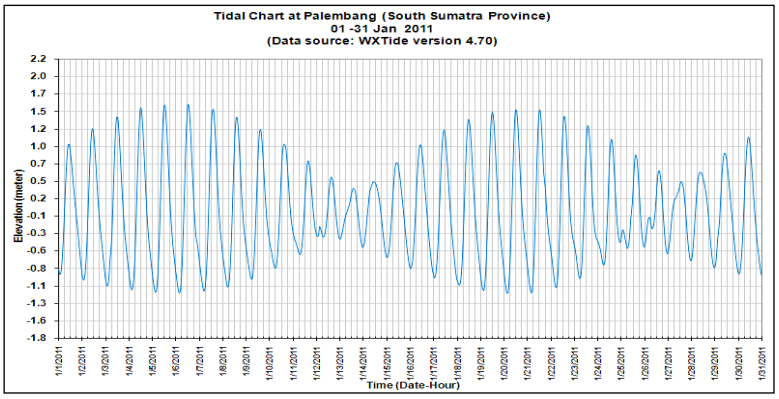


Figure 7. Gelombang pasang surut dan perubahan tabel air di kota Palembang pada januari 2011 (Source : Universitas Sriwijaya).

Alternative Solutions for Domestic Waste Management Structure

From the previous explanation, People who live in houses on stilts, wear as much as 16.3% and 11.3% use a pit latrine cesspool, the rest use other types of processing. Followed by a floating society no one is using domestic wastewater treatment systems. It should be considered in the development of domestic sewage treatment in the area of the swamp is the way How can create an efficient technology to last long. Stages in the life of the community utilizing sanitation facilities is still quite low. Society still considers that the septic tank and the other type is a collection of faeces. So in the selection of technology options, should pay attention to the technical aspects of building the facility itself. Requirements to build this facility itself should avoid systems that are not good for areas with high ground water level as septic tanks. Then the material is susceptible to corrosion. So if in doing studies didapatlah decisions that result in the efficient processing for the watery swamp is latrine by using fiber material modifications. Figure 8 Displaying modfikasi plan design in swampy areas

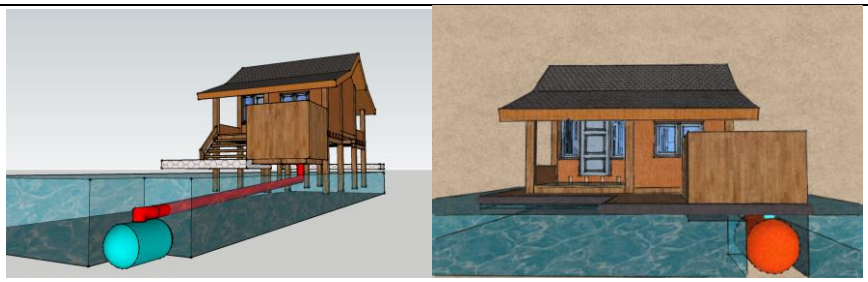


Figure 8. Ilustrasi Modifikasi Desain Sistem Pengolahan pada Daerah Rawa.

To overcome the problem of flotation devices due to water pressure and tidal wave, if you want to use septic tank fabrication or biofilters, Where the pavement foundation raised if such a device it would be difficult and damaging treatment. In addition, it is advisable to fill up water treatment system with full advance when placing the tank is empty. For a floating house, it must be added a cover to protect the movement of the processing system itself.

CONCLUSION

The community in swampy area, 16.7% and 11.3% still use the pit latrine and septic tanks. It necessary to repair the domestic wastewater treatment based on people's habit. But the problems were occur in domestic wastewater treatment system, e.q cracks in concrete masonry wall that exceed of deformation limit.. It is also supported by the movement of the tide influences. The highest up sea level was in 1.6 m and following 1.1 m as the lowest level. Modeling is done by simulating the soil loading Privy aqua system and septic tanks with the help of software PLAXIS 8.2 deformation values issued by the Privy aqua and septic tanks are as follows 854.92 x 10-6m 25,24x10-3m. From references, references, it is concluded that it is time to develop the appropriate technology such as tripikon-s and modification of aqua Privy materials using fiberglass in swampy areas.

REFERENCES

Araz, I. , Fitsum, T., 2011. Analysis of deformation in soft clay due to unloading, CHALMERS, Civil and Environmental Engineering, Master's Thesis 2011:23, Goteborg, Sweden

Australia Indonesia Partnership. 2012. "Wastewater Investment Master Plans Package 2 Palembang, Bandar Lampung & Batam-Final Master Plan Palembang", *Indonesia Infrastructure Initiative*, Australia Indonesia Partnership

Binol, R.R. 2013. One Size Does not Fit All, Delft University of Technology, Delft

Darjanto,Helmi. Penggunaan Bambu untuk mengatasi Sliding pda reklamasi di tanah lunak., Neutron, Vol 4., No.1 Februari 2004.

Departemen Pekerjaan Umum. Pedoman Konstruksi dan Bangunan, Stabilisasi dangkal tanah lunak untuk konstruksi timbunan jalan (dengan semen dan cerucuk). Pd T-11-2005-B

Djonoputro, E.R., Blackett, I., Rosenboom, J.. & Weitz, A. 2010, Understanding Sanitation Options in Challenging Environments, *Waterlines*, 29, no. 3, pp. 186-203.

Djonoputro, E. R. Blackett, I. Weitz, A., Lambertus, A., Siregar, R., Arianto, I., Supangkat, J. 2011. Opsi Sanitasi yang Terjangkau Untuk Daerah Spesifik, *Water and Sanitation Program- East Asia & the Pacific (WSP-EAP).*

D. W. Putri, P. Soewondo, A. J. Effendi, and T. Setiadi, Review of Applied Wastewater treatment technology for floating and flooded communites, IWA International Water Assiciation

D. W. Putri, P. Soewondo, A. J. Effendi, and T. Setiadi, Finding a Solution for treating wastewater in floating toilet, ITB-GIFU

D. W. Putri, P. Soewondo, A. J. Effendi, and T. Setiadi, Existing Application of wastewater infrastructure for coastal, river, and swamp communities (review paper), SIBE 2013

Ghani, A. N. A. 2006. Civil Infrastructure in Land Development : The Sustainable and Environmental Challenge. International Conference on Environment 2006 (ICENV 2006) Universiti Sains Malaysia

H. Dolan and I. J. Walker, 2004, "Understanding vulnerability of coastal communities to climate change related risks", Journal of Coastal Research, Special Issue 39.

Lautrup, B. 2005. Physics of Continuous Matter Exotic and Everyday Phenomena in the Macroscopic World, Institute of Physics Publishing, Bristol and Philadelphia

Lindbo. D, Rashas. D, Hoover. M, 2005 Soil fact, Why do septic tank failed., North Carolina cooperation extention.

Marr, A., Martin, H. 2010. Displacement Design for Deep Excavation, Geocomp cooperation, 125 Nagog Park, MA 01720

Pour,M.S 2012, Judgement under uncertainty;A Probabilistic Evaluation Framework for Decision-Making About Sanitation, Delft University of Technology, Delft

Sanyal, S. 2009. "CAMBODIA Case Study 1: Floating Toilets for the Floating Villages in Tonle Sap Lake".Lien Aid Report- Project of Phat Sanday floating communities on the Tonle Sap Lake, Cambodia

Sugiyono, (2008). Metode Penelitian Kunatitatif Kualitatif dan R&D. Bandung Alfabeta.

Sumidjan, I. Y. 2012. Efisiensi Sistem Biosanter dalam Pengendalian Pencemaran Kawasan Permukiman di Sekitar Bantaran Sungai (Draft). *Pusat Penelitian dan Pengembangan Permukiman.*

Thompson. David B, 2006. "The Rational Method". Engineering Hydrology, Texas Tech University.

Voinov, A., Bousquet, F. 2010, "Modelling with stakeholders", Environmental Modelling and Software, vol. 25,no. 11, pp. 1268-1281

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

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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).

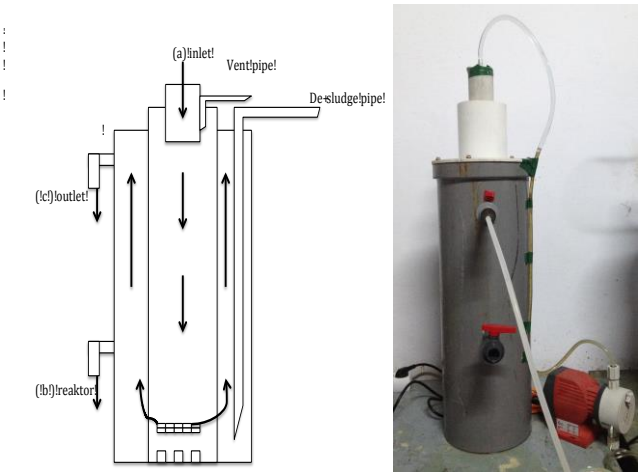
Marthee et al. (2010) said that anaerobic processing is a core technology to recover energy and nutrient from black water waste. Anaerobic processing has been widely emphasized by researchers of sanitation because it is more economic than conventional aerobic method (Khrisna et al., 2009). Anaerobic 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,



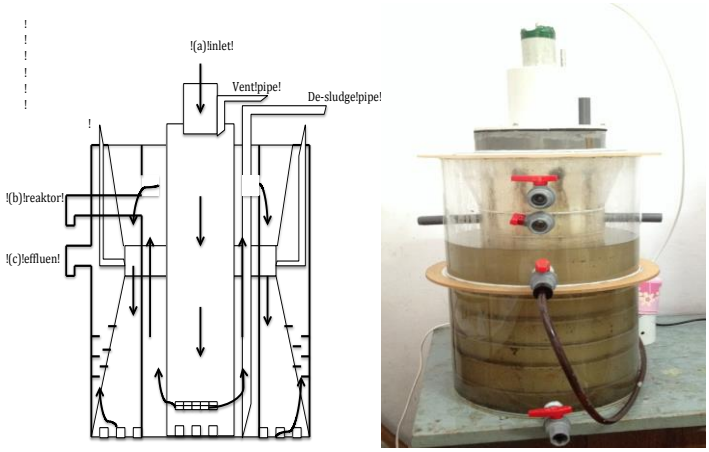


Figure 1. Scheme and photo tripikon-S reactor; (right) control reactor and (left) modified reactor.

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.

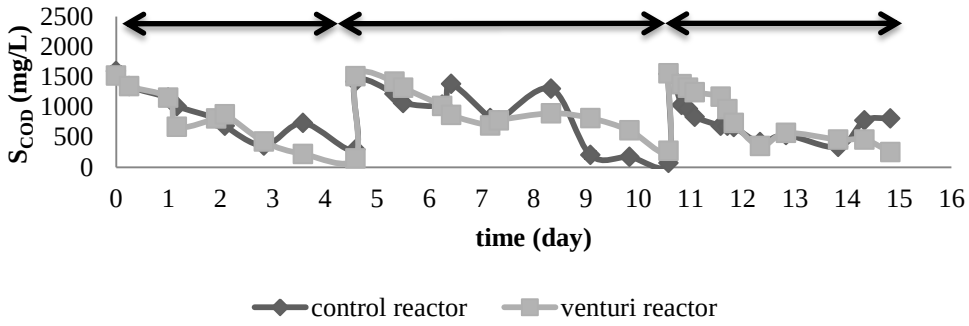


Figure 2. Decreasedconcentration of dissolved COD in the influent concentration variation 1500 mg/I of COD.

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.

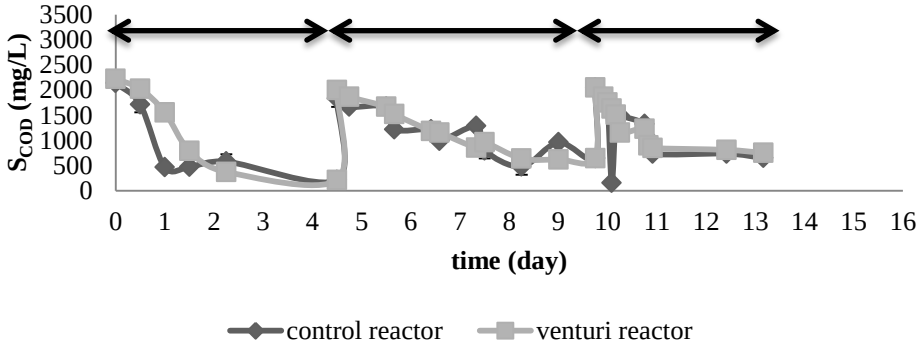


Figure 3. Decrease concentration of dissolved COD in the influent concentration variation 2000 mg/I of COD.

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.**

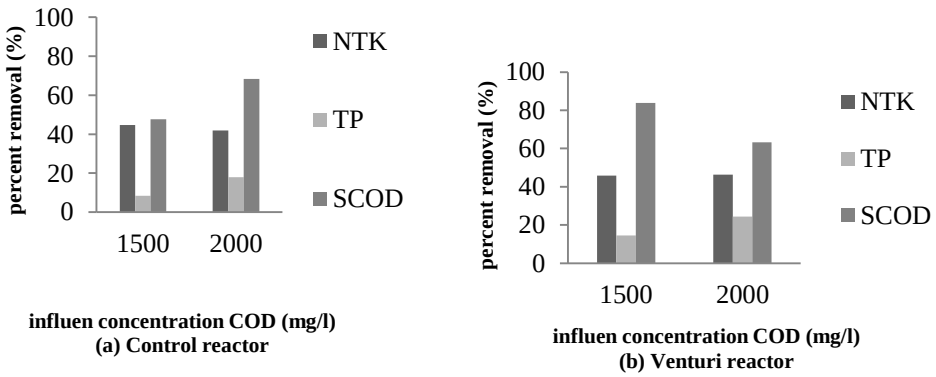


Figure 4. Removal efficiency of NTK, total phospate and $S_{COD.}$

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

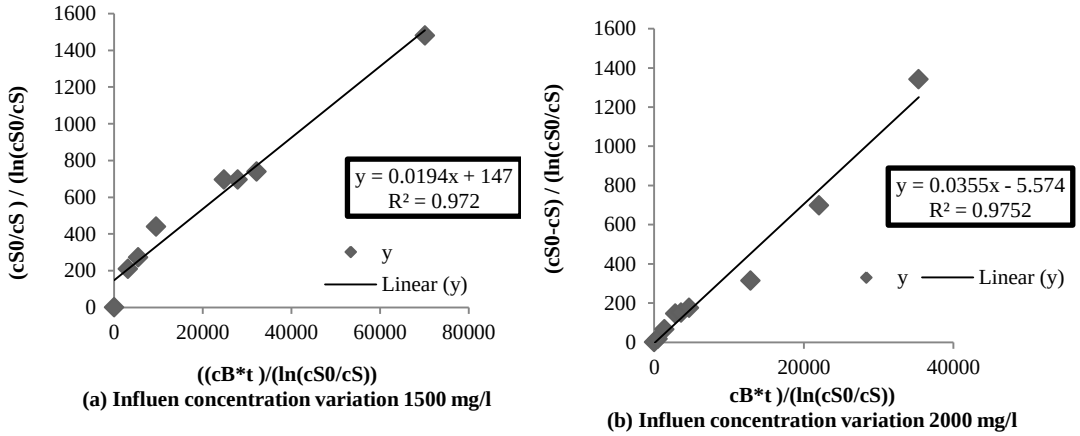


Figure 5. Kinetics of maximum biomass growth in the reactor control.

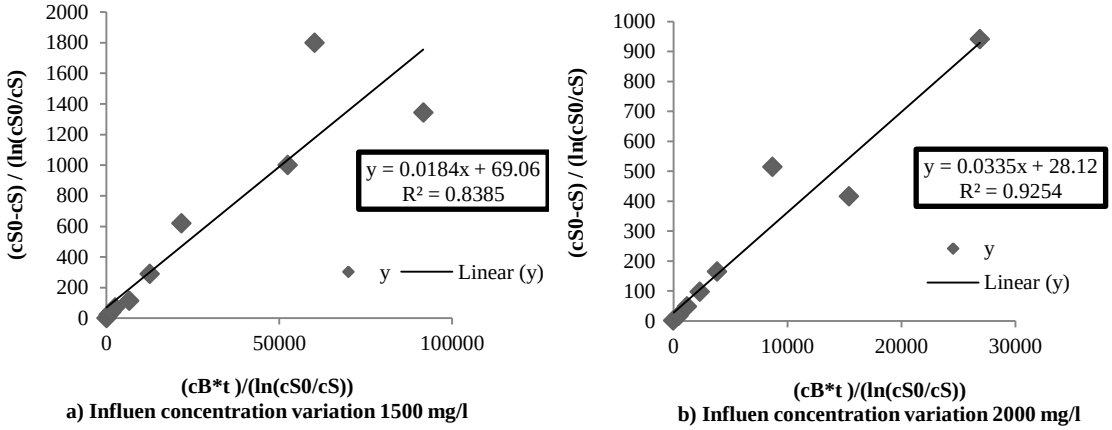


Figure 6. Kinetics of maximum biomass growth in the reactor venturi.

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.

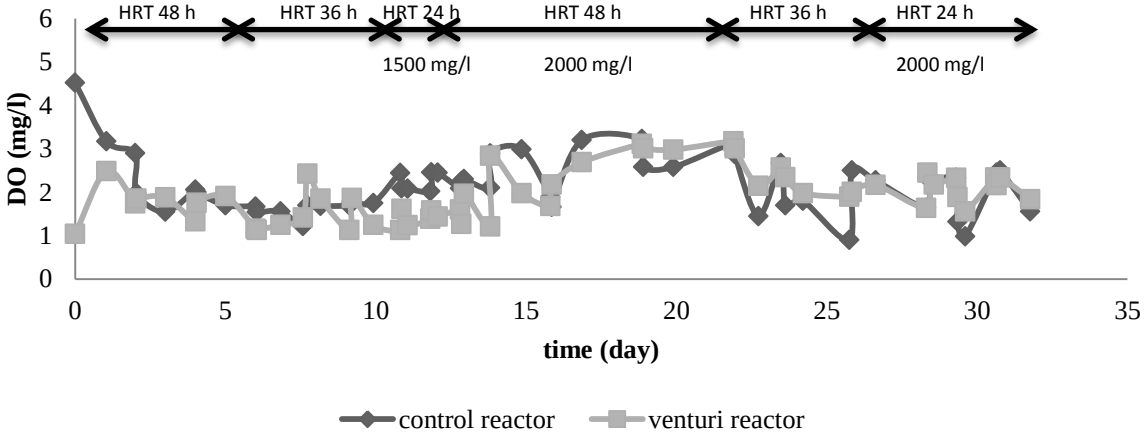


Figure 7. DO concentration in the reactor.

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%.

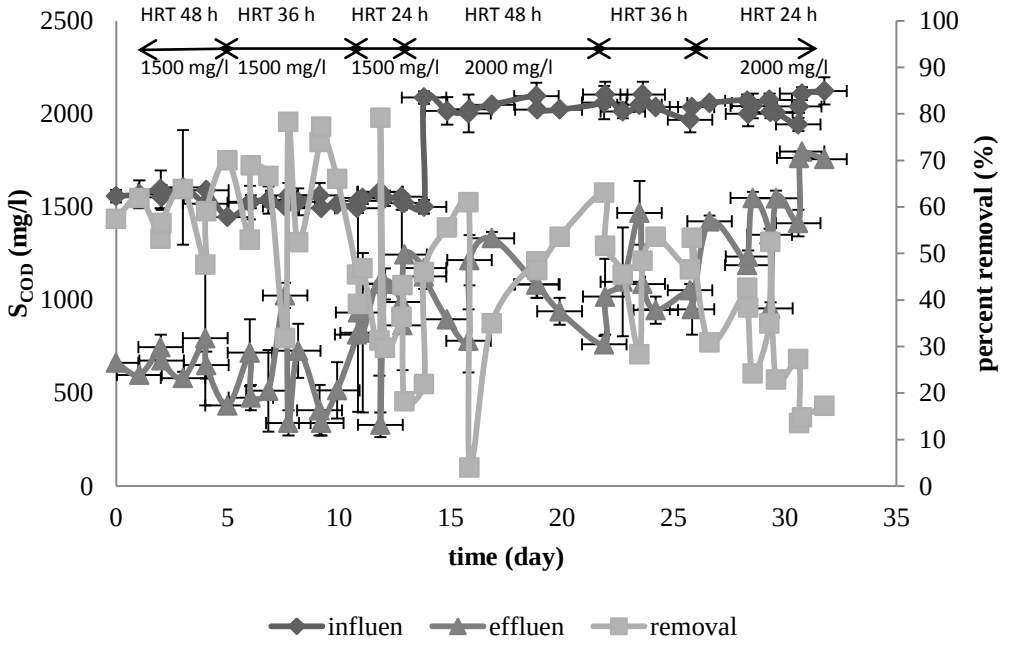


Figure 8. Influent, effluent concentrations of soluble COD and removal efficiency in the reactor control.

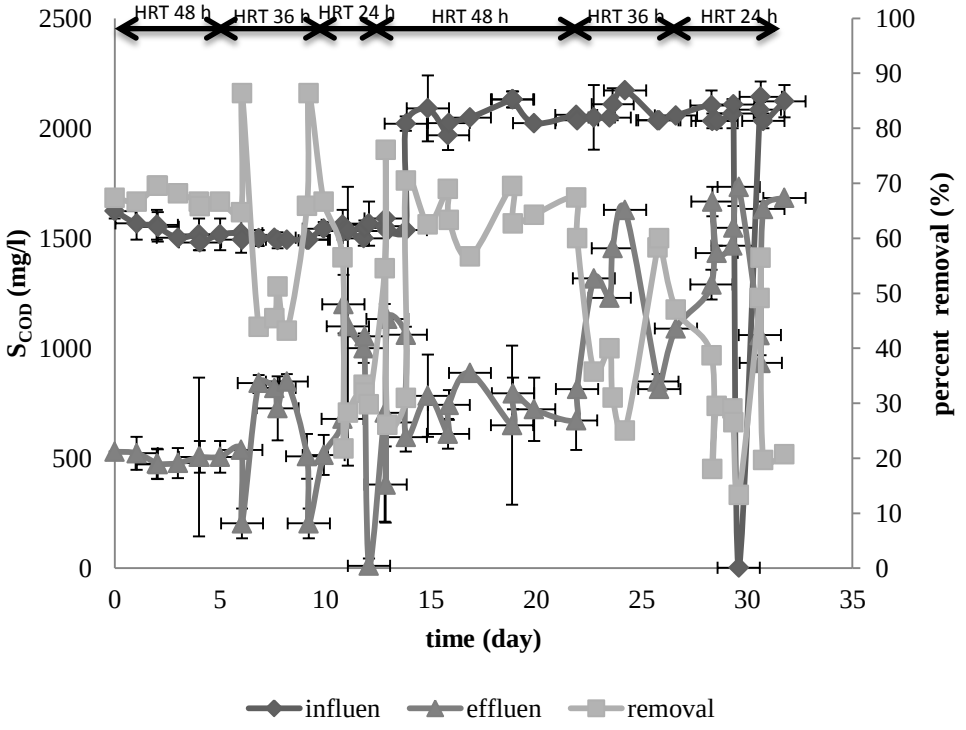


Figure 9. Influent, effluent concentrations of soluble COD and removal efficiency in the reactor venturi.

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%.

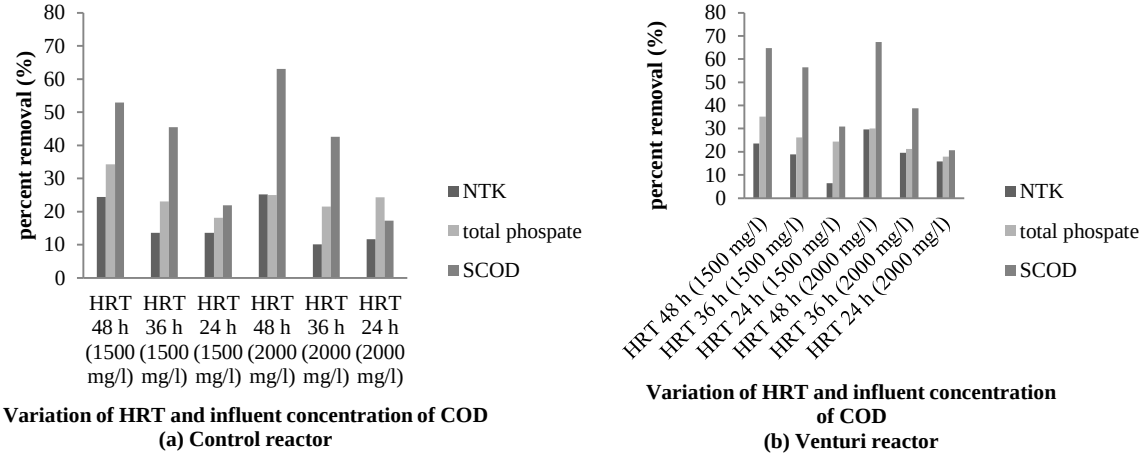


Figure 10. Percent removal in various variations.

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.

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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

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MATERIAL FLOW ANALYSIS OF VEGETABLES WASTE CAUSED BY HORTICULTURAL ACTIVITY (CASE STUDY: BANDUNG CITY)

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Abstract: Material Flow Analysis was used to assess the amounts of vegetables that introduced into Bandung City and become wastes in every trnasaction chain; grower, supplier, wholesale market, retail, consumer and finally collected into final disposal. A huge amount that produced by the peeling processes raised an idea from Mayor of Bandung to apply a policy „peeled vegetables“ before intoduced into Bandung City. Boundary of the mass flow in this study is Bandung City and functional unit used is a unit of weight (tons). Input data used in this research is the data amount of vegetables that go into Bandung City which is calculated based on the level of consumption of vegetables per capita population of Indonesia, adjusted for the population of Bandung City and the number of people around Bandung City who obtained the distribution of vegetable wholesale market in Bandung. Percentage of waste generated in each transaction chain obtained by observation and experiment in the field, the experiment are artificially at the household level and interviews with actors distribution. The resulting output is the number of vegetables waste in every transaction chain vegetables in Bandung City, either through modern markets and traditional markets. From the analysis it can be seen that the amount of vegetables waste in Bandung is 1,252.38 tons / week or 9.54% of 13,126.02 tonnes of waste generated in Bandung City each week.

Keywords: material flow analysis, waste, vegetables, post harvest losses

INTRODUCTION

Every year the population of Bandung City was increased. According to Badan Pusat Statistik (2013), the population of Bandung City in 2012 reached 2,455,517 people. Along with the increasing of population, the need for food was increased too. According to Murthy et al., (2014) vegetable is one of the food sources that rich in fiber and vitamins which are important for the human body. However, in addition to adding nutrition, vegetables also created new problems in the form of waste generated from the sorting process prior to sale. Based on research conducted by Wadhwa and Bakshi (2013) of the FAO, the number vegetables and fruits wastes resulting from the process of sorting, grading and others reached 31.98 million tons in China and 14.95 tons in the USA. Based on the US Environmental Protection Agency (EPA), the amount of junk food in it include vegetables and fruits resulting from the process of sorting, grading, processing and others estimated at 31.75 million tonnes or 12.7% of the 250 million tons of waste solid in the United States in 2008 (EPA 2010a in Buzby et al., 2011). Similar cases have not been investigated in Indonesia, both national and regional scale as in Bandung. Research on material flow analysis has been carried out on plastic polypropylene (PP) glass, as did Nareta and Damanhuri (2014), but has not been conducted on organic waste such as vegetables waste.

Data on the amount of vegetables waste of every chain of production-distribution-consumption in Bandung uncharted thoroughly, whereas vegetables is one of the products which are consumed and accounts for a significant litter. Data on the number of vegetables waste in the process of sorting, processing and others in developed countries has been widely publicized, but in Indonesia has not been done. As an initial overview, based on data from PD Pasar Bermartabat Kota Bandung, every day of the markets in Bandung produced 162.66 m^3 of waste and some of which are biodegradable waste consisting of leftover food, vegetables and fruit. According to Faramita and Rahardyan (2007), waste generation in Bandung every day reach 7,500 m^3. Of these, according to the survey conducted in 2005-2006 by Damanhuri (2008), the composition of organic waste in Bandung by 52% of the total litter, while the rest (48%) in the form of inorganic waste. In the boundary of this study, namely Bandung City, which produces a lot of vegetables waste like Andir Market every day can produce a litter of up to 14 m^3, while markets such thematic Jatayu Market, Cihapit, Cikapundung and others who sell goods -Items non-biodegradable waste only produces less than 1 m^3 per day. From this categorization (thematic and non-thematic) can be estimated that the largest contributor to the waste in the markets in Bandung derived from food losses and food waste, in the form of raw materials, the rest of the food to the food processing former being discarded.

As a food product transaction center, activity in the markets in Bandung City also annually increased along with the increasing population. According to the last census, the number of markets in Bandung City, which is under the management of PD Pasar Bermartabat Kota Bandung in Bandung in 2012 reached 37 markets (Badan Pusat Statistik, 2013). Vegetables waste is one of the types of waste that dominate solid waste in these markets, particularly in markets such as Pasar Caringin parent, Gedebage Market, Market Ciroyom and others. This occurs because the vegetables are imported directly from agricultural production centers around Bandung like Lembang, Cisarua, and others are not directly sold to consumers, but through the process of sorting again-after sorting done at the level of farmers and collectors. Parts of rotten vegetables and not worth selling directly disposed in place and become waste. The total volume of waste and waste into these need to be assessed through the material flow approach (Material Flow Analysis, MFA).

To reduce the burden of waste which is increase every day, the Mayor of Bandung City in 2014 initiated a program to reduction the vegetables waste, in particular by requiring every vegetable that goes to Bandung City to be packed in plastic packaging that is expected to reduce the volume of waste of vegetable origin. Perpetrators of packaging in this case is the supplier of vegetables which are in the upstream chain of transactions before entering into Bandung (Kompas, 2014).

According to research by Sharma and Singh (2011), the number of vegetables fractions become due process of sorting waste in the farm, to the hands of the consumer market could reach 23.19% with an average loss of (food losses) amounted to 14.6%. The main cause of the high levels of litter due to post harvest handling based research Osman et al. (2009) is inadequate knowledge about good handling practices (36.7%), treatment is less efficient (50.3%), poor infrastructure (51.9%), and less funding for technological applications (38 , 8%).

This study has the objective to determine the contribution due to the vegetable waste sorting process (sorting) of the amount of waste generated in the markets holding in Bandung.

The purpose of this study was to obtain details of the production of vegetables in the upper level (the farm) and the amount of waste generated from the process of segregation of the various stages of the transaction chain and downstream (markets). The hypothesis in this study is that the waste generated from the process of sorting vegetables in every transaction chain has a major contribution to the amount of waste generated in the markets holding in Bandung.

RESEARCH METHODOLOGY

This study uses the approach of Material Flow Analysis (MFA). Boundary of MFA system in this study is Bandung. The waste were analyzed only in the form of the number and type of vegetables waste derived from vegetable production (olerikultura) resulting from production centers around Bandung City, such as Kertasari, Pangalengan and Ciwidey which are located in Bandung. Market which is used as the location of the study is only a legally recognized market and is under the management of PD Pasar Bermartabat Kota Bandung, in terms of which have been 6 markets Gedebage Wholesale Market (wholesaler), Andir Market, Kiaracondong Market, Cihaurgeulis Market, Ciroyom Market and Cijerah Market, and market that are under management of *Badan Pengelola Pusat Perdagangan Caringin* (BP3C) ie Caringin Wholesale Market. Collection of data related to waste management from relevant agencies.

Data collection was performed by means of surveys, field trials and interviews with farmers, collectors/suppliers (middlemen), merchant wholesale market, traditional market traders, hypermarkets, supermarkets and for the final stages of the sorting is done in artificial vegetable consumers to perform 5 attempts for each types of vegetables. The survey was conducted by taking samples from each population. Sampling for farmers conducted by random sampling method.

Data processing approach flow of vegetables waste material is done by analyzing the input and output to the amount of vegetables and vegetable waste generated in Bandung and surrounding areas, taking into account other variables, such as the amount of vegetables that come from outside Bandung City. Other data used for the benefit of the description made by descriptive statistical analysis approach, such as the total number, mode, median, mean, standard deviation, distribution curves, and so forth. This analysis is not used for the conclusion of the population, but only to explain the data alone.

RESULTS AND DISCUSSIONS

The types of vegetables studied were the vegetables which are consumed regularly by people in Bandung City, and statistically recorded in West Java Provincial Agriculture Office. The types of vegetables are as listed in Table 1. The vegetables that go to Bandung previously have undergone various stages of sorting and grading, both at farm level (the farm), city, until before entering into Caringin Wholesale Market. The amount of variation varies depending on the type of vegetable sorting. However, to determine the waste generated from the sorting process is not only based on the percentage of sorting, but based on the level of consumption of vegetables. Average sorting for various types of vegetables from upstream to downstream is shown in Figure 2 and Figure 3.

Sorting can be interpreted with a separate product that is not in accordance with the market and the products based on quality standards. The purpose of grading is to improve

customer satisfaction (Utama and Antara, 2013). Grading is the term used in the post harvest activities in an industry. Understanding grading is separation or grading of products based on market needs, or can also be defined by the process of sorting and sizing for commercial purpose (Utama and Antara, 2013). Grading for each type of product different from each other because each product has different characteristics, agronomic practices, as well as climatic conditions during production, diversity of products (size, shape, etc.) and the diversity in demand for different markets (Utama and Antara, 2013).

Stages initial sorting is done in the farm. Sorting at the level of the farm is done to separate marketable vegetables and vegetables are not worth selling, as affected by the disease, suffered mechanical damage due to impact, the size is too small or too big. Average sorting at farm level is 7.11%, with the types of vegetables that have the greatest degree of sorting is chinese cabbage (39.21%) and cabbage (34.71%). In aggregate, after adjusting for vegetable production, the level of sorting at the farm level is 11.05%, as shown in Figure 1. According to Salunkhe and Desai (1984 in Utama and Antara, 2013), vegetable crops have been harvested in fact still alive. It is characterized by the process of respiration by the vegetable crops. The process of respiration in plants remodel existing complex carbohydrates in the plant body into simple carbohydrates are sugars and then oxidized into energy. This reform process produces CO2, H2O and heat. Therefore there wilting vegetables when vegetables are long kept and degrade the quality of the vegetables that produce a lot of waste. Besides litter, as described earlier, that H2O produced during respiration also cause weight loss due to loss of water content vegetables with a percentage of aggregate approximately 9.04% of all kinds of vegetables, as shown in the diagram MFA in Figure 1.

At farm level there is no difference between vegetable sorting for traditional markets and modern markets except the 2 types of vegetables, namely scallion and carrot. For scallion and carrot aimed at the modern market, the larger the percentage sortasinya because most of the dirty part discarded, given the modern market of consumer preferences is more complicated than the traditional market. A striking difference for sorting vegetables in the farm located at the level of grading, or sorting by a specific size. Vegetables for the modern market requires a uniform size, so some vegetables that have non-uniform size sold to the wholesale market, both Caringin Wholesale Market, Gedebage or Andir. The vegetables that go into Modern Market experienced two stages of sorting, the first sorting is done in the farm by the supplier 1 and additional sorting at the packing house is done by the supplier 2. Average sorting vegetables for supplier 1 is 10.39% and for suppliers 2 amounted to 12.85%. Based on figures such as sorting can be seen that, if 100 kg is processed by the packing house (supplier 2), it will produce as much as 12.85 kg of waste. Sorting waste generated at the upstream level are generally used as animal feed or as land fertilizer that is left in the ground. After sorting at the upstream level, vegetables for the traditional market will be sent to the wholesale market, while vegetables for the modern market that has been through the stages of packaging (supplier 2) will be directly distributed to supermarkets, hypermarkets and other modern markets in Bandung.

Based on interviews conducted randomized to 8 retailers supermarket / hypermarket in Bandung, it is known that 100% of vegetables that go into a modern market in Bandung, 97% of which will be on display while the remaining 3% will be returned because there are defects or do not qualify for a decent display criteria. Vegetables are returned in general will be waste and losses are borne by the return of packaging or suppliers 2. Vegetables do not

pass the selection which then become waste will be disposed of by the supplier 2, and is often used by people around the location of the packing house as animal feed or processed as ingredients food, because the quality is still decent returns vegetable consumption.

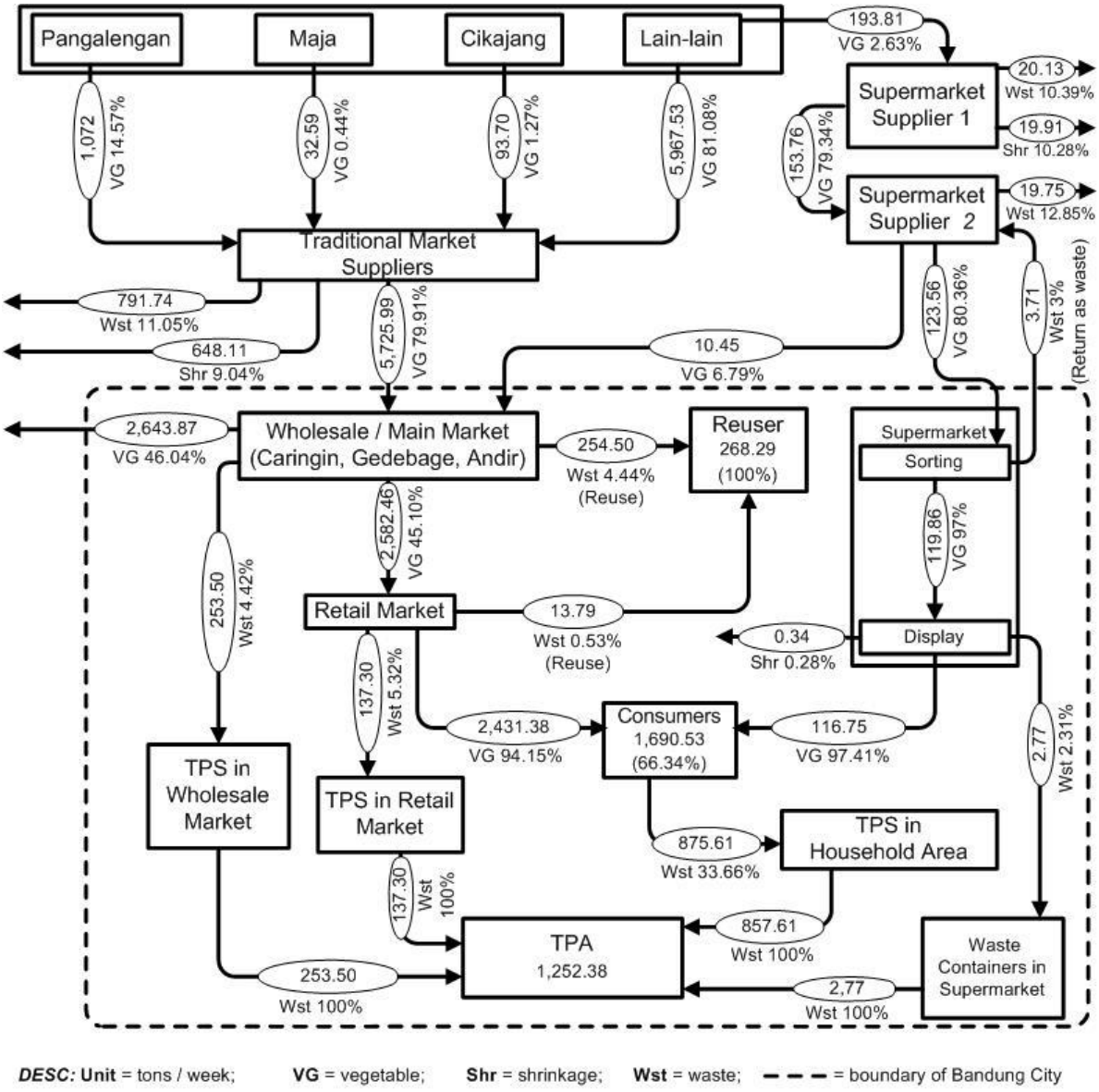

Figure 1. Material flow of vegetables in Bandung City

Based on the above it can be seen that the average percentage of sorting vegetables at the city level or suppliers ranged from 9-13%. In terms of agricultural engineering, the amount of loss due to sorting or grading process is called with post harvest losses. According Tridjaya (2005 in Haryanto and Rochani, 2006) post harvest losses for vegetable products in Indonesia on average about 9.6%. According to Choudhury (2006), some of the causes of the magnitude of post harvest losses are external factors and internal factors.

External factors such as mechanical injury among (damage due to mechanical factors)

where vegetables and fresh fruit has a soft texture and a high water content. Handling erroneous and improper packaging during transport process causes the product vegetables and fruits become discolored (bruising), cuts (cutting), crushed (breaking), and others. Other causes are diseases caused by parasites (Parasitic diseases). Vegetables infected fungi, bacteria, insects and other organisms causing post harvest magnitude lossess on vegetable products and fruits such. Microorganisms can attack the fruits and vegetables quickly due to weak natural defenses of fruits and vegetables in the tissue as well as the abundance of nutrients and moisture that support rapid growth of microorganisms (Choudhury, 2006).

In addition to external factors there are internal factors that cause waste generation in the process of sorting is physiological damage (Physiological deterioration). Tissue of fruits and vegetables is still alive after harvesting is done and continue its physiological activity. Physiological deviations occur because of a shortage of minerals, the temperature is too low or too high, or inadequate environmental conditions, such as humidity is too high. Physiological damage can also occur spontaneously due to the activity of enzymes that lead to excessive maturity (overripeness) and aging (senescence) (Choudhury, 2006). The level of sorting due to external and internal factors can be seen in Figure 2 for vegetables in traditional markets and Figure 3 for vegetables in the modern market.

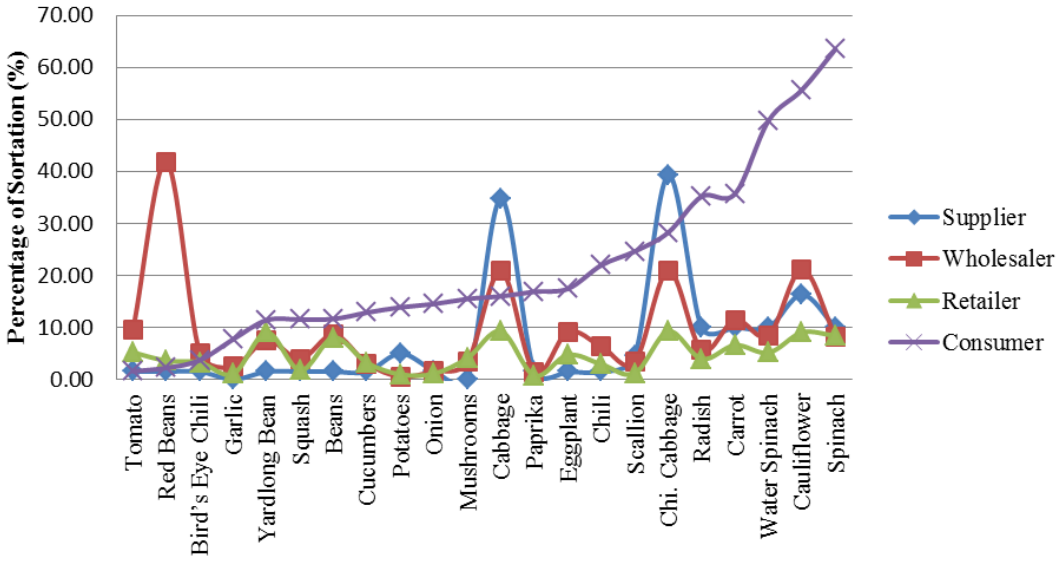

Figure 2. Variation of vegetables sorting from traditional markets, upstream to downstream.

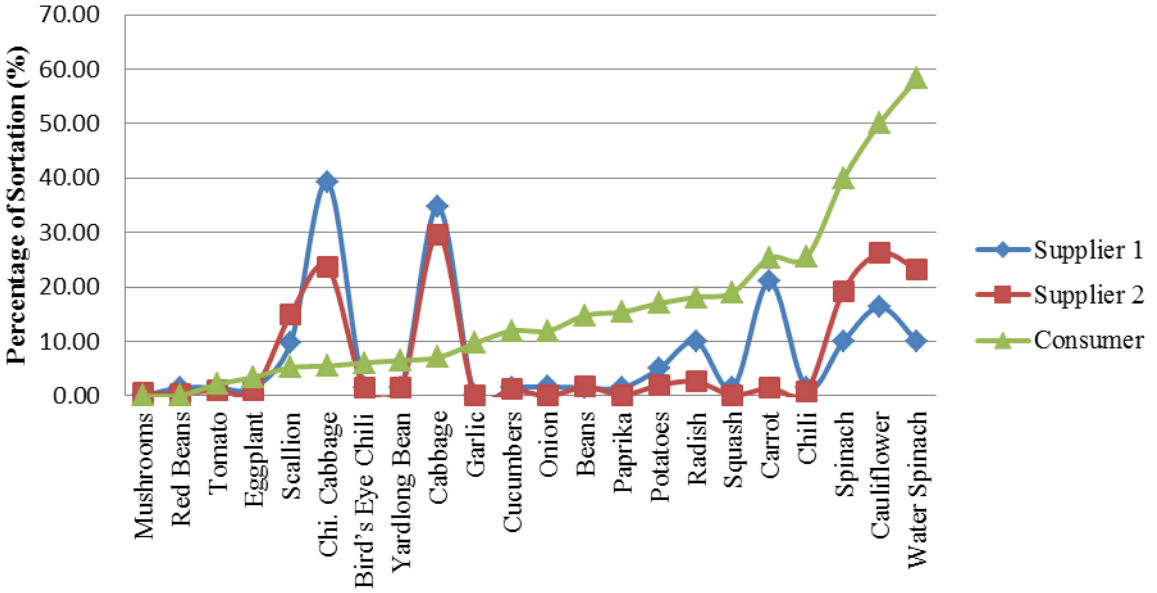

Figure 3. Variation of vegetables sorting from modern markets, upstream to downstream.

After going through various stages of sorting and trade system in the upstream chain, vegetables for the traditional market will be taken to the wholesale market (wholesaler), but the amount of vegetables that go into Bandung City is not recorded in the offices or agencies, both PD Pasar Bermartabat Kota Bandung or Dinas Pertanian Kota Bandung. Therefore, to find out how persentese and the amount of vegetables that go into markets in Bandung then conducted interviews of 100 people of the Bandung. Based on the interview, 95% of the Bandung routinely buy vegetables from traditional markets, while 5% of the modern market. This percentage is used to determine the input MFA in traditional and modern markets. Supporting the input data to determine the amount of vegetables in detail that went into Bandung City based on data vegetable consumption per capita population of Indonesia (Susenas, 2012) were converted into tons / week, after adjusting for the proportion of production - consumption and the number of people in Bandung and areas directly adjacent to Bandung City. The region is that Cimahi City, Bandung Regency and West Bandung Regency, where the majority of the retail market in the region to buy vegetables from Caringin Wholesale Market, Gedebage Wholesale Market and Andir Market, except four commodities namely beans, cucumber, water spinach and spinach.

Based on the data processing Susenas (2012) and interviews, it can be seen that the amount of vegetables that go into Bandung City is 5,845.85 tons / week. Of these, 2,643.87 tons of vegetables will go into the traditional markets outside Bandung City, 2,582.46 tons will go into the traditional market in Bandung City and 119.86 tons will enter through the modern market, such as supermarkets, hypermarkets and other. As we know that the wholesale or main market in Bandung became an intermediary distribution vegetables around Bandung City. Although these vegetables will be brought out to Bandung City, but the impact is sorting the rest of the numbers 508 tons / week will be waste in Bandung City. This number is obtained from the calculation of average sorting for vegetables at a wholesale market in Bandung, which reached 8.86% or be greater in certain seasons when certain types of

vegetable production soared and prices plummeted. From 8.86% of sorting numbers, as much as 4.42% or 253.50 tons will be transported to the landfill, while 4.44% or 254.50 tonnes will be used by reuser, such as; processing plants that process waste seasoning of garlic, red chili and bird's eye chili; as well as ruminant farmers who utilize waste sorting beans, chinese cabbage, cabbage and others, with no continuous retrieval. Vegetables rest of this sorting purchased at the price varies, from Rp 1,000 / kg to 5,000 / sacks. Based on data from PD Pasar Bermartabat Kota Bandung (2013), every day 25.25 m3 of waste generated in the Gedebage Main Market and 14 m3 of waste in Andir Market. Meanwhile, according to the data BP3C (2014) 150 m3 of waste generated from Caringin Wholesale Market. Based on these data, calculation and showed that every third week of the wholesale market produced 331.19 tons of waste. Thus, it can be seen that 76.54% of the waste generated in the three main market is derived from residual sorting vegetables.

After going through the sorting stage Caringin Wholesale Market, Gedebage Wholesale Market and Andir Market, 2,582.46 tons of vegetables that go into traditional retail markets in Bandung will experience the advanced sorting, but the sorting is not performed on all types of vegetables, but only to certain vegetables such as cabbage and chinese cabbage. Both types of vegetables are often external and internal damage after going through the distribution chain transfer or after a one-day storage period. The amount of sorting numbers for the retail market is 5.85% or 151.09 tons / week. According to FAO (2011), the percentage of vegetables waste at the distribution stage by an average of 10% for South Asia and Southeast Asia. Thus, the rate of 5.85% to 8.86% and the wholesale market for the wholesale market is still below the range of the numbers predicted by the FAO (2011). As a wholesale market, not all the waste in the retail market will end up at the polling station, because some vegetable bins will be used for reprocessing or direct use. The level of reuse vegetables waste in the retail market is 0.53% of the total vegetables that go into the retail market, or approximately 13.79 tons / week. The rest of the vegetables, amounting to 137.30 tons / week (5.32%) will end up in the TPS. Based on this amount can be seen that of 215.97 tonnes of waste generated in the retail market in Bandung City, 63.57% of which is vegetables waste.

In contrast to the traditional market, vegetables are on display in supermarkets and hypermarkets are no longer experiencing additional sorting, but during storage in the refrigerator occurred severe shrinkage due to respiration process the amount of about 0.28%. This amount is insignificant compared to loss weight loss in the wholesale market and the retail market, but the magnitude of weight loss in both traditional markets are not recorded and are difficult to measure the exact amount, so it is ignored in this study. Assumed loss does not occur in the wholesale market and retail as it has reached equilibrium moisture content (EMC) when the transport from the wholesale market to the retail market, but it is also due to their short shelf life in the traditional market in general no more than 2 days. Meanwhile, the shelf life of vegetables in the supermarket / hypermarket can reach 4 days for certain types of vegetables. Although sorting does not happen, at the end of the deadline for the sale is not all vegetables are on display in a supermarket will sold out, the remaining unsold vegetables will usually be sold cheaply to catering or food processing industry. If after low sales, there are still remaining vegetables, the vegetables will be discarded and should be categorized as wastage. The amount of wastage is based on interviews ranged between 2-5%, with an average of 2.31% or 2.77 tons / week for all supermarkets and hypermarkets in Bandung City.

At the end of the chain of transactions, both traditional and modern markets, all kinds of vegetables will end up in the consumer. Based on interviews it is known that 95% of consumers of vegetables in Bandung buy vegetables from traditional markets and the remaining 5% of the market to buy vegetables such as supermarkets and hypermarkets modern. Vegetables from the traditional markets in general have a greater percentage of waste compared to vegetables from the supermarket. From the calculation of the percentage of waste sorting vegetables from traditional markets by 21.43%, with the highest percentage of waste derived from spinach, as shown in Figure 2. Meanwhile, in Figure 3 shows that the percentage of waste vegetables from the supermarket result sorting process at the household level reached 16.05%. Based on data from FAO (2011), at the level of consumption (household), the average percentage of vegetables waste and fruits to South Asia and Southeast Asia an average of 7%. When referring to the FAO data (2011), then the percentage of vegetables waste at the household level in Bandung relatively high (above average) due to the range of percentage of vegetables waste ranged between 14-22%. In aggregate, in Figure 1 can be seen that the percentage of waste sorting vegetables at household level reached 33.66% or 875.61 tons / week. When compared with the waste generation of settlements in Bandung, which reached 4951.98 m3 / day or 8665.97 tons / week as the data PD Kebersihan Kota Bandung (2012), then the vegetables waste accounted for 10.1% of the total waste generated in settlements Bandung City. Details of the amount of waste generated by the chain vegetables vegetable trade system as a whole can be seen in Table 1. At the end of the flow in Figure 1 shows that the total amount of waste vegetables in Bandung City is 1252.38 tons / week. Meanwhile, the total amount of waste in Bandung City amounted to 7500.58 m3 / day or 13126.02 tons / week (PD Kebersihan Kota Bandung, 2012). Thus, the proportion of the total amount of vegetable waste in Bandung City is 9.54%.

Table 1. Number of vegetables and vegetables wastes in Bandung based on the transaction chain.

No.	Vegetables	The amount of introduced vegetables to Bandung		The amount of vegetables to consumer				Percentage of waste vegetable Total	
		Traditional Market	Modern Market	Traditional Market		Modern Market			
		(tonne)	(tonne)	(tonne)	(%)	(tonne)	(%)	(tonne)	(%)
1.	Onion	402.51	6.38	24.74	1.67	0.86	2.47	25.60	1.69
2.	Garlic	152.61	2.52	7.59	0.51	0.29	0.82	7.87	0.52
3.	Scallion	326.02	4.15	35.22	2.37	0.30	0.85	35.52	2.34
4.	Potatoes	329.98	5.66	16.29	1.10	1.04	2.96	17.32	1.14
5.	Cabbage	501.73	5.46	133.19	8.98	0.49	1.39	133.68	8.80
6.	Chi. Cabbage	216.92	1.98	63.46	4.28	0.15	0.42	63.61	4.19
7.	Carrot	225.28	2.69	49.82	3.36	0.70	2.01	50.52	3.33
8.	Yardlong Bean	255.10	11.32	65.07	4.39	0.95	2.71	66.01	4.35
9.	Chili	328.48	5.25	43.33	2.92	1.38	3.95	44.71	2.94
10.	Tomato	241.33	3.49	27.21	1.83	0.15	0.42	27.36	1.80
11.	Eggplant	534.18	6.63	79.95	5.39	0.36	1.04	80.31	5.29
12.	Beans	202.72	2.96	27.98	1.89	0.48	1.38	28.46	1.87

No.	Vegetables	The amount of introduced vegetables to Bandung		The amount of vegetables to consumer				Percentage of waste vegetable Total	
		Traditional Market	Modern Market	Traditional Market		Modern Market			
		(tonne)	(tonne)	(tonne)	(%)	(tonne)	(%)	(tonne)	(%)
13.	Cucumbers	103.66	5.36	18.88	1.27	0.73	2.07	19.60	1.29
14.	Water Spinach	521.56	30.37	294.01	19.82	17.40	49.73	311.41	20.50
15.	Spinach	689.73	19.58	478.27	32.23	7.81	22.32	486.07	32.01
16.	Red Beans	47.21	0.43	20.22	1.36	0.01	0.03	20.23	1.33
17.	Squash	172.43	2.98	13.29	0.90	0.60	1.72	13.89	0.91
18.	Radish	88.17	1.06	14.46	0.97	0.21	0.59	14.67	0.97
19.	Cauliflower	152.71	1.64	53.94	3.64	0.81	2.32	54.75	3.61
20.	Bird's Eye Chili	204.95	3.24	14.42	0.97	0.26	0.74	14.68	0.97
21.	Mushrooms	22.74	0.30	2.02	0.14	0.01	0.02	2.03	0.13
22.	Paprika	5.97	0.10	0.39	0.03	0.02	0.05	0.41	0.03
	Total	5,725.99	123.56	1,483.7	100	34.99	100	1,518.72	100

CONCLUSIONS

The vegetables that go into Bandung City through two distribution channels or 2 chain trade system, namely traditional market distribution and modern market distribution. Based on the analysis of material flow to the 22 main types of vegetables consumed in Bandung can be seen that from the input of 5725.99 tons / week of vegetables through traditional markets and 123.56 tons / week of vegetables through modern market generated total vegetable wastes 1252.38 tons / week in Bandung, or 9.54% of the total waste generated 13126.02 tons in Bandung City each week from various sources.

REFERENCES

Badan Pusat Statistik. (2013). *Kota Bandung Dalam Angka*. Bandung: Badan Pusat Statistik Kota Bandung.

Buzby, Jean C., Jeffrey Hyman, Hayden Stewart, and Hodan F. Wells. (2011). *The Value of Retail- and Consumer-Level Fruit and Vegetable Losses in the United States*. The Journal of Consumer Affairs, Fall 2011**: pp 492–515.**

Choudhury (2006). *Recent Developments In Reducing Post Harvest Losses In The Asia-Pacific Region* (In) *Post Harvest Management of Fruit and Vegetables in the Asia-Pacific Region*. Reports of the APO seminar on Reduction of Post Harvest Losses of Fruit and Vegetables held in India, 5–11 October 2004 and Marketing and Food Safety: Challenges in Post Harvest Management of Agricultural/Horticultural Products in Islamic Republic of Iran, 23–28 July 2005. Rome: Asian Productivity Organization (APO).

Damanhuri, Enri. (2008). *A Future of Municipal Solid Waste Management in Indonesia*. Keynote Lecture to the 5th Asian-Pasific Landfill Symposium in Sapporo, Japan, October 22 (Wed)-24(Fri), 2008.

Faramita, Nadia dan Benno Rahardyan. (2007). *Evaluasi Aliran Material Sampah Daur Ulang (Plastik, Kertas, Logam) Kota Bandung*. Lingkungan Tropis, Edisi Khusus Agustus 2007: 195 – 203.

Food and Agriculture Organization (FAO). (2011). *Global Food Lossess and Food Waste: Extent, Causes, and Prevention*. Study conducted for the International Congress "SAVE FOOD!"at Interpack, Düsseldorf, Germany. Rome: Food and Agriculture Organization of The United Nations.

Haryanto, Bambang dan Andjar Rochani. (2006). *Post Harvest Management of Fruit and Vegetables in the Asia-Pacific Region: Indonesia (2).* Reports of the APO seminar on Reduction of Post Harvest Losses of Fruit and Vegetables held in India, 5–11 October 2004 and Marketing and Food Safety: Challenges in Post Harvest Management of Agricultural/Horticultural Products in Islamic Republic of Iran, 23–28 July 2005. Rome: Asian Productivity Organization (APO).

Muhammad, R.H., G.C. Hionu, F.F. Olayemi. (2012). *Assessment of The Post Harvest Knowledge of Fruits and Vegetable Farmers in Garun Mallam L.G.A of Kano, Nigeria*. International Journal of Development and Sustainability, Volume 1 Number 2 (2012): **pp 510-515**.

Muthy, MRK., GP Reddy and KH Rao. (2014). *Retail Marketing of Fruits and vegetables in India: A Case Study on Export of Grapes from Andhra Pradesh, India*. European Journal of Logistics Purchasing and Supply Chain Management, Vol. 2, No. 1, **pp 62-70**, March 2014.

Nareta, Furinaka dan Enri Damanhuri. (2014*). Inventarisasi Dampak Gelas Polypropylene (PP) Air Minum dalam Kemasan (AMDK) pada Kegiatan Recycling Sektor Informal di Kota Bandung*. [Tesis]. Bandung: Program Studi Teknik Lingkungan, Institut Teknologi Bandung.

Osman, Azizah, Nazamid Sari, Rosli Saleh, Jamilah Bakar, Noor Diana Zainal, Masturina Yacob. (2009). *Post Harvest Handling Practices On Selected Local Fruits and Vegetables at Different Levels of The Distribution Chain*. Journal of Agribusiness Marketing, Vol. 2, **pp 39 – 53**, 2009.

PD Pasar Bermartabat Kota Bandung. (2013). *Rekap Jumlah Pedagang dan Jenis Komoditi*. Perusahaan Daerah Pasar Bermartabat Kota Bandung.

Sharma, Gaurav and S.P. Singh. (2011). *Economic Analysis of Post Harvest Losses in Marketing of Vegetables in Uttarakhand*. Agricultural Economics Research Review Vol. 24 July-December 2011 **pp 309-315**.

Survei Sosial Ekonomi Nasional (Susenas). (2012). *Survei Sosial Ekonomi Nasional Tahun* 2012. Jakarta: Biro Pusat Statistik.

Utama, I Made S., dan Nyoman S. Antara. (2013). Pasca Panen Tanaman Tropika: Buah dan Sayur. *Tropical Plant Curriculum Project*. Denpasar: Universitas Udayana.

Wadhwa, M., and M.P.S. Bakshi. (2013). *Utilization of Fruit and Vegetable Wastes as Livestock Feed and as Substrates for Generation of Other Value-Added Products*. Rome: Food and Agriculture Organization.

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THE DEVELOPMENT OF PAVEMENT USING TITANIUM DIOXIDE FOR REDUCTION OF NO_X GAS IN THE AIR

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Abstract: Urban air pollution, with its long- and short-term impact on human health, well-being and the environment, has been a widely recognised problem over the last 50 years. Fuel gases from combustion in motor vehicles, such as nitrogen oxides (NO_x) will be emitted to the ambient air.Nitrogen oxides such as nitric oxides(NO) and nitrogen dioxide (NO_2) are important air pollutants, because they have significant harm to human health and play an important role of being precursor of another dangerous pollutants such as formation of photochemical smog. Anthropogenic activities hold biggest responsibilities for the increasing of NO_x concentration in the ambient air. To anticipate the rapid increase of NO_x concentration, it is important to develop an alternative technology in NO_x abatement.The photocatalytic process using uv light and semiconductor particles is a promising alternative of NO_x abatement. In fact, treatment of pollutants related to environmental problems through photoassisted catalyst has been a much discussed topic in today's literatures, since efficient utilization of solar light for various emission control processes can save the consumption of fossil fuels.Pavementcoated TiO_2anastasewith content of pure TiO_2 of 98.82% at composition of 0.02 g/cm^2 in the photoreactor which flowed by NO_x gas at concentration of 0.327 ppm-0.680 ppm exposed to uv light intensity from 47.9 to 59.0 µW / cm ² within 6 hours, 12 hours, 18 hours and 24 hours. Nitrate and nitrite ions are formed by the photocatalytic paving surface which is diluted with distilled water then measured by ion chromatography. The optimal efficiency of NO_xremoval in this research was 45% which occurred at 18 hours of exposure at 68% -74% humidity. While the resulting of adsorption rate was ranged at 10.932 mg/m^2/day - 19.398 mg/m^2/day, increasing the concentration of NO_3^-in line with the duration of exposure.

Keywords: nitrogen oxides (NO_x), pavement, titanium dioxide (TiO_2), nitrate ion, nitrite ion.

INTRODUCTION

Urban air pollution, with its long- and short-term impact on human health, well-being and the environment, has been a widely recognised problem over the last 50 years. (Gurjar*et. al*., 2008).The Increasingnumber in using motor vehicle as a transportation that use fuel oil (fossil fuels) which produces emissions to be one of factor in the negative impact of air pollution on the environment. Air pollution from the transportation sector in the form of motor vehicle fuel oil (fossil fuels) is triggered again with the higher of amount of fuel use, to be the cause of the air pollution caused by motor vehicle use (Chen *et. al*., 2008). Air pollution from motor vehicles occurred in most of the major cities in Indonesia, one of the city is Jakarta. Contamination that occurred in the Greater Jakarta area alone as much as 85% -90% due to motor vehicle exhaust gas residual as shown by **Table 1**.

Table 1. The Results of Emissions Inventory (Darmanto and Asep, 2011)

Area	Sector	SO_2	NO_2	CO
		Ton/year		
Jakarta	Transportation	21.73%	92.27%	99.94%
	Industry	78.22%	7.63%	0.01%
	Household	0.05%	0.09%	0.03%
	Agriculture	0.00%	0.00%	0.02%
	Total	100%	100%	100%
Bodetabek	Transportation	46.22%	85.79%	93.12%
	Industry	50.15%	13.19%	0.00%
	Household	0.81%	0.62%	0.15%
	Agriculture	2.82%	0.39%	6.73%
	Total	100%	100%	100%

Motor vehicles will emit various gases and particulates consisting of organic and inorganic components that are readily inhaled by humans. Motor vehicle emissions are dangerous because they tend to have a larger fraction and the emissions generated in the middle of bustling urban population (Nasser *et. al*., 2009). Emissions from transportation activity in general are a gas that produced by the combustion process, one of them in the form of nitrogen oxides (NO_x).

Nitrogen oxides (NO_x) is a gaseous compound which is contained in the air (atmosphere) which largely consists of nitric oxide (NO) and nitrogen dioxide (NO_2) and various types of oxides in smaller amounts. Both of these gases have very different properties and both are very harmful to health (Ballari *et. al*., 2010 (a)). NO_x is produced when the fuel burn at high temperatures, in the exhaust gas. Nitrogen oxide (NO) is produced from the burning of waste transportation and will soon be oxidized in the atmosphere to form NO_2 (Parra and George, 2005).

One way to anticipate a rapid increase in levels of NO_x emissions caused by motor vehicles, namely the development of alternative technologies that are placed as close as possible to the source so the number of NO_x released into the air by the antopogenik activity levels are not dangerous. Contact between motor vehicle emissions with the road surface, then the photocatalytic compounds such as TiO_2 can be used for manufacture of pavement that can be used as an air pollution control is done by coating TiO_2 on the surface of the pavement (Hassan *et. al*., 2012).

NO_xremoval through photocatalytic oxidation of NO to NO_3^-or NO_2^-which is not dangerous by semiconductor particles (TiO_2) is a process that is quite beneficial because it can avoid the use of fossil fuels and the use of additional reactants such as ammonia or ozone (Shen *et. al*., 2012) . Schematic process that occurs in the TiO_2 photocatalytic can be seen in **Figure 1**.

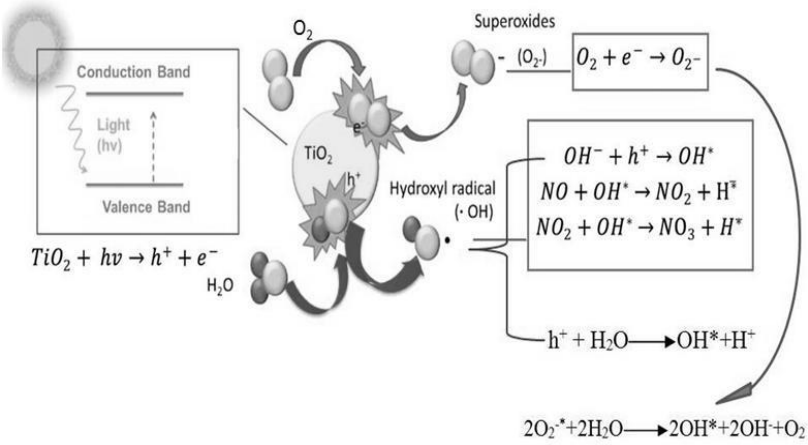


Figure 1. Process Schematic on the Photocatalytic TiO_2 (Dylla *et. al*., 2011)**.**

The illumination of TiO_2 with light of wavelength less than 400 nm generates excess electrons in the conduction band (e-) and positive holes (h) in the valence band.

$TiO_2 + hv \longrightarrow Oh^+ + e^-$ **(1)** (Folli *et. al*., 2010)

Holes react with either physisorbed H_2O or chemisorbed OH^- groups to form hydroxyl radicals (OH*).

$h^+ + H_2O \longrightarrow OH^* + H^+$ atau **(2)** (Ballari *et. al*., 2010(b))

$h^+ + OH^- \longrightarrow OH^*$ **(3)** (Ballari *et. al*., 2010(b))

Excess electron in the conduction band might probably react with molecular oxygen to form superoxide ions.

$e^- + O_2 \longrightarrow O_2^{-*}$ **(4)** (Ballari *et. al*., 2010(b))

Which can further disproportionate to form more OH* radicals.

$2O_2^{-*} + 2H_2O \longrightarrow 2OH^* + 2OH^- + O_2$ **(5)** (Ballari *et. al*., 2010(b))

The OH* radicals are extremely reactive and readily attack NO_x molecules to form NO_3^- and NO_2^- ions (Beelden, 2008).

$NO_2 + OH^* \longrightarrow NO_3^- + H^+$ **(6)** (Beelden, 2008)

$NO + OH^* \longrightarrow NO_2^- + H^+$ **(7)** (Beelden, 2008)

According to Fujushima and Zang, 2006, in Hasan *et. al*., 2012, photocatalytic compounds can significantly reduce NO_x. The use of compounds on the surface of photocatalytic pavement for its existence close to the source of pollution is a promising technology. However, the application of technology for the manufacture of environmentally friendly pavement is still in its infancy and there are many environmental factors, design, and operational factors that still need to be evaluated. In addition, many factors have not been studied as the effects of exposure time and photocatalytic regeneration compounds on NO_x removal efficiency.

The purpose of this study is as one of the alternative friendly technology development environmentally, which can be applied to reduce the air pollution is mainly generated by the transportation sector. Installation of pavement using a catalyst-coated titanium dioxide (TiO_2) in the upper part is expected to make a significant contribution in reducing the concentration of pollutant gases, especially NO and NO_2. While the objectives of this research which are determine the effect of variations in the time of exposure ultraviolet (UV) to the NO_x removal

efficiency, determine the effect degeneration on the photocatalytic compound to NO_x removal efficiency and mass of NO_xremoval compares to the formation of new compounds in the form of nitrate and nitrite compounds through calculation mass balance.

METHODOLOGY

Based on previous research that have been done by Hassan *et al*. (2010), Dylla *et al*. (2011) andOsborn(2012), the photoreactor used in this study form a box that is equipped with inlet and outlet ports that serve as sampling for measuring the concentration of NO_x. According to research Fujishima et. al. 2000 in Dylla et. al., 2011, stated that the process by photocatalytic TiO_2, the smaller wavelength of 400 nm is required for irradiation. Higher intensities more photons are produced, that increase the rate of oxidation fotokatalitiknya. In accordance with that statement, the ultraviolet light source used in this research was a black light uv lamp with a power of 20 watts, 220V with a maximum wavelength of 352 nm. UV lamps totaling 8 pieces placed on top of the inner wall of the reactor in such a way as to allow ultraviolet light to the entire surface of the pavement underneath. UV light intensity at the reactor has range between 47.9 - 59.0 $\mu W/cm^2$. The light source is in the photoreactor can cause heat inside. To reduce the temperature increase in the need to be equipped with a fan that serves as a cooling device (Hunger *et. al*., 2008). A fan placed in the photoreactor than as a coolant also serves as an agitator air flow so that the concentration of NO_x in the photoreactor spread evenly. Specifications photoreactor used in this study can be seen in **Figure 2** below with illustrations contained in **Figure 3**.

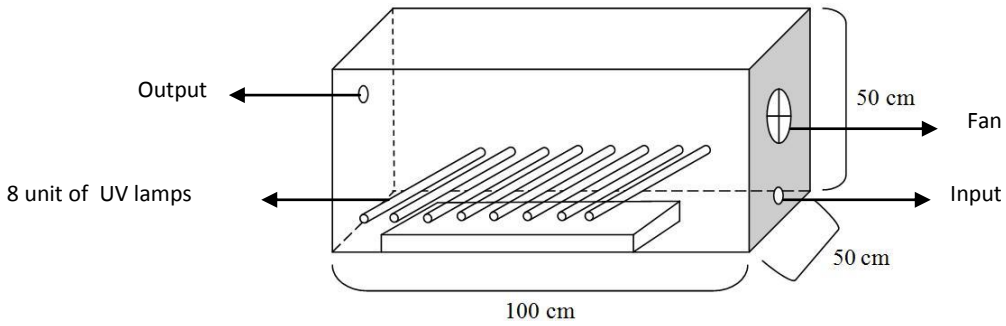


Figure 2. Spesificationof Reactor

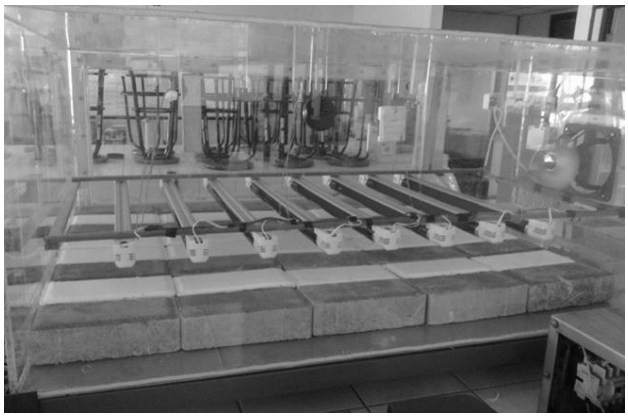
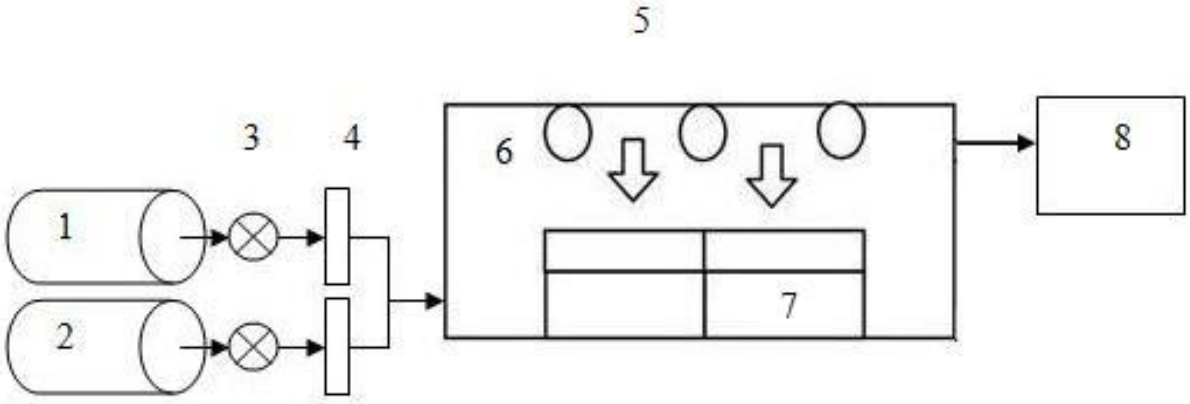


Figure3. Photoreactor

In a research of photocatalytic in laboratory scale required equipment as follows: NO_x sources, photoreactorand a NO_x analyzer (Dylla *et. al*., 2011). The resulting concentration of NO_x in the gas container is still very high so it needs to be diluted with ambient air. Flowmeter necessary as controlling the flow rate into the photoreactor in order to obtain the desired discharge. NO_x in the gas container and the ambient air is pumped into the photoreactor with each discharge of 0.4 L / min and 20 L / min. NO_x gas concentration after passing through photoreactor be measured continuously every 30 minutes by the method of Griess-Saltman-spectrofotometri. Reactor can be seen by the circuit schematic in **Figure 4**.



Description:

1. Sources of NO_x gas
2. Sources of diluent gas
3. Air pump
4. Flowmeter
5. TiO_2- photocatalytic reactor
6. UV lamp
7. Pavementcoated TiO_2
8. Griess method-Saltman-spectrofotometri

Figure 4. Schematic of Photocatalytic Reactor for Researching NO_xAbatement by the PavementCoated TiO_2

Variations used in this research includes the time of exposure to UVdevided into 6 hours of exposure, 12 hours of exposure, 18 hours of exposure and 24 hours of exposure. This variation of the exposure time aims toobserve thedegeneration.

The type of Titanium dioxide as a catalyst used in this research are anatase, anatase has been chosen because this type is the best of the three existing types of TiO_2. Purity of TiO_2 used to reach 98.82% with a particle size of 0.32 µm. Specifications TiO_2 used in this research are shown in **Table 2**.

Table 2. TiO_2 Specifications (Brataco Chemical)

Item	Specsification	Result
TiO_2 (purity)	98.00 % - minimum	98.82
Particle size	0.3 ± 0,05 - µm	0.32
Tinting Strength of Reynolds	1280 – minimum	1280
Oil Absorption	25 ml/100g - maximum	21.2
Residue (325 Mesh)	0.015 % - maximum	0.014

TiO_2 layer on the surface of pavement consists of a mixture of anatase TiO_2 powder, water based resin and water with composition of 4 grams: 2mL: 4mL. Water-based resin used as glue on the surface so TiO_2 can stick to pavement. In a research laboratory scale about photocatalytic require equipment including: sources of NO_x, photoreactor, and a NO_x analyzer (Dylla et. al., 2011). The research design is shown in **Figure 5**.

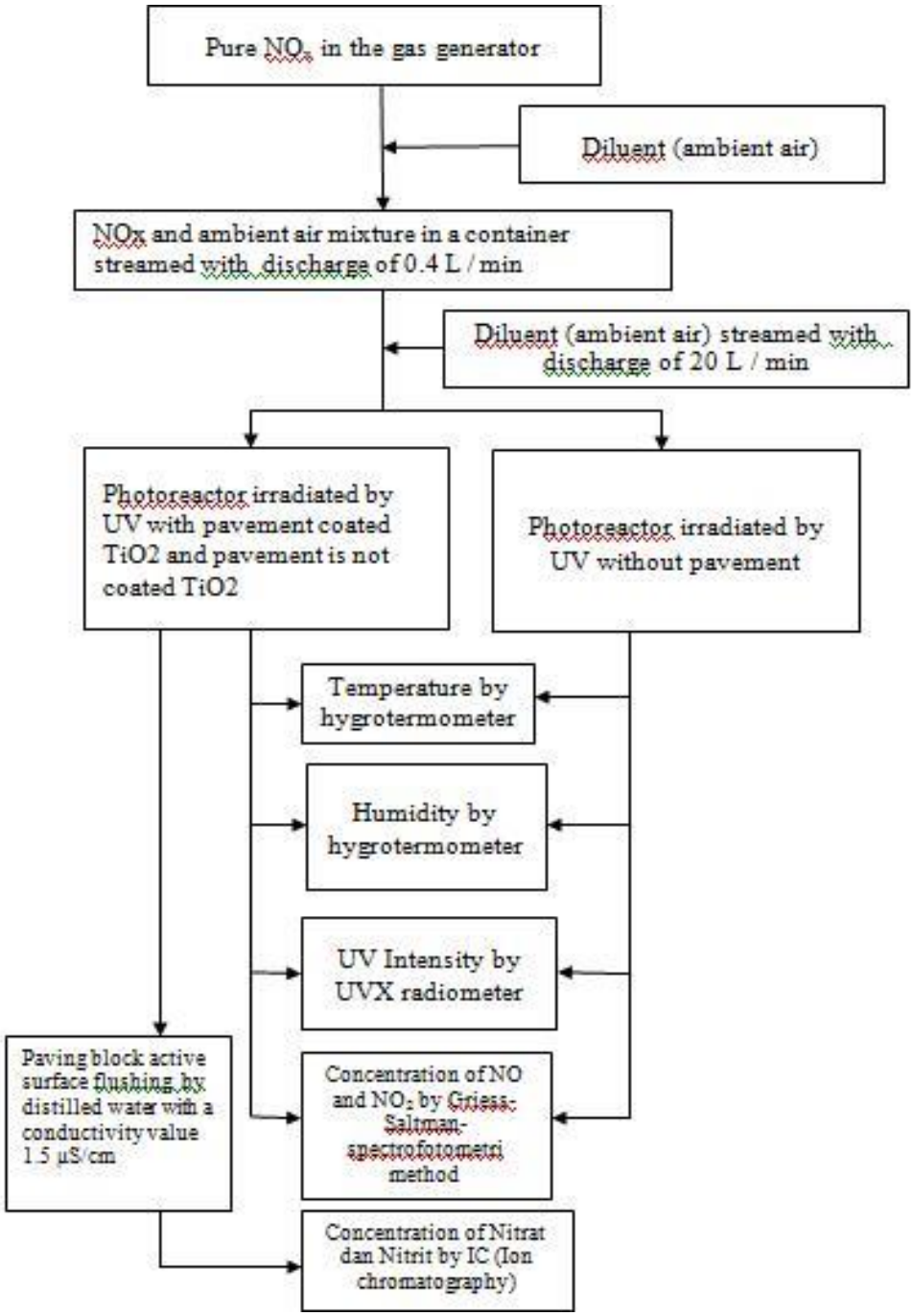


Figure5. The Design of Research

To get the adsorption rate of nitrate ions and nitrite ions from the photocatalytic pavment in units mg/m^2/menit, determined by using the following equation:

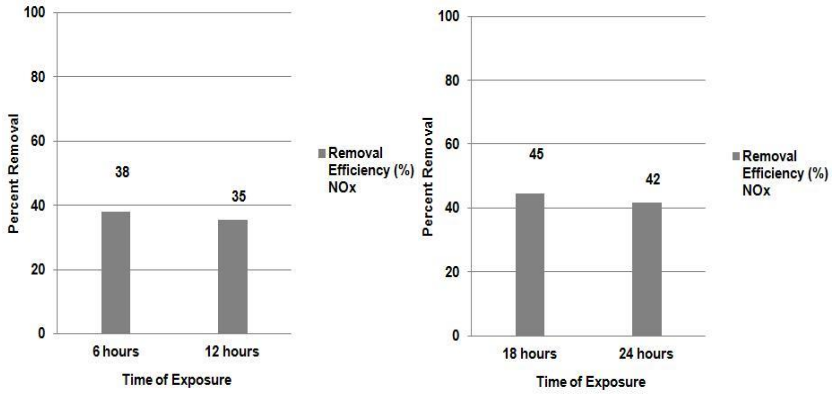
$$\text{Adsorption rate} = (T - B) \times \frac{V_{water}}{A \times t}$$ **(Equation1)**(Khair, 2013)

where,

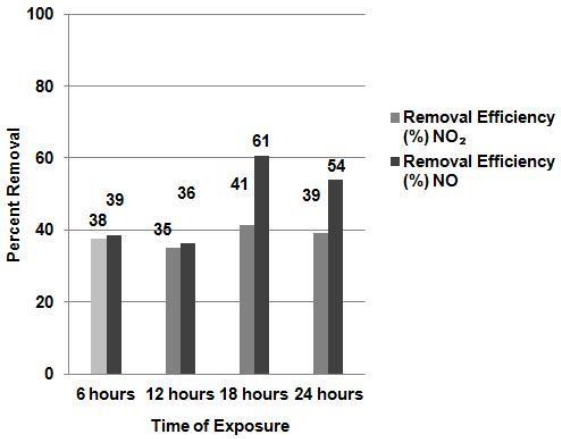
T is the concentration of ions in the TiO_2-coated pavement after exposure (mg / L)
B is the concentration of ions in the TiO_2-coated pavement before exposure (mg / L)
V_{water} is the amount of water used in flushing (L)
A is the active surface area of pavment (m^2)
t is the exposure time pavment (day)

RESULTS AND DISCUSSION

There are many factors that affect the efficiency of the photooxidation, one of them is the possibility of degeneration in photocatalytic properties. It seen at 6 hours of exposure time compared to 12 hours of exposure time whereas 18 hours of exposure time compared to 24 hours of exposure time which each can be seen in **Figure 6 (a)** and **Figure 6 (b)**. From **Figure 6 (a)**appears that there has been a decline of 3% between 6 hours of exposure time and 12 hours of exposure time. The same pattern also occurs in **Figure 6 (b)**. According to Sleiman *et. al*., 2009 in Dylla *et. al*., 2011, stated that the degeneration and accumulation of this product is the result of a function of time and concentration of pollutants.



(a) NO_xRemovalEfficiency per $m^2$of Pavement**(b)**NO_xRemovalEfficiency per $m^2$of Pavement at the Exposure Time 6 and 12 Hoursat the Exposure Time 18 and 24 Hours



(c)NO_2 and NORemovalEfficiency per $m^2$of Pavement

Figure 6. RemovalEfficiencyof Pollutan Gas by Photocatalytic Pavement

Effect of uv on gas removal efficiency of NO_2 and NO gas can be clearly seen from **Figure 6 (c)**. This is reflected in NO removal efficiency which has greater value than NO_2 removal efficiency. NO gas will oxidize to form NO_2 if illuminated by uv light. Equation is as follows:

$N_2 + O_2 \longrightarrow 2NO$ (Dylla *et. al*., 2011)

$2NO + O_2 \longrightarrow 2NO_2$ (Dylla *et. al*., 2011)

Oxidation process by the amount of oxygen that is also contributing to the reduction ofNO. When sunlight (source of uv) is available, NO_2 will undergo photolysis reactions and form O_3.

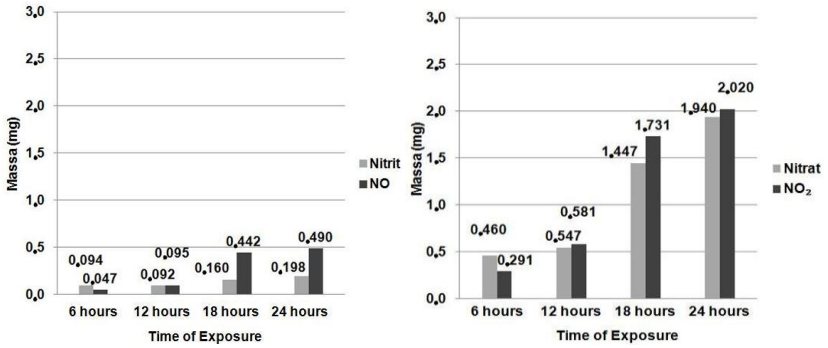
$NO_2 + hv \rightarrow NO + O$ (Dylla *et. al*., 2011)

$O + O_2 + M \rightarrow O_3 + M$ (Dylla *et. al*., 2011)

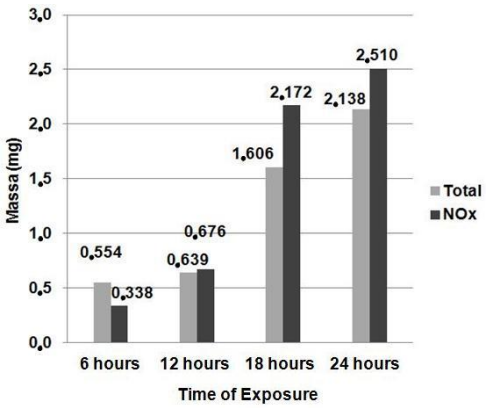
M may be either N_2 or O_2 or other third molecule will absorb excess energy, thus stabilizing the O_3 formed. At the time of O_3formation, reaction with NO to form NO_2 by the following equation:

$O_3 + NO \rightarrow NO_2 + O_2$ (Dylla *et. al*., 2011)

Mass balance in the photocatalytic reactor can be evaluated from the mass elimination of NO_x and the formation of new compounds in the form of nitrate and nitritcompounds. Formation of nitrite and nitrate by hydroxyl ions can be seen in the equation **(6)** and **(7)**.



(a) Mass of Nitrit ion (NO_2^-) and NO (b) Mass of Nitrat ion (NO_3^-) and NO_2



(c) Total Mass and NO_x

Figure 7. Mass Balance

From **Figure 7 (a**), **Figure 7 (b)** and **Figure 7 (c)** shows that the difference between input and output mass covering NO_x, NO and NO_2, have a greater value than the mass that formed after the reaction include nitrite ion (NO_2^-), nitrate ion (NO_3^-) and total mass (mass of $NO_2^-$and NO_3^-). Presence of oxidation-reduction mechanisms which can occur on the surface of TiO_2 illuminated by UV cause equilibrium of the mass balance equation can not be obtain, because the detection of the formation of new compounds is only performed on the results of the oxidation reaction. The formation of new compounds in the form of N_2O can not be done because of limited gas detectors available. Therefore there are a number of missing mass that formed to nitrite or nitrate as a result of a number of NO or NO_2abatement, due to limited gas detectors are available.

To get the adsorption rate of nitrate ions and nitrite ions from the coated TiO_2 photocatalytic pavmentin units mg/m^2/day, determined by using **Equation 1**. Data of load abatement can be seen in **Table 3**.

$$\text{Adsorption rate} = (T - B) \times \frac{V_{water}}{A \times t}$$

$$\text{Adsorption rate} = (0.460 - 0) \times \frac{2}{0.2 \times 0.25} = 18.386 mg / m^2 / day$$

Table 3. The Calculation of Photocatalytic Adsorption Rate on TiO_2 Coated Pavement

Exposure time (hours)	UV intensity µW/cm²	Humidity (%)	Application	NO3- on Pavement with TiO_2 before Exposure (ppm)	NO3- on Pavement with TiO_2 after Exposure (ppm)	Surface Area (m²)	Vol. Diluent	Time (day)	Adsorption Rate $NO3^-$
6	47.9-59.0	65-75	paving	0	0.460	0.2	2	0.25	18.386
12	47.9-59.0	65-75	paving	0	0.547	0.2	2	0.5	10.932
18	47.9-59.0	68-74	paving	0	1.447	0.2	2	0.75	19.289
24	47.9-59.0	68-74	paving	0	1.940	0.2	2	1	19.398

The highest adsorption rate occurs in the 24-hour measurement of exposure time, with a value of 19.938 mg/m^2/day and the lowest adsorption rate of 10.932 mg/m^2/day. If the results of this research compared with the few research that have been conducted by other researcher, it can be said that the results of this research are quite promising. However, several aspects need to be repaired again linked pavement coated TiO_2 and apply the mixture used. In **Table 4** are presented the results of photocatalytic TiO_2 comparison of data from several studies.

Table 4. Comparison of Photocatalytic TiO2 from Multiple Research.

Data Source	UV intensity	Humidity	Application	Adsorption rate
Maggos, et. all., 2007	1 W/cm^2	20 %	Paint	13.824 mg/m^2/day
Maggos, et. all., 2005	0.21 mW/cm^2	50 %	Paint	0.21 mg/m^2/ day
Yu, 2002	0.9 mW/cm^2	25 %	*Pavement*	230 mg/m^2/ day
Khair, 2013	71.82 µW/cm^2	45%	*Pavement*	6.624 mg/m^2/ day

Penelitian ini	**47.9-59 µW/cm^2**	**65-75 %**	*Pavement*	**19.398 mg/m^2/** day

CONCLUSION

The experimental results showed that the photocatalytic process has occurred in pavement coated with titanium dioxide (TiO_2) with a purity of 98.82% anastase much as 0.02 g/cm^2 in the photoreactor which flowed gas at a concentration of 0.327 ppm-0.680 ppm exposed to uv light with intensity 47.9 to 59.0 µW/cm² within 6 hours, 12 hours, 18 hours and 24 hours. This is indicated by the amount of NO_xremoval optimal efficiency in this research that reached 45% which occurred at 18 hours of exposure at 68% -74% humidity. Decrease in gas NO_x removal efficiencies indicate that there has been a degeneration and accumulation of products in the photocatalytic surface that occurs as a result of a function of time and concentration of pollutants.Presence of oxidation-reduction mechanisms which can occur on the surface of TiO_2 illuminated by UV cause equilibrium of the mass balance equation can not be obtain, because the detection of the formation of new compounds is only performed on the results of the oxidation reaction. While the resulting adsorption rate was ranged10.932 mg/m^2/day - 19.398 mg/m^2/day, the increasing concentration of $NO_2^-$and NO_3^-as the exposure time.

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References

Ballari, M. M., M. Hunger, G. Husken, and H.J.H. Brouwers. 2010.(a) Modelling and Experimental Study of the NO_x Photocatalytic Degradation Employing Concrete Pavement with Titanium Dioxide. *Catalysis Today*,**151**: 71-76.

Ballari, M. M., M. Hunger, G. Husken, and H.J.H. Brouwers. 2010.(b) NO_x Photocatalytic Degradation Employing Concrete Pavement Containing Titanium Dioxide. *Journal of Aplplied Catalysis B: Environmental*,**95**: 245-254.

Beeldens, A. 2008. *Air purification by pavement blocks: final results of the research at the BRRC.* Transport Research Arena Europe, Ljubljana.(http://www.brrc.be/pdf/tra/2008_Beeldens.pdfaccessible on april 15, 2013)

Chen,H., Namdeo, A., Bell, M., 2008, Classification of Road Traffic and Roadside Pollution Concentrations for Assessment of Personal Exposure. *Environmental Modelling & Software*,**23**: 282-287

Darmanto, Nisrina Setyo dan Asep Sofyan. 2011. *Analisis Distribusi Pencemar Udara NO_2, SO_2, CO, dan O_3 di Jakarta dengan WRF-CHEM*. Undergraduate thesis. Environmental Engineering FTSL ITB.

Dylla, H., Hassan, M.M., Schmitt, M., Rupnow, T., Mohammad, L.N., Wright, E. 2011. Effects of Roadway Contaminants on Titanium Dioxide Photodegradation of Nitrogen Oxides. *Journal of the Transportation Research Record*, Washington D.C., **2240**: 22-29.

Folli, Andrea and Donald E. Mac phee. 2010.Photocathalytic Cement: Influence of TiO_2Particle Size on Photocatalytic Performance,presentedon*The 8th FIB PhD symposium in civil engineering*, 20-23 Juni 2010.

Khair, Hafizul. 2013. *Pemanfaatan Titanium Dioxide pada Trotoar untuk Mengurangi Gas Pencemar NO_x di Udara*. G*raduate thesis*. Environmetal engineering FTSL ITB.

Hassan, Marwa, Somayeh Asadi, John T. Kevern and Tyson Rupnow. 2012. Nitrogen Oxide Reduction and Nitrate Measurements on TiO_2 Photocatalytic Pervious Concrete Pavement. *Construction Research Congress 2012 © ASCE 2012*: 1920-1930.

Hunger, M.; Husken, G.; and Brouwers, Jos. 2008. Photocatalysis applied to concreteproducts, Part 1: Principles and test procedure. *Materials Science, ZKG International*, **61**: 77-85.

Khair, Hafizul. 2013. *Pemanfaatan Titanium Dioxide pada Trotoar untuk Mengurangi Gas Pencemar NO_x di Udara*. Thesis. Teknik Lingkungan FTSL ITB.

Maggos T., Plassais A., Bartzis J., VasilakosC., Moussiopoulos N., Bonafous L. 2005. Photocatalytic Degradation of NO_xin a Pilot Street Canyon Configuration Using TiO_2 -Mortar Panels, 5thInternational conference on urbain air qualityn Valencia, Spain, 29-31 March 2005, Picada section.

Maggos, Th, J.G Bartzis, M Liakou, dan C Gobin. 2007. Photocatalytic Degradation of NO_xUsing TiO_2-Containing Paint: A real scale study.*Journal of Hazardous Materials*,**146**: 668-673.

Naser,T.M., Isao Kanda, Toshimasa Ohara, Kazuhiko Sakamoto, Shinji Kobayashi, Hiroshi Nitta, and Taro Nataami. 2009. Analysis of Traffic-Related NO_x and EC Concentrations at Various Distances from Major Roads in Japan, *Journal ofAtmospheric Environment*,**43**: 2379–2390.

Osborn, David James. 2012. Quantifiqation of NO_x *Reduction Via Nitrate Accumulation on a TiO_2 Photocatalytic Concrete Pavement*. Thesis. B.S. Lousiana State University, Lousiana.

Parra,J., and George, L. 2005. Performance and Application of an Inexpensive Method for Measurement of Nitrogen Dioxide, Portland State University, (http://www.mcnairprogram.pdx.edu/OnlineJournal 20200405, accessible on June 20, 2013).

Shen, S, B Maria, J Bertram, dan H Liv. 2012. Pervious Concrete with Titanium Dioxide as a Photocatalyst Compound for a Greener Urban Road Environment. *Construction dan Building Materials*,**35**: 874-883.

Yu, Jimmy Chai-Mei. 2002. *Ambient Air Treatment by Titanium Dioxide (TiO_2) Based Photocatalyst in Hong Kong*.AS: Environmental Protection Department. (http://www.epd.gov.hk/epd/tc_chi/environmentinhk/air/studyrpts/files/finalized_technical_report.pdfaccessible on June 25, 2013)

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ANALYTIC HIERARCHY PROCESS FOR THE EVALUATION OF TRANSPORT POLICIES IN BANDUNG CITY

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Abstract: Increased of amounts vehicles in every year can be problems toward transportation governance of Bandung city. The congestion and increased air pollution into special consideration determining the direction of transportation policy in this city. Hence the need for a study that aims to fill these knowledge gaps in the transport sector. This research will be involved with the environment, transportation and other policies relevant to assessing transportation options with multiple criteria such as affordability, implementability, transport quality and quantity of services and environmental sustainability as well. The Analytic Hierarchy Process (AHP) is a method of measurement for formulating and analyzing decisions. It is decision tool support which can be used to solved complex decision problems into account tangible and intangible aspects. in this research uses data was collected through a questionnaire which was divided into four stakeholders, namely; Government, academia, private sector workers and the local community. AHP provides convenience in determining priority criteria for the transportation plan. The result of this research showed that the most of respondents consists of local government, academia, private sector workers, and the local community perceive that sustainable of environmental is a major priority in terms of the criteria determining the transportation plan with a percentage of 28.87%. The quality of transportation services, affordability economically, ease to be implamented and the quantity of transport service were in the range of 21,78% ; 20,17% ; 19,77 % ; 9,39 %, respectively.

Keywords: AHP, criteria, policy, questionnaires, transportation

INTRODUCTION

Bandung is the capital of West Java province. Has an area of 167.7 km^2, Bandung role as a center of social, economic, and governance. As a consequence that carried the function city, this affects the municipality experiencing a many problems.

One important problem is the transportation. Increasing the amount of motor vehicles occur each year, until in 2014 the amount of motor vehicles be 1,539,409. As the details, the amount of motorcycles is 1,113,316. Passenger cars also increased to 351 650. But it is not accompanied by the addition of roads. Therefore to ensure smooth traffic, coupled with the increasing air pollution due to vehicle exhaust in Bandung, it needs a good transportation planning. Many cities in Asia Possess significant potential to reduce both of air pollution and mitigate climate change with a single policy or plan. The air quality and climate change benefits from the single policy or plan are known as co-benefits. Urban policymakers often lack knowledge over which action can deliver the greatest co-benefits.

This study aims to fill these knowledge gaps in the transport sector. Researchers will engage with environmental, transport and other relevant policymakers to assesss the same

transport options along several criteria (affordability, implementability, transport service quality and quantity and also environmental sustainability).

The aim of the different plans to reduce the greenhouse gas emissions and, hence, the adverse climate change impacts, can usually be achieved by different transport policies, each characterized by quantitatively and qualitatively different effects on the transportation system itself, as well as on the natural environment and economic and social context.

In order to choose the optimal policy action to reduce the adverse climate change impacts due to the transport sector, we have applied the analytic hierarchy process (AHP), developed by Saaty (1980), which decomposes the decisional process in a hierarchy of criteria, subcriteria, attributes and alternatives through a set of weights that reflect the relative importance of alternatives. The AHP has become a significant methodology in EIA due to its capability for facilitating multi-criteria decision-making (Ramanathan, 2001).

Tracz and Wawrzynkiewicz (1993) used AHP in the selection of public transport system alternatives. Khasnabis and Chaudry (1994), based on their application of AHP to evaluate transit privatisation projects in Detroit metropolitan area, found that AHP is feasible tool for priority ranking of transportation projects. Tabucanon and Lee (1995), in their study of evaluation of rural highway improvement projects in Korea, concluded that the application of AHP gave more balanced outcomes for various conflicting criteria compared to traditionaleconomic evaluation method.

RESEARCH METHOD

Data Collection

Collecting data through questionnaires which were divided into four stakeholders, namely; The local government, academia, private sector workers and local community. Anf then, the amount of questionnaires distributed 10 pieces for each stakeholder, so that the end result will be collected 40 questionnaires. Distribution of questionnaires in local government, represented by the instance related to the environment, transport, industry, and other relevant instances. Selection of the field of local government in order to know the thoughts and views of stakeholders in Bandung City.

Selection of respondents in the field of academics refer to the lecturer and students related to their field of environment and transport. So expect the choice of academic experts can give a thought to the transportation conditions through scientific and theoretical in Bandung City. While the selection of private sector workers and the public is aimed at knowing the views and desires of users of transport policy that every day feel the road conditions in Bandung City.

Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a method of measurement for formulating and analyzing decisions. Saaty (1980) provided a theoretical foundation for the AHP, that is a decision support tool which can be used to solve complex decision problems taking into account tangible and intangible aspects. Therefore, it supports decision makers to make decisions

involving their experience, knowledge and intuition.

The AHP decomposes the decision problem into elements, according to their common characteristics, and levels, which correspond to the common characteristic of the elements. The topmost level is the "focus" of the problem or ultimate goal; the intermediate levels correspond to criteria and sub-criteria, while the lowest level contains the "decision alternatives". If each element of each level depends on all the elements of the upper level, then the hierarchy is complete; otherwise, it is defined incomplete. The elements of each level are compared pairwise with respect to a specific element in the immediate upper level.

To make a decision in an organised way to generate priorities we need to decompose the decision into the following steps.

a. Define the problem and determine the kind of knowledge sought.
b. Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).
c. Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.
d. Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtained.

Table 1 reports the pairwise comparison scale used in the AHP developed by Saaty (2008). It allows to convert the qualitative judgments into a numerical values, also with intangible attributes.

For computing the priorities of the elements, a judgmental matrix is assumed as follows:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

where *aij* represents the pairwise comparison rating between the element *i* and element *j* of a level with respect to the upper level. The entries *aij* are governed by the following rules: $aij > 0$; $aij = 1/aji$; $aii = 1 \ \forall i$.

Following Saaty (1980, 2000), the priorities of the elements can be estimated by finding the principal eigenvector *w* of the matrix A, that is:

$$AW = \lambda_{max} W \quad (2)$$

When the vector W is normalized, it becomes the vector of priorities of elements of one level with respect to the upper level. λmax is the largest eigenvalue of the matrix A. In cases

where the pairwise comparison matrix satisfies transitivity for all pairwise comparisons it is said to be consistent and it verifies the following relation :

$$aij = a_{ik}a_{kj} \qquad \forall i,j,k \tag{3}$$

Table 1. The AHP Pairwise Comparison Scale

Numerical Values	Verbal Scale	Explanation
1	Equal importance of both elements	Two activities contribute equally to the objective
2	Slightly more important	
3	Moderately more important	Experience and judgement slightly favour one activity over another
4	Much more important	Experience and judgement strongly favour one activity over another
5	Significantly more important	The evidence favouring one activity over another is of the highest possible order of affirmation

Source: Satty (2008)

Saaty (1980) has shown that to maintain reasonable consistency when deriving priorities from paired comparisons, the number of factors being considered must be less or equal to nine. AHP allows inconsistency, but provides a measure of the inconsistency in each set of judgments. The consistency of the judgmental matrix can be determined by a measure called the consistency ratio (CR), defined as:

$$\text{CR} = \frac{CI}{RI} \tag{4}$$

where CI is called the consistency index and RI is the Random Index. Furthermore, Saaty (1980, 2000) provided average consistencies (RI values) of randomly generated matrices (table 2). CI for a matrix of order *n* is defined as:

$$\text{CI} = \frac{\lambda max - n}{n-1} \tag{5}$$

In general, a consistency ratio of 0.1 or less is considered acceptable, this threshold is 0.08 for matrices of size four and 1.11 for matrices of size five.

Table 2. The Average Consistencies Of Random Matrices (RI Values)

Size	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Assessment of Alternative Transport Policies

In order to evaluate alternative transport policies to reduce the adverse climate change impacts. Finally, the authors develop the structure in two different levels; Level 1 is the criteria and the last level represents the alternatives of transportation policy. At level 1 calculation using the analytic hierarchy process (AHP). A determination of priorities of the five criteria that we proposed, namely Quantity and Quality Transport Service, Affordable, implementable, and Environmentally Sustainable. Meanwhile, at level 2, calculating the weighted value based on the rankings obtained from each of the policy alternatives.

We have asked the opinion of 40 people from various stakeholders and asked to rank them in order set 11 alternative transportation policy. This ranking assessment aims to make a judgment in the determination of alternative transport policy. Rank 1 is an alternative policy to get the top value or is the primary and essential. Meanwhile, if you get the latest rankings, it is the weakest policy alternatives or unimportant.

Where the weighting value is based on the reverse of the ranking obtained from the policy. For example, if a policy gets rank 1 then the policy will get the score of 11, if the rank 2 will get a score of 10, and if the policy is to get the last rank, 11, it will get the score 1.

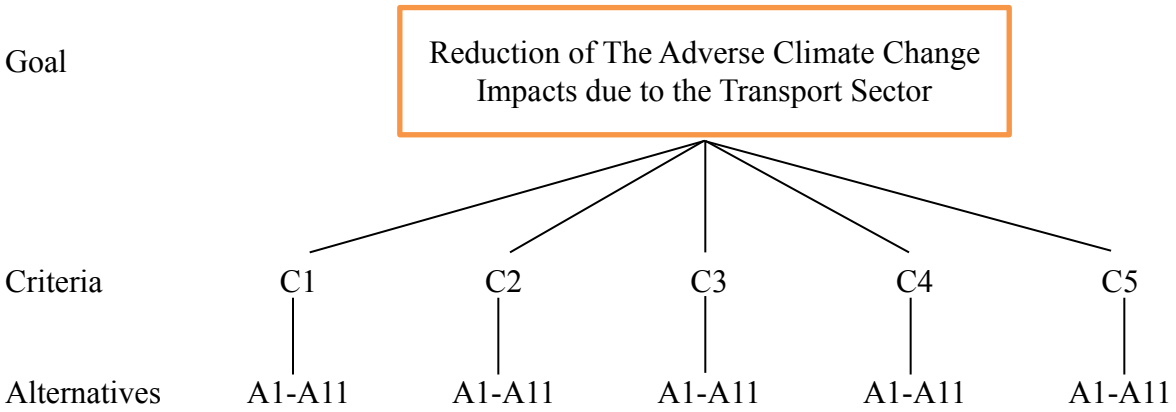

Figure 1. Analytic Hierarchy Structure

Where:
C1 Quantity Transport Service
C2 Quality Transport Service
A1 School Zoning
A2 Pedestarian Facilities
A3 Work Scheduling

C3 Affordable
C4 Implementable
C5 Environmentally Sustainable

A4 BRT (Bus Rapid Transit) System
A5 Revitalization of Angkot
A6 Car Free Day in Certain Road
A7 School Bus
A8 Promoting LRT/MRT
A9 Eco Driving
A10 I/M Program
A11 ATCS System

RESULT AND DISCUSSION

By applying the procedure previously outlined, the results indicate the highest importance to the criteria C5 "Enviromentally Sustainable" (28.87%); This indicates that all stakeholders want a transportation system that relies on environmental sustainability. so that at the current state of the stakeholders have had a future mind to keep the earth from environmental damage as a result of pollution generated by vehicle exhaust.

The second condition and the third is chosen C2 and C3 "Quality and affordability of transport services" with a score of 21.78% and 20.17% is an fact that all stakeholders after the program environmental sustainability also want the convenience and low prices for using transport services.

The last option on the quantity of transport services stated that all stakeholders do not expect much to have the addition of transport services in the city of Bandung. They prioritize environmental sustainability, quality and affordability economically to repair the current transportation services

As results from the eigen vector of the comparison matrix criteria, reported in table 3, whose components provide an estimate of the weights of the criteria. The principal eigen value of this matrix is $\lambda max = 5.052$, with a consistency ratio $CR = 0.01<0.1$. Thus, the results are consistent.

Table 3. Comparison of Matrix Criteria

Criteria	C1	C2	C3	C4	C5	Weight vector	Percen-tage (%)
C1	1.000	0.377	0.395	0.432	0.457	0.0939	9.397
C2	2.653	1.000	0.964	1.117	0.753	0.2178	21.780
C3	2.532	1.037	1.000	0.883	0.620	0.2017	20.170
C4	2.315	0.895	1.132	1.000	0.562	0.1977	19.778
C5	2.188	1.328	1.614	1.781	1.000	0.2887	28.875

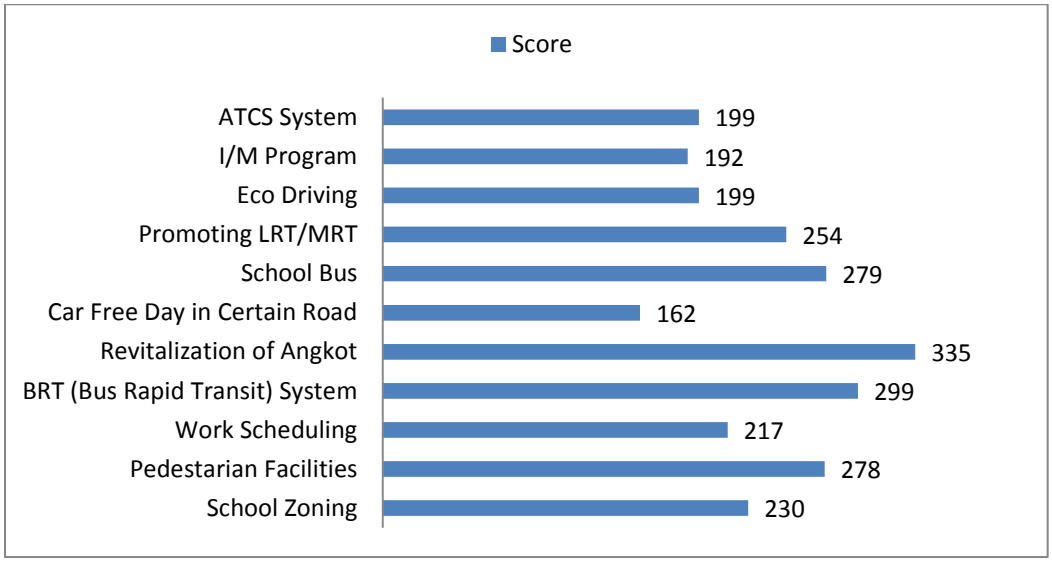

Figure 2. Comparison of Quality Transport Services

This study about the quality of transportation services, all stakeholders who filled out a questionnaire considers the revitalization of public transportatioan (Angkot) is a top priority to improving the quality of transportation services. As known, Angkot is the dominant mode of public transport that are used in Bandung city, and the unavailability of bus rapid transit and the LRT or MRT also. Thus revitalizing angkot becomes expected to begin immediately.

The second option is the presence of a bus rapid transit as neighboriEe cities, namely Jakarta. All stakeholders would want a mode of transportation that is fast, has a special line and able to accommodate more passengers. So that BRT is expected to answer the wishes of the citizens of Bandung to improve the quality of transportation services. Together with other kebiajakan policies that have high scores, such as the presence of a school bus and pedestrian facility improvements.

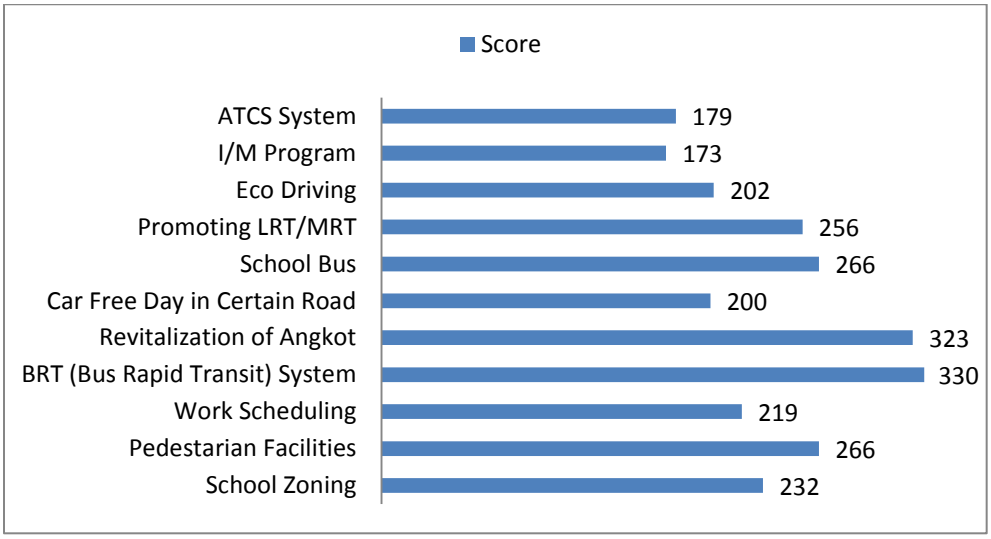

Figure 3. Comparison of Quantity Transport Services

The quantity of transport services do have the lowest percentage in the assessment criteria for the transportation program. But all stakeholders remain hopeful increase in the quantity of transport services by presenting a bus rapid transit as a priority. it is understood the public, BRT can accommodate many passengers so that they can answer the problem of the quantity of transport services. Besides that, the next priority is the revitalization of angkot, school bus and pedestrian facilities in succession in order to increase the quantity of transport services.

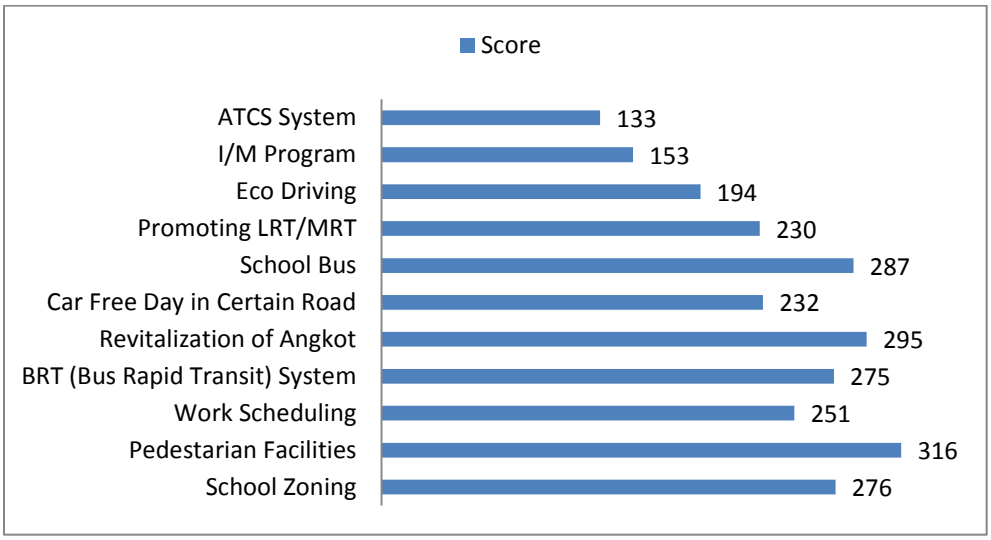

Figure 4. Comparison of Affordability Economically

Transportation services are always associated with economic aspects. Thus the economic affordability is also a criterion in the development of transportation services. The majority of stakeholders considers the repair and manufacture of pedestrian facilities is the main priority is first implemented when talking about the economic aspects of society.

The second option, the revitalization of angkot be expected in the provision of affordable transport services economically. It should also be noted policy of providing school bus and school zoning which also has a high score chosen by stakeholders.

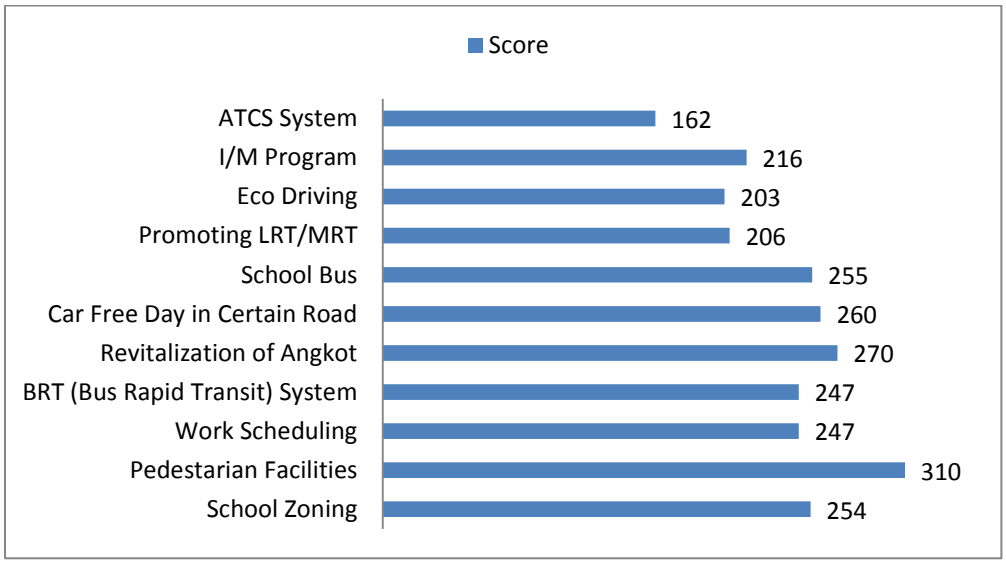

Figure 5. Comparison of Implementable

Ease of implementation is essential in improving transportation services. Majority stakeholder of course able to get the all the policies that have been planned to be realized quickly. Program policies are a top priority of the respondents is the repair and manufacture of pedestrian facilities. It is considered the easiest to implement.

The second option is the revitalization of public transportation, which is returned to the expectations of citizens Bandung because it is easy in the implementation phase. Another option with the holding car free day and the procurement of school buses.

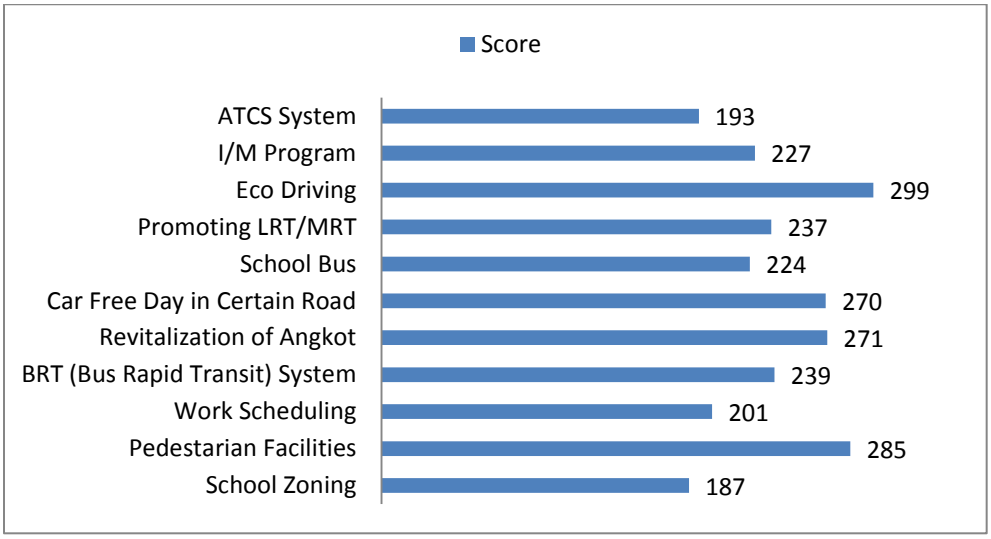

Figure 6. Comparison of Environmentally Sustainable

Transportation services that support environmental sustainability, the majority stakeholder choose eco driving is the best policy, as it seeks to change people's behavior in terms of driving the vehicle and attempted in an effort to fuel savings in ways that can improve fuel efficiency of spending. The second option is to repair and manufacture of pedestrian facilities, so that citizens of the city of Bandung more comfortable traveling by foot, become Bandung as an environmentally friendly city.

CONCLUSION AND SUGGESTION

In this study, AHP provides convenience in determining priority criteria for the transportation plan. With the result that the majority of respondents consists of local government, academia, private sector workers, and the public perceive that environmentally sustainable is a major priority in terms of the criteria determining the transportation plan with a percentage of 28.87%. Followed by the quality of transportation services amounted to 21.78%, Affordability economically by 20.17%. Ease to be implemented by 19.77% and the quantity of transport services by 9.39%.

In the determination of policy alternatives that a total of 11 choices. On the criteria of the quality of transportation services a major priority in the revitalization of public transportation. On the criteria of quantity of transport services a top priority in the implementation of a neat bus transit (BRT). On the criteria of economic affordability of the majority of respondents prioritize pedestrian facilities. Implemented on the criteria of convenience is a top priority pedestrian facilities. And environmental sustainability criteria for prioritizing eco driving the majority of respondents as the best solution in an effort to maintain the environmental quality of the transport sector.

REFERENCES

Berrittella, M., et all. 2007. An Analytic Hierarchy Process for The Evaluation of Transport Policies to Reduce Climate Change. The Fondazione Eni Enrico Mattei.

Gercek, H., Karpak, B. and Kilncaslan, T. (2004) A multiple criteria approach for the

evaluation of the rail transit networks in Istanbul, Transportation, Vol. 31, 203-228.

Khasnabis, S., and Chaudry, B.B., (1994) Prioritising transit markets using Analytic Hierarchy Process, Journal of Transportation Engineering, 120 (1), 74-93.

Lon, V., Higashi, O., and Pheng, P. 2013. Analytic Hierarchy Process for Evaluation of Public Transport Policy Design in Phnom Penh City.

Ramanathan R., 2001. A note on the use of the analytic hierarchy process for environmental impact assessment. Journal of Environmental Management 63, 27-35.

Saaty T. L., 1980. The analytic hierarchy process: planning, priority setting and resource allocation. McGraw-Hill, New York.

Saaty, T.L. 2008. Decision Making with the Amalytic Hierarchy PRocess, *Int. J. Services Sciences, Vol. 1, No. 1*Saaty T.L., 2000. Fundamentals of decision making and priority theory with the analytic hierarchy process. RWS Publication, Pittsburg. 18

Tabucanon, M.T., and Lee, H., (1995) Multiple Criteria Evaluation of Transportation System Improvement Projects: the Case of Korea, Journal of Advanced Transportation, 29 (1), 127-34.

Tracz, M and Wawrzynkiewicz, B., (1993) Knowledge acquisition from multiple experts: a case of transport planning in Poland (Chapter 14), in Wright, J.R., Wiggins, L.L., Jain, R.K., and Kim, T.J. (eds), Expert System in Environmental Planning, Springer-Verlag, Berlin Heidelberg, 261-274.