MODELING OF WET DEPOSITION IN CHEMICAL TRANSPORT SIMULATION

Toshihiro Kitada
National Institute of Technology, Gifu College
Japan
Email: kitada@gifu-nct.ac.jp
Presenter; † Corresponding author.

Abstract: Transport/chemistry/deposition model for atmospheric trace chemical species is now frequently used as an important tool to assess the effects of various human activities, such as fuel combustion and deforestation, on human health, eco-system, and climate. In the analysis of the serious release of radioactive species from the accident of Fukushima Daiichi Nuclear Power Plant in March, 2011, various models were also applied to estimate the amount of discharged radioactive materials and to understand observed spatial distributions (Sectional Committee on Nuclear Accident, Science Council of Japan, 2014[11]; hereafter abbreviated as SCNA). The SCNA report shows that results of some models and also ensemble average of the calculated results of all the participated models successfully captured main features of horizontal distribution of the accumulated deposition of 137Cs. However, it seems there are still by factors of 5 and 1/5 differences between observed and calculated results at the largest.

Thus in this paper I like to show our previous attempts on wet deposition in chemical transport simulation for reference to think about the phenomena. The chemical transport model is required to reproduce correctly mass balance of various chemical species in the atmosphere with keeping adequate accuracy for calculated concentration distributions of chemical species. For the purpose, one of the important problems is a reliable wet deposition modeling, and here, we introduce two types of methods of "cloud-resolving" and "non-cloud-resolving" modeling for the wet deposition of pollutants.

Keywords: Air pollution, transport modeling, wet deposition, cloud resolving/non-resolving

INTRODUCTION

Historically several models such as RADM[2] and STEM-II [1] included not only gas/aerosol phase chemistry but also aqueous phase chemistry in cloud/rain water in addition to the processes of advection, diffusion, wet deposition (mass transfer between aqueous and gas/aerosol phases), and dry deposition. Software of CMAQ (Community Multi-scale Air Quality model [3]) has been released by EPA for public use of a "comprehensive" model. These models are now frequently used by many people, and show their ability to successfully reproduce some features on atmospheric environment such as high ozone concentration episode by photochemical smog reactions. Figure 1 shows a model system for atmospheric trace chemical species. Meteorological model provides hydrometeors' fields as well as flow, temperature, and eddy diffusivity to the comprehensive model for chemical species. Final target of the "comprehensive" model will be that the model can correctly reproduce mass balance of various chemical species in the atmosphere with keeping adequate accuracy for calculated concentration distributions of chemical species; in this situation life times of various primary and secondary pollutants should be correctly predicted. To do so many problems may be still remained. One of the important problems is reliable wet deposition prediction. There may be two types of attitudes for the modeling of the wet deposition; one considers trans-horizontal-grids transport of aqueous phase chemical species with use of partial differential equations for these a simplified modeling.

In the following sections, we will introduce our previous attempts on these modeling techniques..

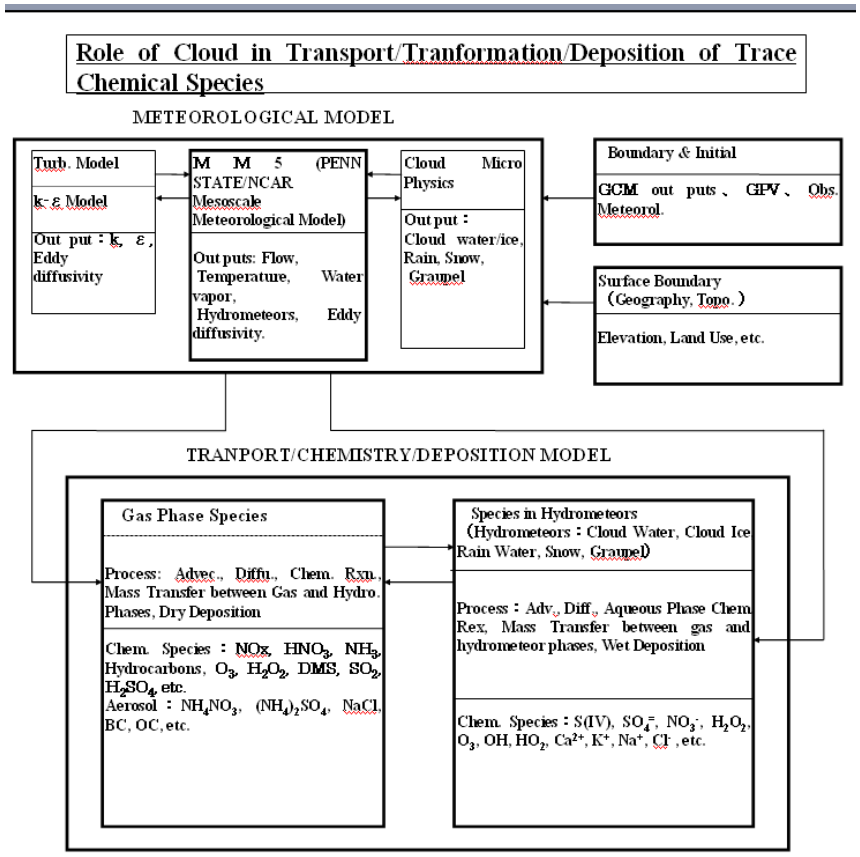

Figure 1. Comprehensive model of transport/transformation/deposition of atmospheric trace chemical species.

CLOUD-RESOLVING MODELING

Cloud-resolving modeling describes dynamics of chemical species in hydrometeors with unsteady partial differential equations, and allows the chemical species to cross grid cell boundary. It usually treats detailed mass transfer processes of chemical species among gas/aerosol and hydrometeor phases. Let us imagine the situation of the complex mass transfer taking place in the atmosphere. First, aerosol may serve as condensation nuclei to form cloud droplets. Then the cloud droplets either further grow with the processes such as accretion and auto-conversion to rain drop or with the Bergeron process to snow particle, or they may disappear by evaporation. These cloud processes can be summarized as Fig. 2 [4, 5, 10].

Associated with each cloud process shown in Fig. 2, inter-phase transfers of air pollutants such as SOx (SO_2, and SO_4^{2-}) and NO_3^- can occur among the phases of gas (aerosol), cloud water, rain water, cloud ice, and snow. For example, mass transfer and transformation of SOx may be written as in Fig. 3. In addition, aqueous phase chemical reactions such as oxidation of SO_2 (aq) in cloud and rain water take place as listed, for example, in Table 1 and 2.

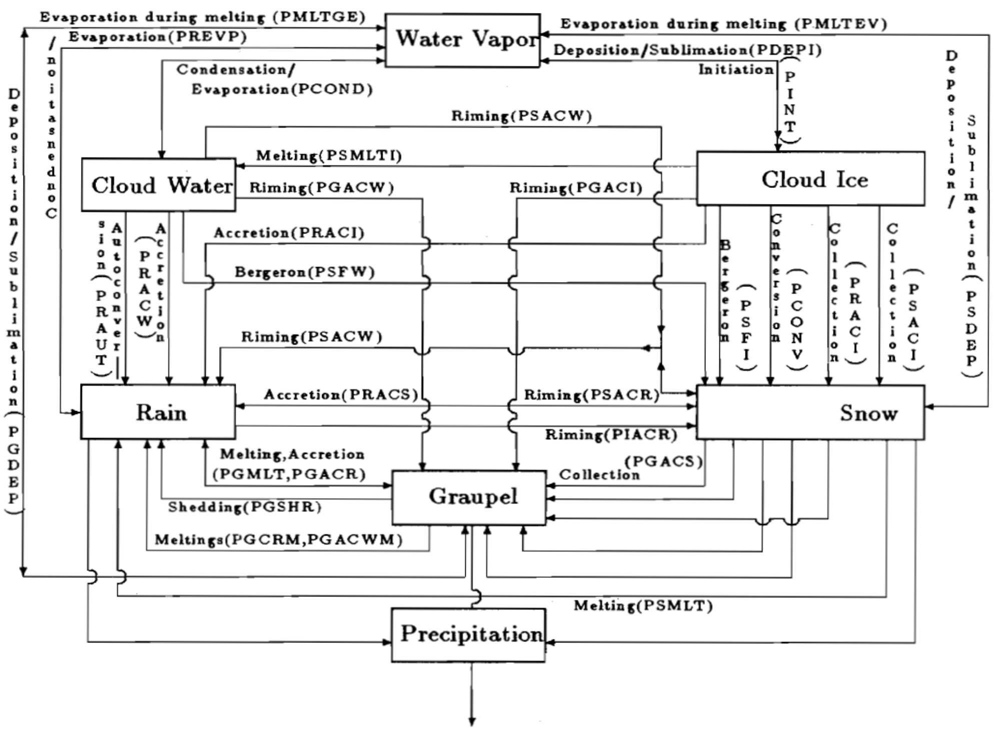

Figure 2. Diagram of inter-hydrometeor-transfers of water substance of the cloud microphysics model after Rutledge and Hobbs, 1984 [4, 5, 10].

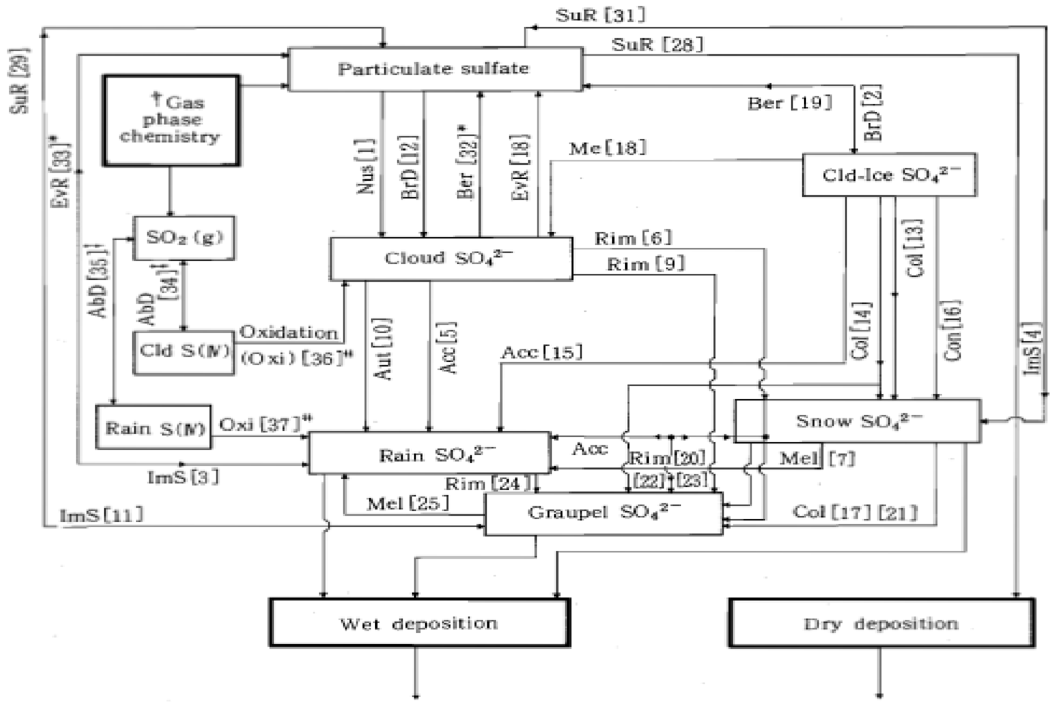

Figure 3. Schematic showing gas-hydrometeor inter-phase transfers of SOx [4, 8]. † The gas phase chemistry model includes the following reactions for SO_4^{2-} production as main mechanism: $SO2+OH \rightarrow SO_4^{2-}$ (lumped mechanism), $SO2+RO2 \rightarrow SO_4^{2-}$ (lumped mechanism), $SO2 \rightarrow SO_4^{2-}$ (oxidation reaction on the surface of aerosol particle). AbD, Absorption-Desorption; Acc, Accretion; Aut, Autoconversion; Ber, Bergeron process; BrD, Brownian diffusion; Col, Collection; Con, Conversion; EvR, Evaporation; ImS, Impaction scavenging; Mel, Melting; NuS, Nucleation scavenging; Oxi, Oxidation; Rim, Riming; SuR, Sublimational Release.

Table 1. Aqueous phase equilibrium reactions [5]

	Reactions	Equilibrium constants M or M (atm.)$^{-1}$	Source
EQ1	$SO_2(g) \Leftrightarrow SO_2(aq)$	$1.23\exp[3120 \cdot f(T)^*]$	PS
EQ2	$SO_2(aq) \Leftrightarrow H^+ + HSO_3^-$	$1.23 \times 10^{-2}\exp[1960 \cdot f(T)]$	PS
EQ3	$HSO_3^- \Leftrightarrow H^+ + SO_3^{2-}$	$6.61 \times 10^{-8}\exp[1500 \cdot f(T)]$	PS
EQ4	$NH_3(g) \Leftrightarrow NH_3(aq)$	$75\exp[3400 \cdot f(T)]$	PS
EQ5	$NH_3(aq) \Leftrightarrow NH_4^+ + OH^-$	$1.75 \times 10^{-5}\exp[-450 \cdot f(T)]$	PS
EQ6	$HNO_3(g) \Leftrightarrow H^+ + NO_3^-$	$2.6 \times 10^6\exp[8700 \cdot f(T)]$	C
EQ7	$CO_2(g) \Leftrightarrow CO_2(aq)$	$3.4 \times 10^{-2}\exp[2420 \cdot f(T)]$	PS
EQ8	$CO_2(aq) \Leftrightarrow HCO_3^- + H^+$	$4.46 \times 10^{-7}\exp[-1000 \cdot f(T)]$	PS
EQ9	$HCO_3^- \Leftrightarrow CO_3^{2-} + H^+$	$4.68 \times 10^{-11}\exp[-1760 \cdot f(T)]$	PS
EQ10	$O_3(g) \Leftrightarrow O_3(aq)$	$1.13 \times 10^{-2}\exp[2300 \cdot f(T)]$	PS
EQ11	$H_2O_2(g) \Leftrightarrow H_2O_2(aq)$	$7.45 \times 10^4\exp[6620 \cdot f(T)]$	PS
EQ12	$HO_2(g) \Leftrightarrow HO_2(aq)$	$2 \times 10^3\exp[6640 \cdot f(T)]$	PS
EQ13	$OH(g) \Leftrightarrow OH(aq)$	$25\exp[5280 \cdot f(T)]$	PS
EQ14	$H_2O \Leftrightarrow H^+ + OH$	1×10^{14}	PS

$^*f(T) \equiv \frac{1}{T} - \frac{1}{298}$ where T is temperature in K.
PS: Pandis and Seinfeld (1989).
C: Chameides (1984).

Table 2. Aqueous phase chemical reactions [5].

	Reactions	Rates s^{-1}, $M^{-1}s^{-1}$ or $M^{-2}s^{-1}$	Source
R1	$H_2O_2 \xrightarrow{h\nu} 2 \cdot OH$	1.0×10^{-6}	ES
R2	$OH + HO_2 \rightarrow H_2O + O_2$	$1.1 \times 10^{12}\exp[-1500/T]$	PS
R3	$OH + H_2O_2 \rightarrow H_2O + HO_2$	$8.1 \times 10^9\exp[-1700/T]$	PS
R4	$HO_2 + HO_2 \rightarrow H_2O_2 + O_2$	$2.4 \times 10^9\exp[-2365/T]$	PS
R5	$S(IV) + O_3 \rightarrow S(VI) + O_2$	for $SO_2(aq)$: 2.4×10^4 for HSO_3^-: $4.2 \times 10^{13}\exp[-5530/T]$ for SO_3^{2-}: $7.4 \times 10^{16}\exp[-5280/T]$	PS
R6	$S(IV) + H_2O_2 \rightarrow S(VI) + H_2O$	$3.7 \times 10^{12}\exp[-4430/T]$	PS
R7	$S(IV) + \frac{1}{2} \cdot O_2 \xrightarrow{Fe^{3+},\ Mn^{2+}} S(VI)$	*	M

$$^* pH \leqslant 5: \ -4.6 \times 10^{23}\exp\left[-\frac{13{,}700}{T}\right][Mn^{2+}][HSO_3^-] - 8.8 \times 10^{15}\exp\left[-\frac{11{,}000}{T}\right][Fe^{3+}]\left(\frac{[SO_2(aq)] + [HSO_3^-]}{[H^+]}\right).$$

$$pH > 5: \ -4.6 \times 10^{23}\exp\left[-\frac{13{,}700}{T}\right][Mn^{2+}][HSO_3^-].$$

PS: Pandis and Seinfeld (1989).
M: Martin (1984).
ES: estimated for noon time in Jan. at 40°N.

Hence governing equations for chemical species in gas (and aerosol) and hydrometeors are summarized as follows:

For gas and aerosol phase species,

$$\rho\frac{\partial C_1}{\partial t} + \rho\vec{V} \cdot \nabla C_i = \nabla \cdot \rho\widetilde{K} \cdot \nabla C_i + R_i + S_i - G_i^j, \quad i = 1, 2, \ldots\ldots, I_1 \qquad (1)$$

where C_i is the non-dimensional concentration of the ith chemical species in gas phase, ρ is the air density, R_i is the chemical reaction rate, S_i is the non-flux-type emission source, and G_i^j is the mass transfer rate between gas and the *j*th hydrometeor phases; the rate consists of the relevant processes, for example, for SOx shown in Fig. 3.

For chemical species in hydrometeors,

$$\frac{\partial C_i^j q_j}{\partial t} + u\frac{\partial C_i^j q_j}{\partial x} + v\frac{\partial C_i^j q_j}{\partial y} + W_j\frac{\partial C_i^j q_j}{\partial z} - \frac{q_i \partial \rho V_j}{\rho \partial z} C_i^j = \frac{\left(R_i^j + {}_kT_i^j + G_i^j\right)}{\rho}, \ \mathrm{i} = \mathrm{I}_1+1, \ldots, \mathrm{I}_2 \quad (2)$$

where C_i^j is the concentration of the *i*th chemical species in the *j*th hydrometeor, q_j is the water content of the *j*th hydrometeor, $W_j = w - V_j$, V_j is the gravitational falling velocity of the *j*th hydrometeor such as rain, snow, and graupel, for which prescribed size distributions are assumed; for example, so-called Marshall-Palmer size distribution [9],

$$N_{D,j} = N_{oj} \exp^{-(\lambda_j D_j) dD_j} \text{ and } \lambda_j = \left(\frac{\pi \rho_j N_{oj}}{\rho q_j}\right)^{0.25} \text{ for rain, snow, and graupel;}$$

$N_{D,j}$ stands for the number density of droplets of the *j*th hydrometeor in the diameter range between Dj and Dj+dDj, and ρ_j is the density of the *j*th hydrometeor. R_i^j is the chemical reaction rate of the *i*th species in the *j*th hydrometeor, and ${}_kT_i^j$ is the mass transfer rate of the *i*th chemical species between the *j*th and *k*th hydrometeors, the inter-phase mass transfer processes among hydrometeors are shown, for example, in Fig. 3; the term R_i^j is formed with the chemical reactions in Table 1 and 2.

APPLICATION OF CLOUD-RESOLVING MODELING: ACIDIC SNOW FORMATION OVER THE SEA OF JAPAN

In winter, cold air mass is accumulated over Siberia, and huge amounts of air pollutants, emitted from East Asian continental countries such as China and Korea, are also injected into the air mass. When this cold and pollutants-rich air mass flows out over the warmer Sea of Japan, thermal convection develops to form organized roll vortices aligned with main wind direction heading toward Japan. Hence the humid air mass, supplied with water vapor from the Sea of Japan, frequently brings heavy snow fall and also acidic deposition in the coastal area of Japan on the Japan Sea side. To analyze how and how much the acidic species are formed in the cloud streets associated with the roll vortices, our cloud-resolving model was used [5].

Figure 4 illustrates relative location of the East Asian countries, the Sea of Japan, and Japan, and also shows typical direction of the cold and polluted air mass movement and typical time required for the air mass's crossing of the Japan Sea; as an example, approximate time of the passage is written in the figure. Figure 5 is the calculation domain idealized as two-dimensional situation.

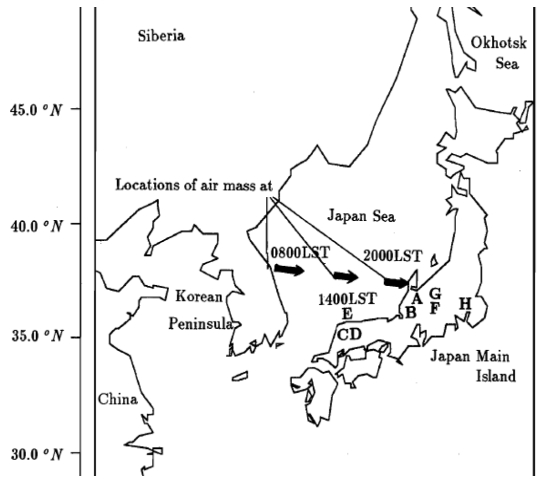

Figure 4. Typical traveling course of the continental air mass moving over the Sea of Japan in winter; formation of cloud and formation of acidic species associated with the cloud were simulated along the course. The locations of the air mass at 0800, 1400, and 2000LST are indicated with thick solid arrows. The symbols from “A” to “H” represent observation points for acid deposition.

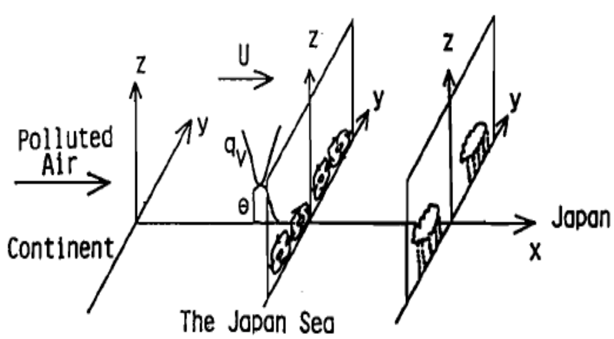

Figure 5. Schematic diagram of the 2-D calculation domain for convective cloud streets over the Japan Sea in winter, where q_v denotes water vapor mixing ratio, and θ the potential temperature [4, 5, 8].

Figures 6a,b show the calculated water content maps of cloud water and snow, respectively. They are the results after 12 hours’ advancement of the air mass over the Japan Sea. Similarly, Figures 7a,b,c are the calculated pH and SO_4^{2-} in the cloud water, and SO_4^{2-} in the snow, respectively. Figure 7a suggests (1) the pH value of cloud water over the Japan Sea in winter can be around 4 or less, (2) the pH value is lower where the cloud water content is smaller; thus, pH is low at the edge of the cloud. The contour map of SO_4^{2-} in Fig. 7b indicates (3) SO_4^{2-} is trapped at the cloud base where upward air flow exists and (4) SO_4^{2-} accumulates at the cloud top, in particular, in the interstitial air of the clouds. However, (5) SO_4^{2-} in the snow phase is much larger than in the cloud phase as shown in Fig. 7c. Interestingly, the cloud and snow formation sometimes keeps pollutant concentration in the lower atmosphere rather high as suggested in Fig. 8, which compares vertical profiles of SO_4^{2-} between D1 (with cloud and snow) and D0 (without them) cases; that is, in the cloud and snow case the cloud traps the pollutant and the snowfall returns the pollutant in the cloud again to the below-cloud level, and if the sublimation of the snow occurs, then the pollutant can be backed to gas and aerosol phase in the lower layer; of course, if there is no condition for the snow sublimation, then the pollutant in the snow will deposit onto the earth's surface without raising atmospheric concentration.

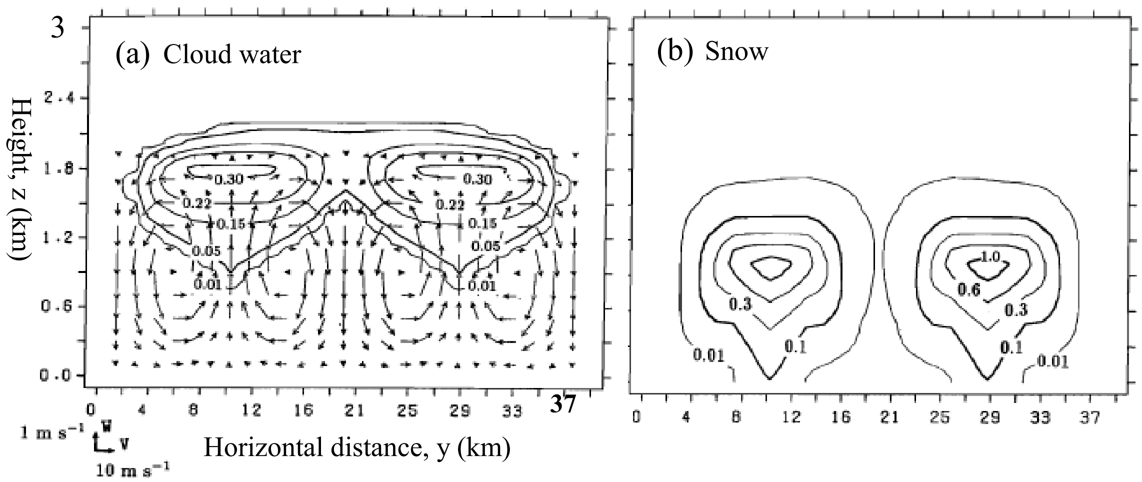

Figure 6. Vertical cross sections of calculated (a) cloud water, and (b) snow at 2000LST; unit in g kg-air^{-1} [4, 5].

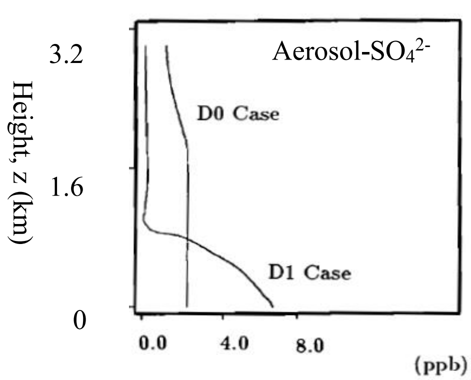

Figure 8. Vertical profiles of calculated aerosol-SO_4^{2-}: the cases of D0 (no-cloud) and D1 (cloud) at 2000LST along y=10.5 km [4, 5, 8].

NON CLOUD-RESOLVING MODELING

Non cloud–resolving modeling usually (1) does not use unsteady partial differential equation for chemical species in hydrometeor phases, (2) does not allow the pollutants in hydrometeor phases to directly cross horizontal grid cell, and (3) is thus a simplified approach; many of the comprehensive models such as RADM [2], STEM-II [1], and CMAQ [3] currently use this non cloud-resolving model.

In this section we will introduce our non cloud-resolving modeling and its application [4, 6]. If we use a spherical coordinate to describe transport/transformation equation for trace chemical species, governing equation can be written as follows:

$$C\frac{\partial X_i}{\partial t}+CU\frac{\partial X_i}{\partial x}+CV\frac{\partial X_i}{\partial y}+C\dot{\sigma}\frac{\partial X_i}{\partial \sigma}=\frac{\partial}{\partial x}\left(CE_\phi\frac{\partial X_i}{\partial x}\right)+ \frac{1}{\cos\theta}\frac{\partial}{\partial y}\left(C\cos\theta\, E_\theta\frac{\partial X_i}{\partial y}\right)+\frac{\rho g^2}{\pi^2 r^2}\frac{\partial}{\partial \sigma}\left(C\rho r^2 E_\sigma\frac{\partial X_i}{\partial \sigma}\right)+R_i-\Lambda CX_i,\quad i=1,2,.....,I \qquad (3)$$

where $dx = r\cos\theta\, d\phi$, $dy = r\,d\theta$, $\sigma = (P-P_T)/\pi$ is the normalized pressure coordinate, $\pi = P_S - P_T$, $\dot{\sigma}=\left\{\left(\frac{\partial z}{\partial t}\right)_\sigma + \vec{V}\cdot\nabla_\sigma z - W\right\}\frac{\rho g}{\pi}$,

X_i is the non-dimensional concentration of the i th chemical species, C and ρ are the air density in kmol m^{-3} and kg m^{-3}, respectively, θ and φ are the latitude and longitude, r is the distance from the earth's center, Ps and P_T are the atmospheric pressure at the earth's surface and top boundary, respectively, z is the altitude of σ surface, U, V, and W are the wind velocity for Φ, θ, and z directions, respectively, $\dot{\sigma}$ is the vertical velocity in σ coordinate, and R_i is the chemical reaction term. In Eq. (3), the last term on the right hand side stands for the wet deposition process; Λ is the scavenging coefficient due to cloud water, rain, and snow, and was derived for aerosol particle and gaseous species as follows (see for detail Kitada [4]; Kitada and Nishizawa [6]:

For wet deposition of SO_4^{2-} particle by rain drop [4],

$$\Lambda_{p,rain} = 6\times10^{-4}\eta_r P^{0.75} \text{ in } s^{-1},$$

and for that by snow [12],

$$\Lambda_{p,snow} = \frac{\rho_w g \eta_s \left(3.6\times10^{-6}P\right)}{\rho_a V_t^2} \text{ in } s^{-1},$$

where P is the precipitation intensity in $mmhr^{-1}$, η_r is the collection efficiency of aerosol particle by rain and was assumed to be 0.3~0.5, η_s is the same but by snow and is summarized in Slinn [13], ρ_w and ρ_a are the density of water and air in kgm^{-3}, respectively, and Vt is the average settling velocity of snow flake in ms-1, and $V_t = (102+51\log_{10} d_c)/100$ is recommended [7].

For wet removal of gaseous species by rain, the following equation was derived (Kitada [4]; Kitada and Nishizawa [6]):

$$\Lambda_{SO2} = \beta\frac{\alpha P}{3.6H} \text{ and } \alpha = 10^{-6}RTH_{eff,SO_2}$$

where H is the height of the cloud top in m, R is the universal gas constant (=0.082

$\ell\, atm K^{-1} mol^{-1}$), T is the air temperature in K, and H_{eff,SO_2} is the inverse of the effective Henry's law constant for SO_2 in $mol \ell^{-1} atm^{-1}$ (see [5] and [6] for detail), and β is an "equilibrium index" and represents the ratio of the real S(IV) concentration to the hypothetical equilibrium S(IV) concentration in rain water; and was determined with a series of numerical experiments in which concentrations of S(IV) etc. in rain drop falling through polluted atmosphere were calculated; β is 1 for SO_2, 0.38×10^{-8} for HNO_3, and 0.055 for H_2O_2.

APPLICATION OF NON CLOUD-RESOLVING MODELING

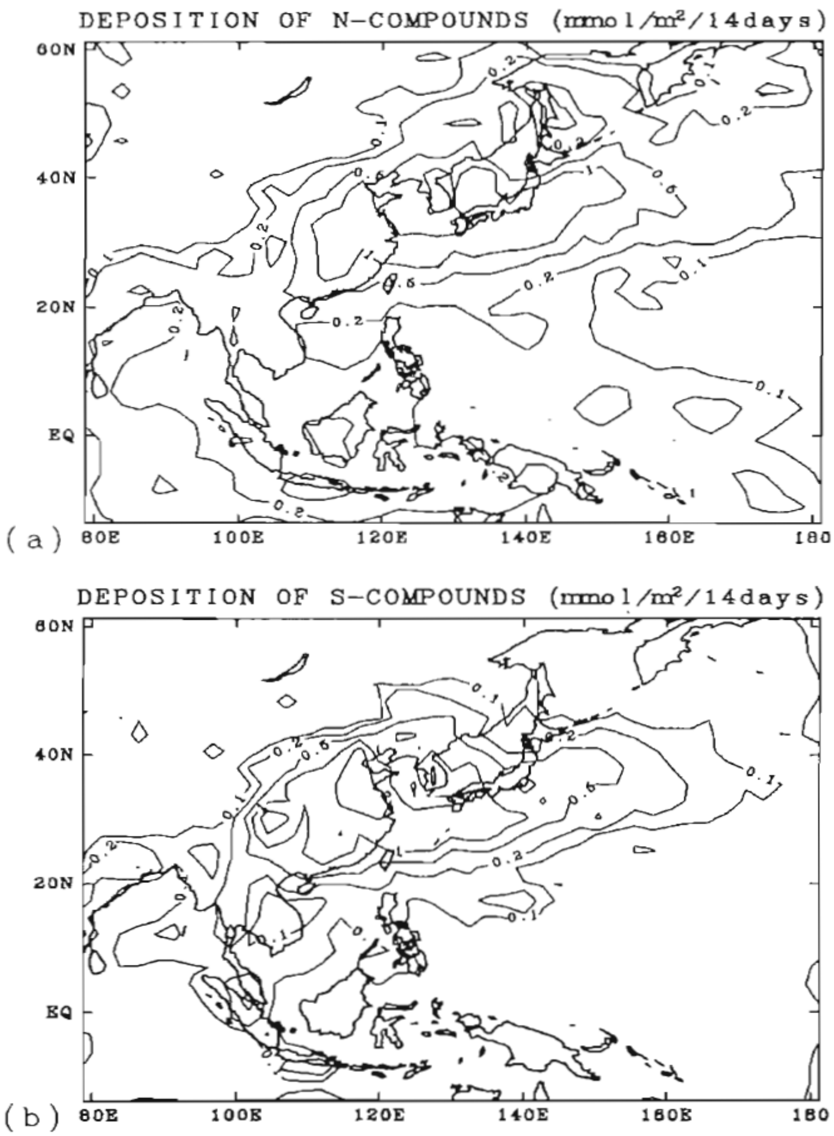

Figure 9. Calculated total deposition (dry + wet) in BASE case: (a) N- and (b) S-compounds in mmol m^{-2} $(14\ day)^{-1}$. The calculation was performed from 00GMT March 1 to 00GMT March 15, 1994. Contour lines are drawn for 0.1, 0.2, 0.5, 1.0, and 2.0 in mmol m^{-2} $(14\ day)^{-1}$.

The model described in section 3 was applied for pollutants transport in East Asia. Figure 9 shows, as an example of the results, the calculated total deposition of N- and S-compounds for 14 days [6].

SUMMARY AND CONCLUSION

Two types of the modeling methods for the wet deposition processes, i.e., "cloud-resolving" and "non-cloud-resolving", were introduced. Examples of their applications were also briefly described. For meso- and micro-scale phenomena such as the formation of acidic fog, the cloud-resolving approach described here should be further investigated. Also in Fukushima Nuclear Power Plant case, to consider transport equations of radioactive materials in cloud and rain phases directly may lead to better agreement with observation. A recent meeting on the modeling of atmospheric transport and deposition of radioactive nuclei in the Fukushima case may be referred in the web site [14].

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EMISSION REDUCTION FROM IMPLEMENTATION OF BUS RAPID TRANSIT CORRIDOR 13th IN JAKARTA

Lailatus Siami [1], Asep Sofyan[2*,†], and Russ Bona Frazila[3]
[1,2]Environmental Engineering Department, Institut Teknologi Bandung, Jl. Ganesha No. 10, Bandung, Indonesia.
Email: asepsofyan@yahoo.com
[3] Civil Engineering Department, Institut Teknologi Bandung, Jl. Ganesha No. 10, Bandung, Indonesia
* Presenter; † Corresponding author.

Abstracts: Green transport nowadays become important concern related to emission reduction. This is also become one of policy brief in Jakarta Macro Transportation (JTM) plan. Busway or so-called BRT as one of reliable mass tranportation in Jakarta has been developed for 12 corridor. 13th corridor is planned as elevated with length 14.6 km typed 2 lanes 2 way. Are this scenario will be significantly affect for emission reduction? This main question will be figured out in this research. Eventually, emission of transportation sector in Indonesia reached almost 200 Gg/year up to 2012. In the research, road networking model is used for representing actual condition of complex urban road in Jakarta. By the result of road assignment, will be estimated the traffic volume every road. Hence, Emission load calculated by bottom – up emission inventory and carried out from road segmentation. Afterwards, emission will be mapped out by spatial distribution resolution 1 km x 1 km that reveals emission reduction due to development of busway 13th is 9% of all emission, respectively. This sufficiently high rate of emission reduction due to fuel shift from fossil fuel to gas considered.

Keywords: Busway corridor 13th, Road networking model, Emission Inventory, Load Emission

INTRODUCTION

The transportation sector is contributes around 23% of GHG emissions overseas (Li et al., 2010). In fact, this sector is the largest source of pollution of the atmosphere contributing to global warming (Progiou and Ziomas, 2011). Road transport contributed to the increase in emissions of air pollutants and cause environmental and health problems depends on the type and concentration of pollutants (Souza et al., 2013).

Jakarta, the capital city of Indonesia, keep becomes the largest center of urbanization which means mobility level of people and goods would higher constantly. In addition, with urban sprawl of the city will enforce people in suburb (Bodetabek) to do activity in the heart of Jakarta and daily moving in and to Jakarta. Traffic congestion has become usual pattern.

Car-oriented development is still the prevalent paradigm of urban development in the developing countries that triggers from exponential growth of private cars in emerging economies. The most widely adopted strategy on mass transportation is BRT development. BRT is a public transport concept that allows high-capacity buses to operate at a rapid speed with some priorities through an integrated system including dedicated lanes, stations, and technologies and advanced branding (United Nations Centre for Regional Development, 2014).

In Jakarta itself, traffic management conduct by Jakarta Macro Transportation (JTM) plan since 1985. It comprised by three main policies in mass transportation development, traffic restriction, and road capacity development. In line with these, DKI Jakarta Act No.1 of 2012 about Spatial Plan 2030, Article 22 paragraph (2) states that efficient road transportation will be realized if the target of 60% of the population using public transport and increase the average speed - the road network average a minimum of 35 km/h.

Regarding with emissions reduction, the existing literature has investigated the individual impacts of bus service improvements mostly. Yet, only few studies assessed the combined effects of various strategies on transit bus emissions (Alam et al., 2014).

The main objective of this research is to know the effect busway 13th corridor in reduct the emission load in 2017. The study will covers CO, NOx, PM_{10} and VOC from car, motorcycle, bus, minibus and truck. The method used in this study is road network model and adapted Emission inventory from EMEP / European Environment Agency in 2013. The emissions inventory is the basis of air quality modeling and analysis and also to understand the shape and the transport of pollutants and the reference to pollution control (Fu, et al 2013). However, many factors that affect vehicle emissions and large amounts of data will be needed in the inventory of emissions from vehicles. So, it is arduous to develop an accurate inventory of emissions for major cities (Wang et al, 2008).

Description of the study corridor

DKI Jakarta is capital city of Indonesia lied on 6°12’ south latitude and 106 °48’ east longitude with the width 662.33 km^2 (BPS, 2012). The study location includes all public roads and toll (**Figure 1).** Type modes of transportation in Jakarta are divided into mass transit and private vehicles. For mass transport is dominated by minibus, bajaj and busway. While, private vehicles consisting of cars and motorcycles.

Nowadays, the number of busway is already in operation reached 12 corridors (**Figure 2**). And the number of passengers in 2012 reached 304,799 passengers/day or 111,251,869 passengers annualy. As for the plan of development with elevated busway are on 13, 14 and 15 corridors whereas the line 13th connecting Ciledug - Blok M. Corridors 14th connecting Kalimalang - Block M. And corridor 15th connecting Depok – Manggarai.

METHODOLOGY

Calculation

In this study, the calculation of vehicles number is use road network model. As for input are OD (Origin - Destination) matrix and road networking data (Arifin, 2012) of Jabodetabek in 2012 (SATURN, 2013). In the network model, the area is divided into several zones of travel. Each zone is represented by 1 zone center (centroid) connected to the road network through the centroid connector. Here, the road network in Jakarta road network is divided into some 42 zones (see **Table 2**).

Table 1. Number and Zone of Jakarta Road System

No	Zone	No	Zone
211	Gambir	**241**	Tebet
212	Sawah Besar	**242**	Setiabudi
213	Kemayoran	**243**	Mampang Prapatan
214	Senen	**244**	Pasar Minggu
215	Johar Baru	**245**	Kebayoran Baru
216	Menteng	**246**	Kebayoran Lama
217	Tanah Abang	**247**	Cilandak
218	Cempaka Putih	**248**	Pancoran
222	Penjaringan	**249**	Jagakarsa
223	Tanjung Priok	**251**	Matraman
224	Koja	**252**	Pulo Gadung
225	Cilincing	**253**	Jatinegara
226	Pademangan	**254**	Kramat Jati
227	Kelapa Gading	**255**	Pasar Rebo
231	Kalideres	**256**	Cakung
232	Grogol Petamburan	**257**	Duren Sawit
233	Tamansari	**258**	Makasar
234	Tambora	**259**	Ciracas
235	Kembangan	**261**	Cipayung
236	Cengkareng		
237	Palmerah		
238	Kebon Jeruk		

OD Matrix to be assigned in Jabodetabek road network data is as follows (see **Table 3**).

Table 2. In part OD Matrix 2012

Zone	211	212	….	510	511
211	0	405	….	2	14981
212	410	0	….	2	5464
……	……	…..	….	……	……
510	2	2	….	0	
511	16102	5778	….	235	379468

The vehicles number passing each segment of road in the city represent as vehicles volume in units pcu/h is converted into the number of vehicles with passenger car equivalence (Department of Public Works, 1997). Emissions inventory calculations performed road segments when the vehicle working and using the following equation (EMEP / European Environment Agency, 2013):

$$\mathbf{E_{i,k,T} = N_k \times L_{A,T} \times e_{i,k}} \qquad \textbf{(1)}$$

$E_{i,k,T}$ is pollutant emission of i[g] at time T. N_k is vehicle typed k. $L_{a,T}$ is length road of a [km] at time T. And $e_{i,k}$ is emission factor [g/km] for pollutan i, for vehicle typed k, at time T. Emission factor showed by **Table 4** below.

Table 3. Summary of Emission Factor

No.	Pollutan	Vehicle Typed	Emission Factor (g/km)
1.	**CO**	Car	37.3
		Motorcycle	14.7
		Bus	5.71
		Minibus	2.71
		Truck	1.85
2.	**NOx**	Car	1.8336
		Motorcycle	0.0576
		Bus	15.84
		Minibus	8.989
		Truck	4.183
3.	**VOC**	Car	2.77
		Motorcycle	8.18
		Bus	1.99
		Minibus	0.706
		Truck	1.07
4.	**PM_{10}**	Car	0.0022
		Motorcycle	0.176
		Bus	0.909
		Minibus	0.479
		Truck	0.333

Source: EMEP- Corinair, 2013

Transportation demand was forecasted for 2017 using the main transportation network in place in 2012. The transport networks in BAU scenarios in 2012 and 2017 are assumed to be the same. The 2017 BAU scenario assumes that elevated busway 13th corridor would be implemented in 2017. The scenarios with the corresponding assumptions on transport network and enforced policies are summarized in **Table 5**.

Table 4. Summary of Emission Factor

Scenario	Transport network and enforced policies
Baseline	2012 Transportation demand + No action
BAU 2017	2017 Transportation demand + No action
Busway 2017	2017 Transportation demand + Elevated Busway 13th Corridor development

Figure 1. Study area of DKI Jakarta (PU Cipta Karya, 2012)

Policy scenario were developed based on the mass transportation typed *Bus Rapid Transit/Busway*, this is based on a comparison of the cost of the various types of mass transit (see **Table 1)**.

Table 5 Characteristics of Mass Transportation (Velocity,Construction Cost, Capacity)

No	Mode Type	Velocity	Cost	Capacity	Total Investment
		Km/h	Mill. USD/km	Passanger/ dir./h – Cor.	Km/ million US$
1	Bus Rapid Transit (Busway)	10 – 30	0,5 – 2,5	15.000 – 35.000	275/275
2	Light rail Transit (Monorail)	15 – 25	12 – 25	18.000 – 40.000	27,8/600
3	Mass rapid Transit (Subway)	30 – 35	30 – 105	20.000 – 70.000	14/900

Source: ITDP in transportation department in figures 2012, 2012

Mass transportation with the most efficient velocity, capacity passanger and total investment is bus rapid transit (BRT/busway). Some developing Asian cities consider BRT in their public transport planning because of its advantages of lower investment cost and flexible implementation over rail systems. Moreover, BRT is recommended that would shift private vehicle users to a transport sector which emits lower CO_2 (Satiennam et al, 2015).

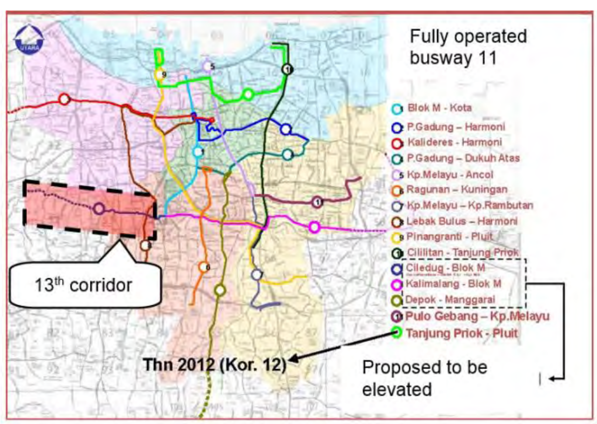


Figure 2. Busway corridor which has been operating in the city of Jakarta in 2012 (Transportation Department in figures, 2012)

On previous study (Ernst, 2006) showed that the possibility of shiftment from private transportation to buses by 14%. In the scenario, elevated busway to be implementated is corridor 13th. The length of the corridor 13th is 14.6 for a type of application 2x1 lanes (2 lanes 2 way).

RESULTS AND DISCUSSION

Traffic Volume

OD Matrix to be assigned to the Jabodetabek road network data for baseline is shown in

Table 6 below.

Table 6 In part Result of Baseline

Zone	**211**	**212**	**….**	**510**	**511**
211	0	405	….	2	14981
212	410	0	….	2	5464
……	……	…..	….	……	……
510	2	2	….	0	
511	16102	5778	….	235	379468

So the vehicles volume on the road traffic Jakarta as follows.

Table 7 In part Result of Baseline Vehicle Volume

Simulation/buffer		**Vehicle Volume**	**(pcu/hr)**
A node	B node	Total	Fixed
C 211	50091	29,205	0
50091	C 211	32,685	0
C 212	50090	10,674	0
50090	C 212	11,669	0
C 213	50045	13,760	0
……….	……….	……….	……….
……….	……….	……….	……….
90137	41448	6,280	0
90138	50160	4,541	0
90139	90130	2,323	0

Details proportion of passing vehicles on the main road and highway can be seen in **Figure 5**. The roads with the densest volumes are on the road Ciputat Raya. The number of cars, motorcycles, buses, minibuses, and trucks respectively - helped as many as 10,132; 49,076; 280; 407 and 650 units a day. The number of cars and trucks at most dominating motorway Gatot Subroto respectively - also 7823 and 4477 units per day.

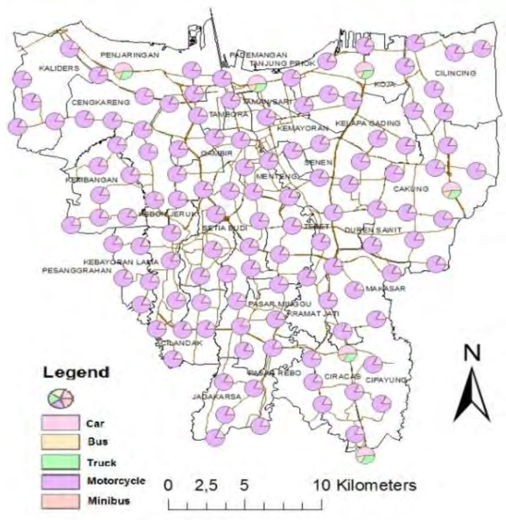


Figure 3. Mode Share based on typed in Jakarta by 2012

The proportion of vehicles that dominate the toll road in Jakarta is a car, whereas on a main road motorcycles dominate. This is the main cause of congestion (Ferdinansyah, 2009). The level of preference for private vehicles in Jakarta is quite high due to social status, security and comfort of the rider. Lacks of public transport services also trigger the use of private vehicles (Dissanayake and Morikawa, 2010).

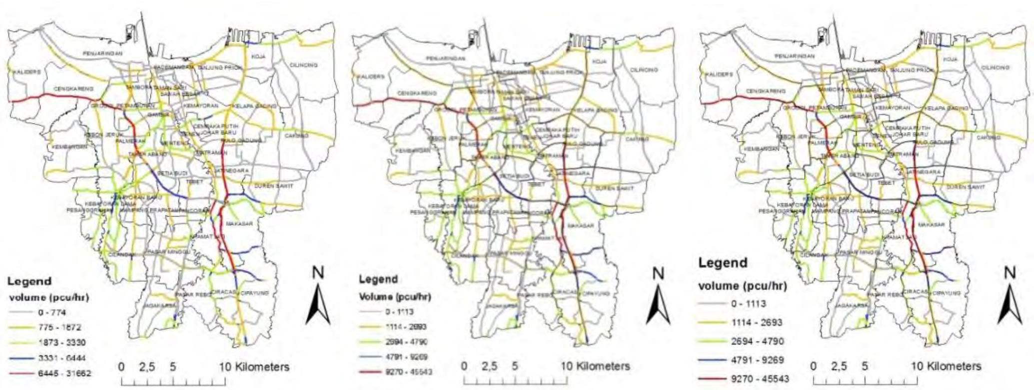
At baseline, where a scenario have not be applicable in 2012. The volume of vehicles on each road follows the path of a primary arterial road (**Figure 4**). In West Jakarta, the heavy volume of vehicles are in Cengkareng sub-district is on the road Daan amounted to 31,662 pcu/h (passenger car unit/hour). This is due to the high number of trips from the town Tangerang to Jakarta and vice versa (Sunggiardi, 2009). In addition, compared to other major roads in Jakarta, Daan Mogot road is one of the arterial roads at speeds below 10 km/h (Putranto, 2010). Activities dominant land use in the surrounding streets is in the form of services trade industry, and offices.

In South Jakarta, the heavy volume of vehicles are in Kebayoran Lama sub-district is on the road Ciputat Raya amounted to 23,992 pcu/h. The basic capacity of 4,950 pcu/h and per direction basis capacity of 5,560 pcu/h. Triggers number of vehicle volume is due to the use of the main road to the mobility of vehicle and to South Tangerang. In Ciputat there are also several small terminal, as in Jombang market, Bintaro market and Serpong market. Certainly, this will increase the number of vehicles passing on Ciputat Raya road. In East Jakarta, in Kramat Jati district heavy volume of vehicles crossing located on the May. Jend. Sutoyo street of 7,137 pcu/h. Several roads with heavy volumes estimated road network model are the road with high-frequency congestion. This is in line with the data traffic jam-prone areas in Jakarta.

Highway has a volume of most solid vehicles are toll roads Gatot Subroto in Central

Jakarta area Tanah Abang subdistrict with a volume of 16,470 pcu/h. Volume ratio and capacity on the road is around 0.91. This means that the road almost reached the degree of saturation. Toll road in East Jakarta with heavy volume is Jagorawi and the junction with the volume of vehicles Cawang 7,182 pcu/ h and 6,831 pcu/h. One treatment to reduce the density of vehicles in Jakarta is the modal shifts vehicle. Modal shifts of vehicles from cars and motorcycles allows changes to the ratio of VOC/NOx in the atmosphere (Nugroho, 2010).

The spread of the volume of vehicles on the scenario BAU 2017 did not undergo significant changes as well as Scenario of busway 2017. West Jakarta areas with high vehicle volume remained at Daan Mogot Street.



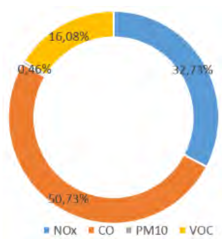
(a) (b) (c)

Figure 4. (a) Traffic Volume each segment in Jakarta by 2012**.** **(**b) Traffic Volume each segment in Jakarta by 2017. (c) Traffic Volume each segment in Jakarta based on busway 13th scenario by 2017

Load Emission

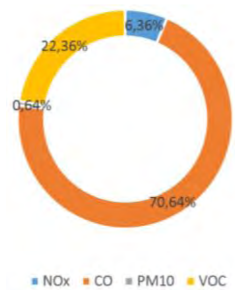
As a whole, baseline emission inventory on road segmentation in Jakarta by 2012 resulted 148,343 Gg/yr for NO_x; CO as 229,953 Gg/yr; PM_{10} as 2,089 Gg/yr. and VOC emission as 72.867 Gg/yr. CO plays the largest contribution as 50,73% of all pollutants and NOx as 32,73% as the second largest (**Figure 5a**). Meanwhile BAU scenario 2017 resulted emission load of NO_x as 29,687Gg/yr; CO as 330,748 Gg/yr; PM_{10} as 3,003 Gg/yr and VOC as 104,807 Gg/yr (**Figure 5b).** After Busway corridor 13th applied, NO_x as 29,651.47Gg/yr; PM_{10} as 2,991.55Gg/yr and VOC as 104,269.76 Gg/yr. CO still play as the largest emission for 329,377.52 Gg/yr and reached 72.48% of all pollutant typed (**Figure 5c).**

As we can see in **Figure 6 above**, the BAU Scenario resulted the largest emission load of NOx pollutant is laid on toll roads, toll roads i.e. IR. Wiyoto Wiyono with emissions amounting to 5,820.25 Gg/year. The highest NOx pollutants emissions on the main road, is located on the road of Ciputat Raya with emissions by 530.35 Gg/year. For NOx Emissions are highest on the motorway, although on a main road of vehicles is more varied.



(a)

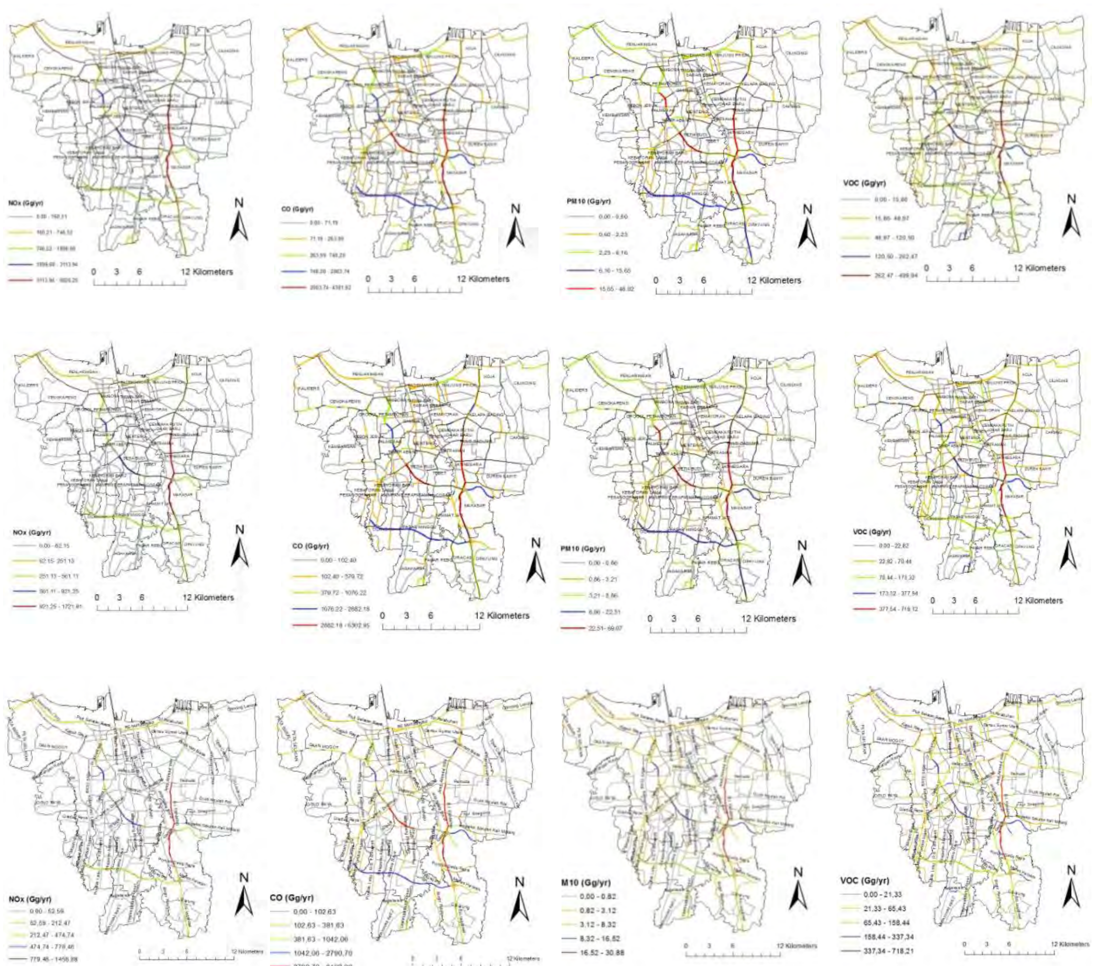
(b)



(c)

Figure 5. Emission Share of : (a) Baseline scenario in 2012. (b) BAU 2017 Scenario (c) Busway Corridor 13th in 2017

This is due to the number of vehicles of trucks that travel the highway more than the number of vehicles traveling on the main road. In addition, the length of the road on toll roads with the highest emission is longer than the main road. Emission load of CO highs along the Jakarta-Cikampek toll road of 1,695.94 Gg/year. On the main road, the largest emissions load of CO is on the road Ciputat Raya amounted to 1,279.58 Gg/year. Meanwhile, the highest CO emission load is on the highway, this is due to the number of cars and trucks more in that way. The largest PM_{10} emission load laid on toll roads, toll roads is located in IR. Wiyoto Wiyono with emissions amounted to 48.02 Gg/year. Emissions of the pollutants PM_{10} highest on the main road, is located on the road of Ciputat Raya with emissions by 10.82 Gg/year. On the highest emissions PM_{10} emissions are on the highway, although on a main road kind of vehicles is more varied. This is due to the number of vehicles of the same trucks that travel the highway more than the number of vehicles traveling on the main road. In addition, the length of the road on toll roads with the largest emission is longer than the main road. The highest VOC pollutants emissions load on the main street, namely in roads Ciputat Raya with emissions by 499.94 Gg/year. VOC emission load is in toll roads located in IR. Wiyoto Wiyono with emissions amounted to 430.28 Gg/year.



a) NO_x (b) CO (c) PM_{10} (d) VOC

Figure 6. Emission Load Based on Type of Pollutant: Baseline in 2012 (up). BAU Scenario in 2017 (middle). Busway Corridor 13th Scenario in 2017 (bottom).

In **Figure 6 Middle** can be seen, the emission load of each segment road in 2017 in DKI Jakarta. In General, the pattern of load emissions BAU scenario 2017 unchanged and only the values of the quantity of emissions are increasing at each toll road. When compared to scenarios Do – Nothing in 2012, pollutants NOx and VOC decline. While the pollutants CO and PM_{10}, the shares of load emissions are fixed.

In **Figure 6 below** can be seen, the emission load of each segment road in Jakarta. VOC pollutants Pattern is almost the same with NOx emissions burden, of which the highest are on the roads in and around Cawang Panjaitan. While the pattern of CO pollutant almost the same with those of PM_{10}, where the highest emission is around toll road Cawang and Letjen. S. Parman.

Table 8 Comparison of scenario result

cenario	Traffic Volume (smp/jam)	NO_x (Gg/yr)	CO (Gg/yr)	PM_{10} (Gg/yr)	VOC (Gg/yr)
BAU 2017	2,006	29	330	3	104.81
Scen. 3 Busway	2,002	25	326	2.43	103.06
Emission load reduction (%)		13%	1%	19%	2%

CONCLUSION

Emission inventory on road segmentation in Jakarta by 2012 resulted 148,343 Gg/yr for NO_x; CO as 229,953 Gg/yr; PM_{10} as 2,089 Gg/yr. and VOC as 72.867 Gg/yr. CO plays the largest contribution as 50.73% of all pollutants and NOx as 32.73% as the second largest. However the largest emission load located in other lane and it is resulted that emission load reduction from Busway 13th corridor operation is unsignificant with the rate 9%, repectively. In addition, the lane of this corridor is shorter compare than others. It is needs a further study to understand fully how much the exact emission load reduction of mode shitment to busway that illustrate CNG as fuel in combination with operational changes that lead to further improves emission reductions. To such degree emission reduction on busway depending on their operations, technology, age and passenger loading that eventually transit buses could be as polluting as private cars on a per passenger basis (Lau et al., 2012).

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ESTIMATION OF TOTAL CARBON EMISSION FROM FOREST FIRES: CASE STUDY OF BORNEO ISLAND

Arno Adi Kuntoro[1,*,†] Ade Wahyu[2], Hendri[3]:
[1]Faculty of Civil and Environmental Engineering, Institut Teknologi Bandung, Indonesia
Email: arnoak@ftsl.itb.ac.id
[2]Ministry of Environment and Forestry of Indonesia
Email: wahyuforester@yahoo.com
3Universitas Papua, Indonesia
hendri888@gmail.com
* Presenter; † Corresponding author.

Abstract: The availability of combustible materials and their flammability are important aspects in forest fires studies, especially to predict the total carbon emission to the atmosphere. From point of view of earth system modeling, Dynamic Global Vegetation Model (DGVM) provides most of the basic computations for simulating the interactions between terrestrial ecosystem and the atmosphere, including carbon accumulation in vegetation bodies, litter and soil/peat, by considering the effect of climate conditions and its variability. In this study, a modified Lund Potsdam Jena Dynamic Global Vegetation Model (LPJ-DGVM) for application in tropical area is used to simulate the total amount of carbon emitted to the atmosphere in Borneo Island from 1980 to 2006. Simulation results show that the annual average carbon emission from forest fire in Borneo Island is 0.02 to 0.06 GtC/y, with the highest emission during 1997-1998 El-Niño event, which is about 0.05 GtC if only considering the burned of aboveground vegetation, to about 0.62 GtC by also considering the burned of peat layer.

Keywords: DGVM, forest fire, carbon emission, Borneo

INTRODUCTION

Tropical forests together with tropical peatlands are one of largest carbon storage in the terrestrial ecosystem. With average carbon stock per hectare about 157.1 t/ha, the total carbon stored in Asia and South East Asia was about 44.5GtC, in which about 31%was located within Indonesian territory [1]. The total areas of tropical peatlands were estimated about 38 million ha which mostly located in Southeast Asia. Total peat carbon stored in this region was about 50.4GtC, with more than 90% was located in peatlands area in Indonesian territory [2]. In general, tropical forests and tropical peatlands act as a carbon sink.About 30% of Indonesian land territory is located in Borneo. Most area of this island was covered by rainforest. However, rapid land cover changes since the early 1970s has reduced its forest cover to about 71% in 1980s with further decrease up to 54% in 2000s [3]. Many studies suggest that large scale deforestation and forest fire might contributes to more CO_2 emission to the atmosphere such those occurred during an extreme El-Niño in 1997-1998 which was followed by a large forest fire in Borneo Island [4],[5].

Forest fires can be analyzed from three aspects: combustible materials, their flammability and fire sources. This study is focused in the analysis of the availability of combustible materials, which is closely related to the estimation of total carbon pool in vegetation, litter and soil/peat and their flammability. Fire sources in human induced landscapes are quiet complex to be modeled. Such analysis should include various factors such as demography, distance of disturbed area to the forest boundary, road, etc., which is mostly beyond the capability of the current DGVM.

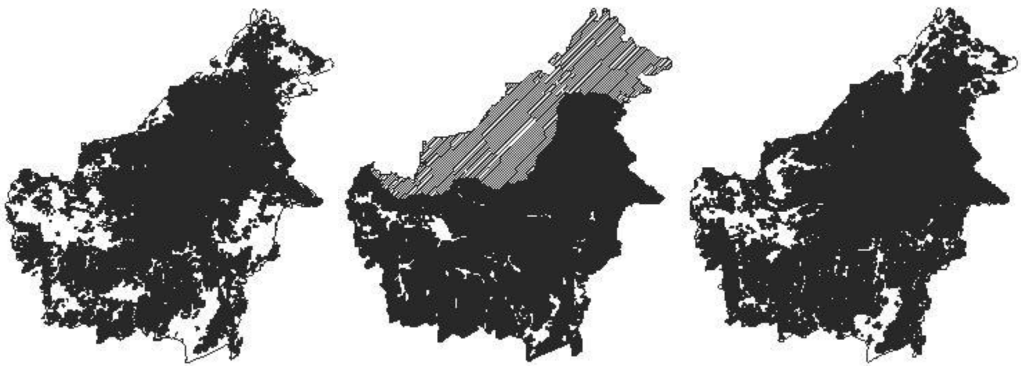
Many studies focused on field investigation and direct measurement, for example:[4],

[6], [7],[8], while other studies focused on GIS application, for example [9],[10],[11]. Lund-Postdam-Jena Dynamic Global Vegetation Model (LPJ-DGVM) is a model which was originally developed for global scale analysis [12]. In this study, a modified LPJ-DGVM is used for regional scale analysis to simulate the total carbon emission from forest fire in Borneo Island from 1980 to 2006.

MATERIALS AND METHODS

Study Area

Borneo Island is located between 108°45'E and 119°30'E, 7°15'N and 4°15'S, with total area about 734.000 km^2. Wood-log productionsfrom Borneo islandwere very high during the mid of 1980s until late of 1990s and suddenly decreased after 1998. Together with illegal logging, the high wood production is one of the main causes of the rapid decrease of forest cover in this island. Deforestation in Borneo Island also leads to the increase of forest fire occurrence. One of the largest forest fire event was occurred in 1997-1998, resulted in 3 to 4.5 million hectares of forest loss in Borneo Island [13],[14]. Forest degradation in Borneo Island is shown in Figure 1.



1950* 1980** 2000**

Figure 1. Forest Degradation Map in Borneo Island

Source:
* Ministry of Forestry, Republic of Indonesia; ** [3]

Carbon Emission From Forest Fire

In general, decomposition is affected by external factors (e.g.: temperature and soil moisture) and internal factors (e.g.: litter type). The effects of temperature and soil moisture on decomposition have been widely recognized and study on this field is progressing as people awareness on the effect of global warming to carbon sequestration is also increasing [15].

One of the most commonly used equations to describe mass decay in decomposition is the first-order equation [16],[17]. This equation can be written as:

$$\frac{x}{x_0} = 1 - e^{-kt} \qquad (1)$$

where$x$ is the remaining mass, x_o is the initial mass, k is the decay constant and t is the

time in years.
In general, leaf and fine woody materials are decomposed faster than root and coarse woody materials. Therefore, different decay coefficient for different sources of litter materials (leaf and woody) is used in the model. The following constants are used:

$k_{10}leaf = 0.1$ (2)

$k_{10}branch = k_{10}root = 0.3$ (3)

where $k_{10}leaf$, $k_{10}branch$, and $k_{10}root$ are the decay rate at 10°C for leaf, branch and root, respectively.
In LPJ v1, litter and soil decomposition are computed by using the following equations:

$$k_{dec} = k_{10} k_T k_m \quad (4)$$

$$k_T = exp\left(308.56\left(\frac{1.0}{56.02} - \frac{1.0}{T_{soil} + 273.0 - 227.13}\right)\right) \quad (5)$$

$$k_m = \frac{(1 - e^{-1.0\,w})}{(1 - e^{-1.0})} \quad (6)$$

where k_{dec} is the decomposition rate, k_{10} is the decay rate at 10°C, k_T is the temperature response of decomposition, k_m is the moisture response of decomposition, T_{soil} is the soil temperature (°C) and w is the soil moisture content.
These set of equations are used for general type of soil. In this study, moisture responses of decomposition equations suggested by [18] are added into the model for application in peat soil.

$$k_{m\_peat} = 1 - \left(\frac{w_{opt} - w}{w}\right)^5 \quad \text{for } w < w_{opt} \quad (7)$$

$$k_{m\_peat} = 1 - (1 - 0.025)\left(\frac{w - w_{opt}}{1 - w_{opt}}\right)^3 \quad \text{for } w \geq w_{opt} \quad (8$$

where k_{m_peat} is is the moisture response of decomposition for peat soil and w_{opt} is the optimum soil moisture content = 0.75.

Computation of Fire Module

In LPJv1, area affected by fire is computed as function of litter availability, tree resistance
index and length of fire season.

$$A = I_{fire}\, \exp\left[\frac{I_{fire} - 1}{a_1 (I_{fire} - 1)^3 + a_2 (I_{fire} - 1)^2 + a_3 (I_{fire} - 1) + a_4}\right] \quad (9)$$

$$I_{fire} = \frac{1}{n_{day}} \sum_{day=1}^{n_{day}} P_{fire} \quad (10)$$

$$P_{fire} = \exp\left[-\pi \left(\frac{d_{sw}}{m_e}\right)^{2.0}\right] \quad (11)$$

$$m_e = \sum_{pft=1}^{npft} \frac{litter_{ag\,pft}}{litter_{ag\,total}}\, flam_{pft} \quad (12)$$

where A is thearea affected by fire, I_{fire} is the fire index, a_1 to a_4 are constants, n_{day} is the number of day in a year (365 or 366), P_{fire} is the length of fire season, d_{sw} is the daily soil water content, m_e is the moisture factor, $litter_{agpft}$ is the above ground litter for each tree “Plant Functional Type” (PFT), $litter_{ag\ total}$ is the total above ground litter and $flam_{pft}$ is the flammability index (constant for each PFT).
Carbon flux from forest fire are computed using the following equations:

$$Cflux_{atm_{veg}} = A.(1 - resist_{tree}).nind.(lm + sm + hm + rm) \quad (13)$$

$$Cflux_{atm_{lit}} = A(1 - resist_{tree}).nind.(litter_{ag}) \quad (14)$$

$$resist_{tree} = c \quad (15)$$

where$clux_{atmveg}$is the carbon flux to the atmosphere from burned vegetation, A is the area affected by fire, $resist_{tree}$ is tree resistance index, $resist_{tree}$is thetree resistance index, *nind* is the number of individual, *lm, sm, hm* and *rm* are the leaf, sapwood, heartwood and root mass, respectively, $clux_{atmlit}$is the carbon flux to the atmosphere from burned litter and $litter_{ag}$ is the litter carbon mass.
In the modified fire module, area affected by fire is computed as function of existing land cover type, tree resistance index, length of fire season and interannual climate variability.

$$A = k_3 k_4 I_{fire} \exp\left[\frac{I_{fire}{}'-1}{a_1{}'(I_{fire}{}'-1)^3 + a_2{}'(I_{fire}{}'-1)^2 + a_3{}'(I_{fire}{}'-1) + a_4{}'}\right] \quad (16)$$

$$I'_{fire} = \frac{1}{n_{day}} \sum_{day=1}^{n_{day}} P_{fire}{}' \quad (17)$$

$$P_{fire}{}' = k_1 \exp\left[-\pi \left(\frac{d_{sw}}{m_e}\right)^{k_2}\right] \quad (18)$$

$$m_e = constant = 0.95 \quad (19)$$

where A is thearea affected by fire, k_3 is the correction factor for inter-annual climate variability, k_4 is the correction factor for length of fire season, I_{fire} is the fire index, a_1' to a_4' are constants, n_{day} is the number of day in a year (365 or 366), P_{fire} is the length of fire season, d_{sw} is the daily soil water content, k_1 and k_2 are functions of land cover, m_e is the moisture factor, taken as constant.

Vegetation Fire Resistance

Some studies show that vegetation resistance index is strongly correlated with tree diameter, for example [4]. In LPJ v1, fire resistance index of each PFT is set as constant value (e.g.:evergreen tree = 0.2, raingreen tree = 0.5). To approximate the tree mortality rate due to forest fire as function of tree diameter, data from [8] and [19] are plotted together to obtain a regression function as follow:

$$mortal_{tree} = 0.6685D^2 - 1.4439D + 0.8784 \quad (20)$$

$$resist_{tree} = 1 - mortal_{tree} \quad (21)$$

where, $mortal_{tree}$ is the PFT fire mortality rate, $resist_{tree}$ is the PFT fire resistance index and D is the tree diameter.

Fraction Of Vegetation And Litter Consumed By Fire

In LPJ-DGVM, carbon pool is distributed into vegetation, litter and soil pools. During forest fire event, some fractions of these carbons are consumed by fire and released to the atmosphere. In LPJv1, it is assumed that all carbon pool in vegetation (leaf, wood and root) and litter in the burned area are entirely consumed by fire (Eq.13 and 14), while soil carbon is not affected by fire. A research from [20] suggest that only about 25% of above ground vegetation materials (mainly leaf and small woody parts) in the burned area are fully consumed by fire and emitted to the atmosphere, while root materials are less affected by fire. In case study of East Kalimantan, [4] shows that above ground litter materials were completely burned during 1997-1998 forest fire event. These approaches can be expressed in the following equations:

$$Cflux_{atm_{veg}} = A\,.\,resist_{tree}\,.\,nind\,.(0.25\ lm + 0.25\ rm + 0.25\ hm) \quad (22)$$

$$Cflux_{atm_{lit}} = A.\,resist_{tree}\,.\,nind\,.\ (1.0\ litter_{ag}) \quad (23)$$

$$Cflux_{lit_{lit\ ag}} = A\,.\,resist_{tree}\,.\,nind\,.(0.75\ lm + 0.75\ rm + 0.75\ hm) \quad (24)$$

$$Cflux_{lit_{lit\ bg}} = A\,.resist_{tree}\,.nind\,.\ (1.0\ rm) \quad (25)$$

where $cluxatm_{veg}$is the carbon flux to the atmosphere from burned vegetation, A is the area affected by fire, $resist_{tree}$ is tree resistance index, *nind* is the number of individual, *lm, sm, hm* and *rm* are the leaf, sapwood, heartwood and root mass, respectively, $cluxatm_{lit}$is the carbon flux to the atmosphere from burned litter, $litter_{ag}$ is the litter carbon mass, $cluxlit_{lit_ag}$is the carbon flux to the above ground litter from dead-unburned vegetation (leaf , sapwood and heartwood), $cluxlit_{lit_bg}$is the carbon flux to the below ground litter from dead-unburned vegetation (root).

Fraction of Peat Consumed By Fire

Carbon release to atmosphere from peatlands mainly caused by two factors: the lowering of soil water table and fires in degraded peatlands[20]. For the first factor, soil water table has positive feedback to carbon accumulation in peatlands. The high soil water table reduces decomposition rate, while accumulation of organic carbon in peat might also increases water holding capacity which maintain soil water table [21],[18]. For the second factor, soil water table has positive feedback for fire prevention. In case study of Central Kalimantan, [24] shows that peat is highly susceptible to fire if soil water level is less than the critical threshold of 40cm below peat surface.

In LPJv1, water balance computation uses 2 layers of soil: upper layer with 50cm depth and lower layer with 100cm depth. In general, soil water fraction is computed by:

$$w_i = \frac{uw_i}{whc_i d_i} \quad (26)$$

wherew_i is the soil water fraction, uw_i is the height of water table, whc_i is the water holding capacity as function of soil type and d_i is the height of soil layer (0.5m for upper layer, or 1.0m for lower layer).

In this study, it is assumed that peat layer is located at the top of soil layer. By applying the threshold of 40cm below surface with water holding capacity (*whc*) for peat soil = 0.8 and soil layer height of 50cm, then w_i'=0.25

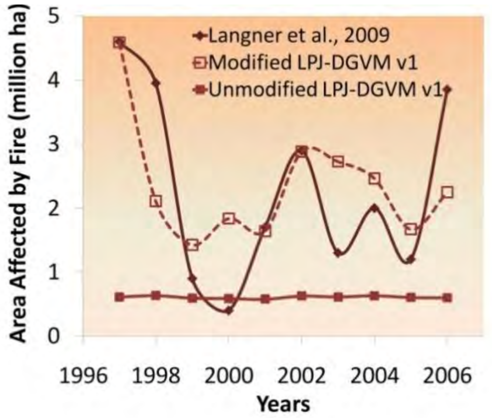
In further computation, soil water fraction value of 0.75 and 0.33 (slightly higher than the value of w_i') are used to approximate the function of peat fire resistance as shown in Eq.27.

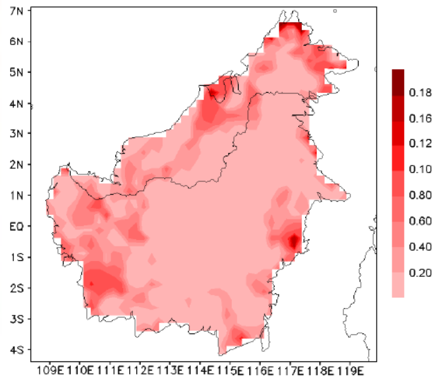
$$k_{peat} = c\frac{\sum_{day=1}^{n_{day}}(d_{sw}<0.33)}{\sum_{day=1}^{n_{day}}(d_{sw}<0.75)} \quad (27)$$

where$c$ is a constant, d_{sw} is daily soil water fraction, and n_{day} is number of day in a year.

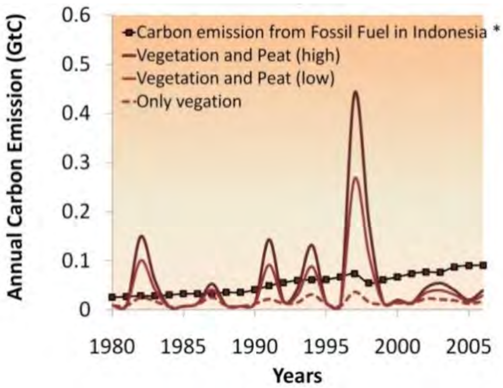
RESULTS AND DISCUSSIONS

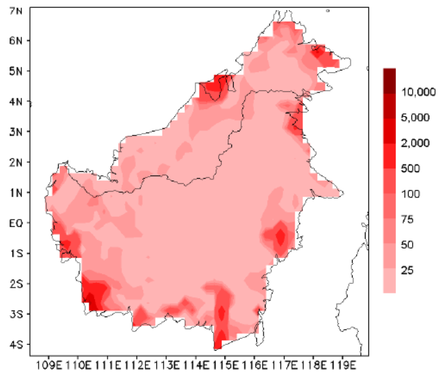
Carbon emission from forest fire is computed as function of area affected by fire, carbon accumulation (in vegetation, litter and soil/peat) and fraction of carbon consumed by fire. **Figure 2a** showscomparison of total area affected by fire in Borneo Island from 1997 to 2006 between the simulation result and the data compiled by [14]. Simulation result using the modified LPJ-DGVM shows nearly similar pattern although in some simulation years the result also shows underestimate (e.g.: 2006) and overestimate value (e.g.: 2000, 2002).





a) Total area affected by fire (1976-2006) b) Average area affected by fire (1980-2006)





*source: (http://beta.worldbank.org/climatechange/dat

c) Carbon emission from fossil fuel (data) and from forest fire in Borneo Island (simulated), in GtC.

d) Annual average carbon emission from forest fire (1980-2006) in gC/m^2

Figure 2. Simulation result of area affected by fire and carbon emission from forest fire in Borneo Island

Figure 2b, 2c and **2d** shows simulation result from 1980 to 2006. Compared to hotspot distribution compiled [14], **Figure 2b** shows that area affected by fire simulated by using the modified LPJ-DGVM shows relatively similar pattern. Simulation result tends to be underestimates in some areas of Central Kalimantan. In West Kalimantan, simulation result shows similar pattern with the data but tend to be slightly overestimate in the West Coast area.

In case study of East Kalimantan during 1997-1998 forest fire, [4] shows that the average burnt depth of peat is about 50cm. Based on this event, three scenarios of fire emission are used: 1) High scenario by assuming ~50cm of peat is burned, 2) Low scenario by assuming ~25cm of peat is burned, and 3) by assuming no peat fire. **Figure 2c** shows simulation result of annual carbon emission from forest fire in Borneo Island from 1980 to 2006 in time series, based on the above scenarios. The result shows that the average carbon emission from 1980 to 2006 is between 0.02GtC/year (for no peat scenario) to 0.06GtC/year (for high scenario). For large forest fire event during 1997-1998, the total carbon emission from forest fire (two years cumulative) is between 0.05GtC (for no peat scenario) to 0.62GtC (for high scenario). During large forest fires (e.g.: 1982-1983 and 1997-1998), total carbon emission from forest fire in Borneo Island alone might be higher than the total carbon emission from fossil fuel in Indonesia.

CONCLUSIONS

In this study, a modified of LPJ-DGVM is used to simulate carbon emission from forest fire during period of 1980 to 2006. Simulation result of carbon accumulation shows relatively good result and still between the range of maximum and minimum of the data. During 1997-1998 forest fire event in Indonesia, the total carbon emission in Indonesia caused by the fire from some cited references are 0.81 to 2.57 GtC from peat fire and 0.05 GtC from overlying vegetation [4], 0.2066 GtC[23] and 0.493 GtC[5]. During the same event about 10 million hectares area were affected by fire. Some cited references are 9,745,000 ha [23] and 11,698,379 ha [5]. By assuming that 68% of the total carbon emission from Indonesia area were contributed from Borneo Island, it estimated that carbon emission from Borneo Island were about 0.138 to 1.745 GtC.

This analysis shows that modeling approach can be used to connect a detail and direct field measurement data, e.g.:[4] with a wider range of spatial analysis in GIS based data, e.g.:[5],[9]. Extrapolating a field measurement data into larger area and/or interpolating a GIS based data might result in bias due to the different conditions both in spatial scale, temporal scale and other local conditions. By using a model such as LPJ-DGVM, both data can be integrated to reproduce past and present event, which can be used further as basis for future mitigation plan to reduce carbon emission, especially from forest fires.

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PHOTOSENSITIVITY OF GRAPHITIC CARBON NITRIDE FILMS OBTAINED BY EVAPORATION

Hitoe Habuchi[a,*,†], Shiori Fujita[b], Hirofumi Takikawa[c]
[a,b]National Institute of Technology, Gifu College, Japan
[c]Toyohashi University of Technology, Japan
Email: [a]habuchi@gifu-nct.ac.jp, [b]2014s17@edu.gifu-nct.ac.jp, [c]takikawa@ee.tut.ac.jp
* Presenter; † Corresponding author.

Abstract: Graphitic carbon nitride (g-C_3N_4) comprises a two-dimensional sheet of carbon and nitrogen atoms. In the present study, g-C_3N_4 films were prepared by evaporating guanidine carbonate for evaluating the photosensitivity of the films. The X-ray diffraction peak of the g-C_3N_4films was observed at 2θ=27.6°, corresponding to interlayer stacking. The N/C atomic ratio obtained by energy dispersive X-ray spectroscopy was approximately 133%. The results indicated characteristics associated with two-dimensional carbon and nitrogen atom structures. The optical energy gap was estimated to be 2.88 eV at N/C =136%, and it decreased with elevation in substrate temperature. Photo sensitivity spectra were obtained by irradiation with monochromatic light. The photocurrent originated from electronic transition between energy bands because the photon energy at which the photo sensitivity increases was consistent with the optical energy gap.

Keywords: Graphitic carbon nitride; photosensitivity; photocurrent; optical absorption spectra

INTRODUCTION

Carbon compounds are used to produce multiple organic compounds including hydrocarbons and inorganic compounds such as CO_2 and SiC. The crystalline formation of carbon nitride is more difficult than that of silicon nitride. Ever since Lie and Cohen reported that carbon nitride can show stability via theoretical calculations [1], many groups have attempted to prepare crystalline C_3N_4 using chemical vapor deposition, sputtering, and arc ion plating [2-10]. Samples obtained in their studies were usually amorphous carbon nitride (a-CN_x) because nitrogen is difficult to incorporate into a carbon network. Furthermore, carbon nitride scan exist with polymeric formations. The synthesis method of crystalline C_3N_4, such as α-C_3N_4 or β-C_3N_4,has not been established.

Berzelius et al. (1834) reported the synthesis of a polymeric carbon nitride for the first time [11].Presently, polymeric carbon nitride is called graphitic carbon nitride(g-C_3N_4) because it comprises a two-dimensional sheet such as graphite. g-$C_3N_4$is easily synthesized by thermal polymerization of melamine and dicyandiamide [12].g-C_3N_4powder is a semiconductor with an energy band gap of 2.7 eV; furthermore, it shows photo catalytic properties of organic contaminant degradation. Although the photo catalytic efficiency of pure g-$C_3N_4$is very less, the addition of a small amount of Pt nano particles activates H_2 production [13]. After this discovery, compared to titanium dioxide (TiO_2), g-C_3N_4 has been actively studied as a new photo catalyst. Thus, g-C_3N_4can possibly be applied to the material in an environmental improvement system for organic pollution in air [14]. However, g-C_3N_4 has not been quantitatively evaluated because g-C_3N_4 is obtained in the powdered form when melamine is used for the synthesis. In this study, the structure and optical properties of g-C_3N_4 films prepared by guanidine carbonate evaporation are discussed.

EXPERIMENTAL

g-C_3N_4 Film Preparation

The g-C_3N_4 films were prepared using an evaporation method reported by Miyajima (2014) [15]. Guanidine carbonate(97% pure) was used as the source material. Guanidine carbonate (3.0 g) was placed at the bottom of the quartz test tube, as shown in Figure 1. Borosilicate glass or quartz substrates were also placed in the tube away from the guanidine carbonate. The tube was capped with quartz wool. It was heated in air to a target temperature of 600°C–630°C at a rate of 10 °C/min using a tube furnace (NISSIN SEIKI CO., LTD, TMF-300N).The temperature was kept constant for 2 h. After heating, the tube was naturally cooled to room temperature. The heating caused the polymerization of guanidine carbonate and the polymer was subsequently evaporated [15]. The evaporated polymer formed g-C_3N_4 sheets on the substrate.

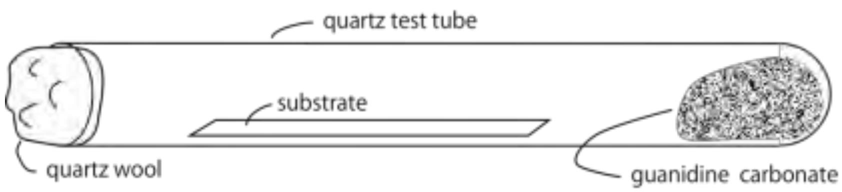


Figure 1. Apparatus for preparing g-CN_x films using guanidine carbonate.

Energy Dispersive X-Ray Spectroscopy and X-Ray Diffraction

A scanning electron microscope (SEM, Hitachi HighTechnologies, S-3400N) was used to observe the film's surface. The elemental composition ofg-C_3N_4filmswas estimated using energy dispersive X-ray spectroscopy (EDS, Horiba, X-MAX50).X-ray diffraction (XRD, RigakuSmartLab) was used to determine the crystalline structure of films. The wavelength of the X-ray beam was λ=1.54 Å (Cu Kα).

Optical Energy Gap

The optical transmittance spectra were obtained using a UV-VIS-NIR spectrometer (Shimadzu, UV-3150). The thickness and refractive index were calculated using spectral oscillation of optical interference.The optical energy gap $E_{04}$was defined as the photon energy at which the optical absorption coefficient was 10^4 cm^{-1}.

Photosensitivity

For electrical measurements, gap electrodes of aluminum were created on the sample surfaces using a vacuum evaporation method. The gap and width of the electrodes were 60 µm and 5 mm, respectively. Sampleswere illuminated by monochromatic light passed through a monochromatorand optical filters using a Xe lamp as a light source. The current was monitored by applying a constant voltage of 20 V to electrodes usinga source meter (Keithley 2635B).The photocurrent was defined as the difference between the dark and illuminated currents.Normalization of photocurrent is usually requiredbecause the incident light power variesby the wavelength of the monochromatic light. We used spectroscopic photosensitivity(A/W), defined as photocurrent divided by incident light power into the surface area between electrodes, for normalization.

RESULTS AND DISCUSSION

Structural analysis

Figure 2 shows the atomic concentration of a g-C_3N_4 filmobtained by EDX. The concentrations of silicon, aluminum, and oxygen increased withincreasing electron accelerating voltage. The detected presence of these atoms was due to signals from the sample substrate.Therefore, the atomic concentration represents accurate values at lower electron accelerating voltage. In this study, the N/C ratio was determined using the concentration at an electron accelerating voltage of 3 kV. Figure 3 shows the N/C atomic ratio and the thickness of g-C_3N_4films as a function of distance D from the edge of guanidine carbonate powder. The film was thickest at D=65 mm. The N/C ratios were almost flat and approximately 1.33,which were agreeable with that of g-C_3N_4 powder having the theoretical structure of a CN network sheet.

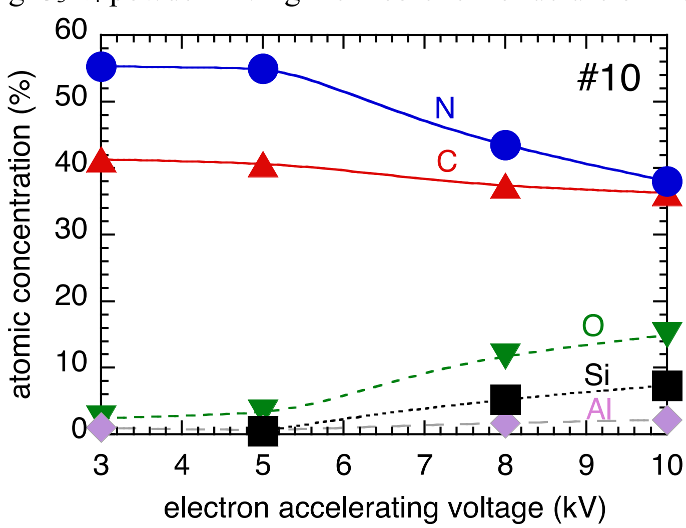


Figure 2. The atomic concentration of a g-C_3N_4 film as a function of electron accelerating voltage.

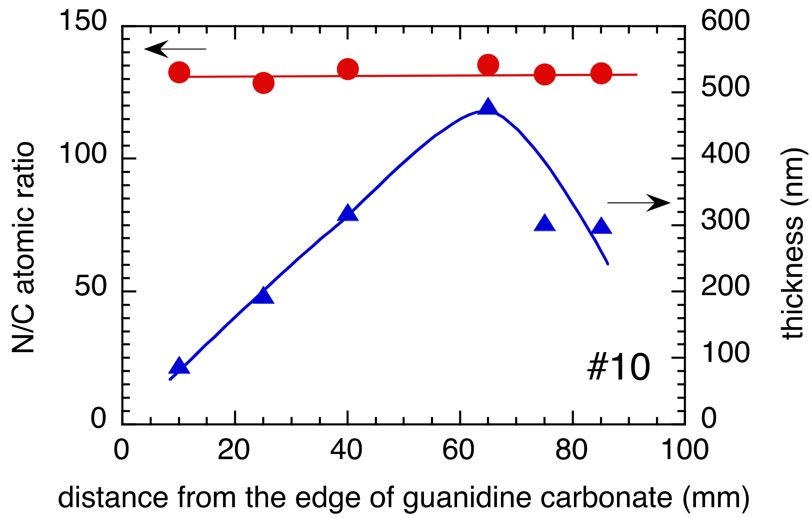


Figure 3. The N/C atomic ratio and the thickness of g-C_3N_4 films as a function of the distance from the edge of guanidine carbonate, where they are represented by circle and triangle plots, respectively.

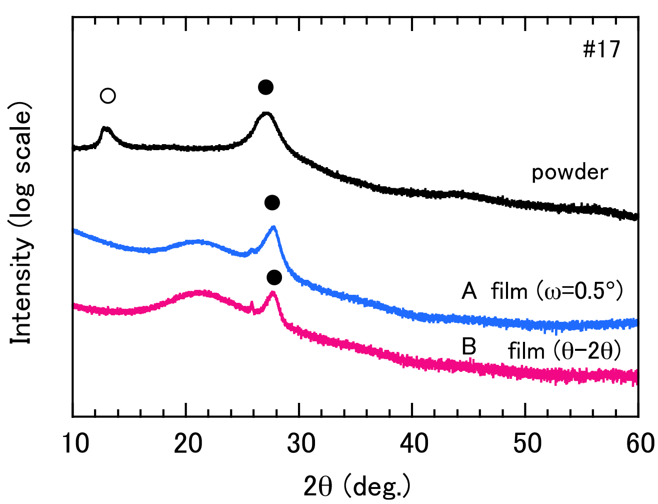
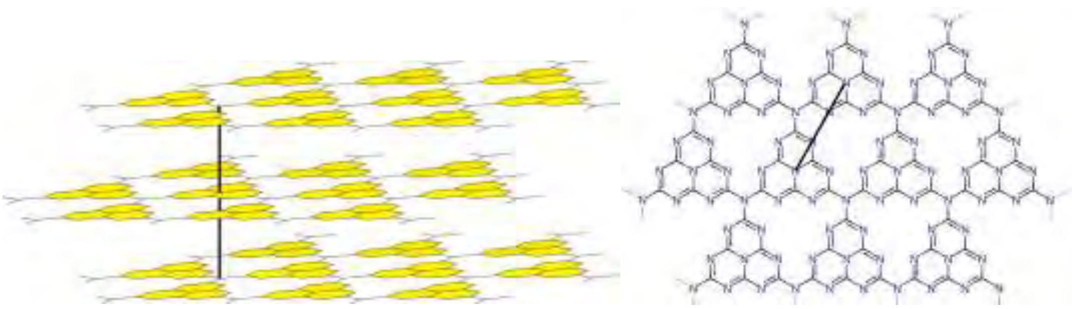


Figure 4. XRD pattern of g-C_3N_4 powder and film, where lines A and B were obtained by q- $2q$and the grazing angle method, respectively.



(a) interlayer distance (b) in-planar distance

Figure 5. Structure of g-C_3N_4 and the distance between diffraction planes.

Figure 4 shows XRD patterns of the remaining powder after heating and a g-C_3N_4 film. As for XRD measurement of the film, two methods were used. One was the q- $2q$ method and the other was the grazing angle method, where the incident angle $W$was fixed at 0.5°. The XRD pattern of the powder was owing to a typical g-C_3N_4 structure [13]. Themain peak indicated by a solid circle (2θ=27.6°) corresponded to interlayer stacking as shown in Figure 5 (a).The peak indicated by an open circle (2θ=12.8°) originated from an in-planar repeat period, such as the distance between pores as shown in Figure 5(b). This peak did not appear on the XRD pattern of the film. This could be because the sheet size of the CN network of the film is smaller than that of g-C_3N_4 powder.The appearance of the main peak with the grazing angle methodindicates that the g-C_3N_4 sheet was not aligned in the direction parallel to the substrate.

Optical Properties

The temperature at the center of the furnace was different from the substrate temperature because of uneven temperature distribution in the furnace. Therefore, g-C_3N_4 films were prepared while monitoring the substrate's temperature Ts during heating. Figure 6 shows the N/C ratio and optical energy gap E_{04} with various Ts. Note that E_{04} decreased with elevating Ts. Heating at high temperature was needed to obtain an energy gap less than 3.0 eV (energy gap of rutile titanium dioxide) for the g-C_3N_4 film.When the heating temperature was low, thermal polymerization was not very active. Therefore, the N/C ratio of the film at lower Tswas approximately close to that of the precursor. In this case, the N/C ratio theoretically increased with decreasing Ts because melem ($C_6N_7(NH_2)_3$)was the precursor of g-C_3N_4.The experimental results differed from our hypothesis; however, the reason for this is currently unknown.

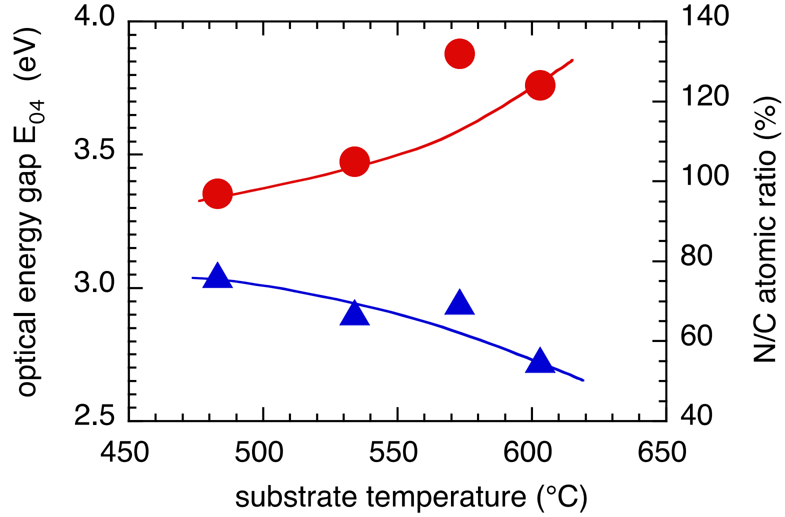


Figure 6. The optical energy gap E_{04} and N/C atomic ratio with various substrate temperatures.

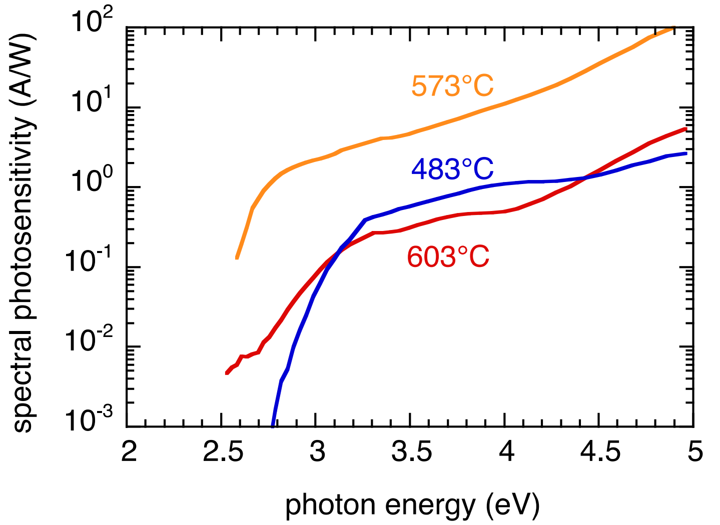


Figure 7. The spectral photosensitivity of g-C_3N_4 films with various substrate temperatures.

Figure 7 shows spectral photosensitivity of g-C_3N_4 films with various T_s. The magnitude of photosensitivity was different among samples because of differences in film thickness and surface conditions. The photosensitivity spectrum of the film at T_s=483°Cand 573°C showed increases of approximately 3.0and approximately 2.6 eV, respectively. The edge of photosensitivity of the film at T_s=603°C was obscure. This could be because the photocurrent originated from electronic transition between energy bands because the photon energy at which the photosensitivity rose was consistent with the optical energy gap.

CONCLUSIONS

In our study, the g-C_3N_4 films were prepared via evaporation of guanidine carbonate to evaluate their photosensitivity. The N/C atomic ratio was approximately 133%. The diffraction caused by the CN network layer was observed by XRD; however, an in-planar repeat period, such as the distance between pores of nitrogen, was not confirmed. We estimated that the CN sheet size of films was smaller than that of original g-C_3N_4 powder. The optical energy gap $E_{04}$was estimated to be 2.88 eV at N/C =136%. This value is smaller than the energy gap of rutile titanium dioxide. Moreover, the photocurrent of g-C_3N_4 films was observed. We confirmed that the photocurrent flows because of electronic transition between energy bands. Therefore, the application of g-C_3N_4 as a photo catalytic material is advantageous for efficient conversion of solar light.

ACKNOWLEDGMENTS

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EVALUATION OF CONTINUOUS AND FILTER-BASED METHODS FOR MEASURING $PM_{2.5}$ MASS CONCENTRATION IN BANDUNG URBAN AREA

Fatimah Dinan Qonitan[1*], Puji Lestari[2†], and Haryo S. Tomo[3]
Master Program of Environmental Engineering
Faculty of Civil and Environmental Engineering, Institut Teknologi Bandung
JalanGanesha No. 10, Bandung 40132
E-mail: [1]fdinanq@gmail.com, [2]pujilest@indo.net.id, [3]haryotomo@gmail.com
Presenter; † Corresponding author.

Abstracts: Assessing the effects of air pollution to public health requires continuous and accurate measurements of particle with aerodynamic diameter < 2,5 µm ($PM_{2,5}$). This study seeks to evaluate sampling performance of samplers from newly established monitoring network, Surface Particulate Matter Network-SPARTAN for $PM_{2,5}$ mass concentration measurements at an urban site in Bandung, Indonesia. Sampling were carried out during January-August 2014 where a filter based sampler, AirPhoton® Filter Sampler, an automated continuous sampler, AirPhoton® Nephelometer, operated in parallel and simultan with the reference instrument, Harvard Impactor. 21 days intercomparison study showed good agreement (R^2=99,4% P-Value=0,000) between $PM_{2,5}$ mass concentration measured by two filter based method, Filter Sampler ($\bar{x}$=31,55 µg/Nm^3) and Harvard Impactor ($\bar{x}$=34,10 µg/Nm^3). Nephelometer backscatter in 532 nm wavelengths (green) resulted hourly estimates of $PM_{2,5}$ mass concentration. Hourly estimates of $PM_{2,5}$ has $\bar{x}$=36,754 µg/Nm^3 and stdev=20,610 µg/Nm^3, which is similar with filter-based measurement result, $\bar{x}$=36,80 µg/Nm^3 and stdev=8,04 µg/Nm^3.

Keywords: fine particulate, urban, nephelometer, filter, impactor

INTRODUCTION

$PM_{2.5}$, particles with aerodynamic diameter less than or equal to 2.5 µm, is one of the main pollutants of the atmosphere. Highest $PM_{2.5}$ pollution commonly found in large cities with high population density (Liu et al., 2009). Long term exposure of $PM_{2.5}$ is a strong indicator of chronic obstructive pulmonary diseaseand cardiorespiratory mortality (Pope, 2000).$PM_{2.5}$ aerosols present a high risk of deposition in the alveoli of lungs and are associated with a greater general health risk than coarse aerosols (Lipmann, 1998 in Fujii *et al.,* 2014).

Former research by Zannaria et al. (2008) about respirable particulates exposure in Bandung concluded that the citizens potentially exposed to 16,56 – 26,86 µg/m^3 $PM_{2.5}$ everyday. This condition meets the ambient national standard, but needs to be considered as early warning for long term $PM_{2.5}$ monitoring needs in Bandung. Increasing tendency of emission load and Bandung topographical condition which is not well ventilated potentially cause increasing health risks due to $PM_{2.5}$ exposure for the population (Zannaria et al.,2008).

Surface Particulate Matter Network-SPARTAN is a newly established global particulate monitoring network consists of automated continuous monitoring using *Nephelometer* and integrated sampling on filters using Filter Sampler. Combinations of these samplers allows to obtain hourly $PM_{2.5}$ mass concentrations estimates (Snider et al., 2013). This study seeks to evaluate Surface Particulate Matter Network-SPARTAN samplers' performance for measuring $PM_{2.5}$ mass concentration in an urban site in Bandung, Indonesia. Previous studies in Halifax (low $PM_{2.5}$), Atlanta (moderate $PM_{2.5}$), and Beijing (high $PM_{2.5}$) resulted that the nephelometer readings were in good agreement with reference instruments at all three sites (R^2>0.80) and Filter Sampler were in good agreement with federal reference method (FRM) instruments with coefficient of variation of R^2=0.96. In Bandung, evaluation conducted by comparing the samplers' performance with a reference instrument, Harvard Impactor, (Marple et al., 1987) which operated in parallel and simultaneously with Filter Sampler and Nephelometer.

RESEARCH METHODOLOGY

Sampling of fine particulate ($PM_{2.5}$) was carried out in the PAU Building (Interuniversity Research Center), Institut Teknologi Bandung Campus, Bandung. Samplers mounted on the open roof of the building, which is at 6°53'16.9"S 107°36'36.0"E and 826 meters above sea level. The location is adjacent to the main road, industrial, incinerator, settlement, trade, shops, traditional markets, and transportation that represent the mixing area of human activity in urban areas.

Sampling of fine particulate matter (PM2.5) was performed using three measurement instruments, namely AirPhoton® Filter Sampler, AirPhoton® Nephelometer (AirPhoton® Combined Sampling Station, AirPhoton® LLC, Baltimore, MD, USA), and Harvard Impactor (MS&T Area Sampler, Air Diagnostics and Engineering, Inc., Harrison, ME,USA). Sampling was performed in two stages as in **Fig 1.**

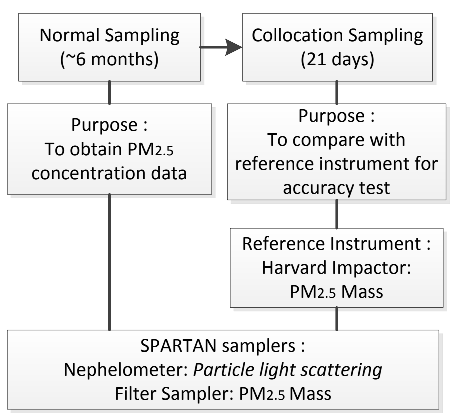

Fig 1. Sampling stages

During Normal Period (Jan 10 – Jun 29, 2014), Nephelometer sampled continuously while Filter Sampler (4 L/m^3)actively sampled 160 minutes/day for 9 days so that a total of 24 hours of sampling per filter was obtained. During Collocation Period (Jul 18 – Aug 20, 2014, all samplers sampled continuously (~24 hours/day), in parallel with reference instrument Harvard Impactor (10 L/m^3).

RESULTS AND DISCUSSIONS

In this section will be explained about the results of evaluating SPARTAN samplers performance for $PM_{2.5}$mass concentration measurements in Bandung urban area.

Filter Sampler Performance Evaluation

Data during Collocation Sampling (21days) will be used to evaluate Filter Sampler sampling performance. $PM_{2.5}$ Filter Sampler compared with $PM_{2.5}$ Harvard Impactor using linearity test method (**Fig2**)

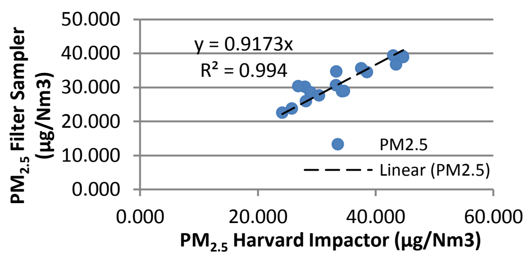

Fig 2. Linearity test for$PM_{2.5}$Filter Sampler

Linearity test results between PM2.5 Filter Sampler (n = 17, =31,55 µg/Nm3) with PM2,5 Harvard Impactor (n = 17, =34,10 µg/Nm3) showed that there is a statistically significant relationship between the two parameters with p-value of 0.000. That is, if the PM2.5 measured by Harvard Impactor increases, then PM2.5 measured by Filter Sampler has the same linear tendency to increase. Low slope of 0.92, indicating that Filter Sampler tends to underestimate Harvard Impactor measurement, which is the true value. This can be caused by Filter Sampler configuration that uses nuclepore filter instead of a cyclone as ~PM2.5 size cut. Harvard Impactor uses a cyclone inlet PM2.5 which is more accurate for size selection. Moreover, coefficient of determination R2 showed a near perfect correlation, 99.08% indicates that the differences between the two filter-based samplers results are not significant. Thus, Filter Sampler is a realiable measurement method to measure PM2.5 mass concentration in Bandung.

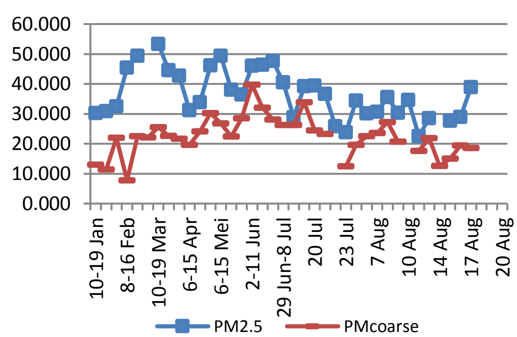

Fig 2. $PM_{2.5}$ (µg/m^3) Filter Sampler

During this period, the average concentrations of $PM_{2.5}$ was 36.80 μg/Nm^3 while the average for PM_{coarse} 22.45 μg/Nm^3. Thus, the average $PM_{2.5}/PM_{10}$ is 0.629 ($PM_{10} \approx PM_{2.5} + PM_{coarse}$). 24-hour gravimetric filter measurements are the reference method for monitoring $PM_{2.5}$ based on Government Law No. 41 Year 1999, however this method has several limitations such as; high operation cost, high maintenance need, and provide no real time information (Molenar, 2005).Real-time and continuous data are important for evaluating temporal variation of $PM_{2.5}$ exposure to human and creating control emission strategy. In response to the above concerns, the use of nephelometry as a real-time continuous $PM_{2.5}$ aerosol monitoring instrument has emerged to complement filter-based measurements (Molenar, 2005; Radojevic, 2011).In this study, gravimetric mass $PM_{2.5}$ will be combined with Nephelometer *particle light scattering* to create hourly $PM_{2.5}$ estimates in Bandung.

Nephelometer Performance Evaluation

Nephelometers have proven to be capable of making highly accurate, real-time, and continuous measurements of the aerosol scattering coefficient. However, the estimate of aerosol mass by nephelometery has high uncertainties due to natural variability of $PM_{2.5}$ aerosol parameters, ambient humidity, and design configurations (Molenar, 2005; Radojevic, 2011). This constraints made estimation of $PM_{2.5}$ mass by nephelometry must be calibrated with simultaneous gravimetric measurements of the ambient $PM_{2.5}$ to obtain accurate results (Molenar, 2005).

AirPhoton® Nephelometer records*particle light scattering* data continuously at 450 nm (blue), 532 nm (green), and 632 nm (red) wavelengths during the measurement period. Combination of backscatter data and $PM_{2.5}$concentration data per 9 days measured using Filter Sampler can be used to estimate the hourly $PM_{2.5}$ concentration. The formula for estimating $PM_{2.5}$concentration are shown in **Equations 1 and 2** (Snider et al., 2014).

$$\mathrm{b_{sp,dry,1h}} = \frac{\mathrm{b_{sp,1h}}\{\mathrm{RH} < 80\%\}}{f_m(RH)} \quad \textbf{(Eq. 1)}$$

$$\mathrm{PM_{2,5,dry,1h}} = PM_{2,5,dry,9d}\,\frac{\mathrm{b_{sp,dry,1h}}}{b_{sp,dry,9d}} \quad \textbf{(Eq. 2)}$$

Where: $\mathrm{b_{sp,1h}}$= Backscatter averages for 1 hour; $\mathrm{b_{sp,9d}}$= Backscatter average for 9 days; f_m(RH)= Higroscopic mass correction factor, correction for water uptakein aerosol = 1 + 0,2 RH/(100 – RH); $\mathrm{PM_{2,5,dry,1h}}$= Hourly $PM_{2.5}$ mass concentration estimates; $PM_{2,5,dry,9d}$= 9-day filter result for $PM_{2.5}$ mass concentration.

Nephelometer $PM_{2.5}$ estimatescompared with Harvard Impactor $PM_{2.5}$gravimetricto evaluate Nephelometer performance (**Fig 3**).

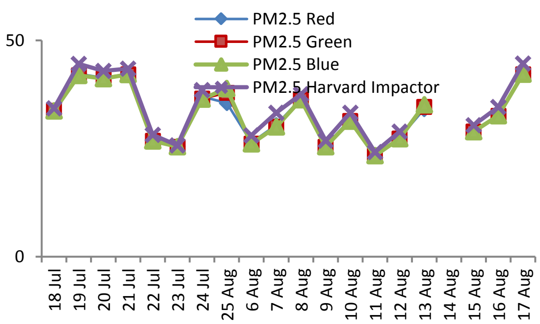

Fig 3. Comparison of $PM_{2.5}$ Nephelometer (RGB) and Harvard Impactor (μg/m^3)

Results showed that there are no significant differences between estimates by the three wavelengths, which are 32, 765 μg/m^3 (red), 32, 574 μg/m^3 (blue), dan 32,561 μg/m^3 (green).Linearity test between Harvard Impactor $PM_{2.5}$ and Nephelometer $PM_{2.5}$ resulted R^2=0.9923 for red scatter, R^2=0.9902 for green scatter, and R^2=0.9897 for blue scatter. Therefore, nephelometer scatter in all wavelengths could be used for estimating hourly $PM_{2.5}$ estimates in Bandung.

Hourly $PM_{2,5}$Concentration Estimates

Strong correlation (R^2=0.88) found between $PM_{2.5}$ estimates using green scatter with $PM_{2.5}$ mass measured by Beta Attenuation Monitor (BAM) in Beijing during February 24 – March 29, 2013. However, the usage of red scattering and blue scattering for estimating $PM_{2.5}$ still needs further investigations (Snider *et al.,* 2013). Because of those considerations, estimation of horly $PM_{2.5}$ in this study performed using green scattering (532 nm) data. Hourly $PM_{2.5}$ estimates during January – August 2014 showed in **Fig 4.**

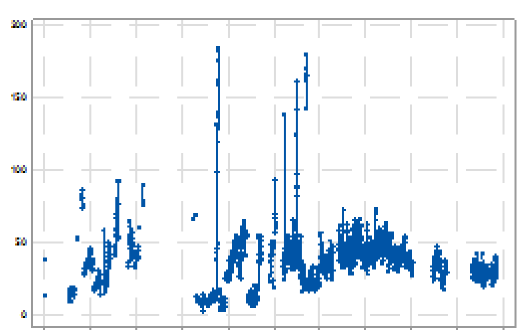

Fig 4. Hourly $PM_{2.5}$ mass concentration estimates (μg/m^3), 10 Jan 14 09:00 – 21 Aug 14 09:00

Average of hourly $PM_{2.5}$ concentrations estimates on the entire measurement period is

36.547 μg/Nm^3 with standard deviation of 20.610 μg/Nm3. While, the average concentrations of $PM_{2.5}$ from Filter Sampler are 36.80 μg/Nm^3 with standard deviation of 8.04 μg/$Nm^{3.}$ This insignificantly different average values shows that the hourly $PM_{2.5}$ estimates represents filter based measurement well, while larger standard deviation showed that the estimates successfully explained periods of high and low $PM_{2.5}$ concentrations well. This data can be used for assessment of health risk associated with air pollution in Bandung. Combination of these data with data from another SPARTAN locations can be used to assess impact of $PM_{2.5}$ pollution for global health applications.

Another study at an adjacent location to this study, precisely in the rooftop of Nuclear Technology Center for Materials and Radiometry building (6.91ºS 107.60ºE, 630 mdpl) in 2002 – 2011 using a Gent stacked filter unit for 24 hour, 2 measurements per week, and at flowrate 15-18 lpm (Santoso *et al.,* 2008; Santoso *et al.,* 2012; Santoso *et al.,* 2013). Results showed that yearly averagees of $PM_{2.5}$ mass concentration = 14,0 μg/m^3 (2002-2004), 19.0 μg/m^3 (2005), 20,3 μg/m^3 (2006), 20,6 μg/m^3 (2007), and 16,50 μg/m^3 (2011). The study and this study indicates that although $PM_{2.5}$ concentration still meets national quality standards, air quality tends to deteriorate from year to year in the urban area of Bandung. Air quality deterioration is associated with increasing tendency of emission load and Bandung topographical condition that are not well ventilated. This condition could potentially increase the health risk from exposure to $PM_{2.5}$ to the population (Zannaria, et al., 2008).

Research by Lestari and Mauliadi (2009) during rainy season of September 2005 – 2006 and dry season of Maret 2005 – Juli 2007 in Tegalega area, Kota Bandung which represents urban area with mixing activities showed average of $PM_{2,5}$ 30 μg/m^3 in rainy season and 48 μg/m^3 in dry season. Sampling performed using *Dichotomous Sampler* and *Minivol* in 4 meters height from ground. Emission sources identified during the rainy season in the study are diesel vehicles (17%), $(NH_4)_2SO_4$ (14%), biomass burning (13%), NH_4NO_3 (12%), soil dust (10%), motorcycles (9%), volcanic dust (6%), and cars (9%), while during dry season are $(NH_4)_2SO_4$ (25%), electroplating industries(24%), biomass burning (16%), aged sea salt (13%), diesel vehicles (12%), motorcycles (7%), and solar vehicles (3%) (Lestari and Mauliadi, 2009). Moreover, further study is needed to determine seasonal and diurnal variability based on $PM_{2.5}$ mass concentration data determined in this study in relations with human activities and meteorological conditions.

CONCLUSIONS

This study seeks to evaluate sampling performance of samplers from newly established monitoring network, Surface Particulate Matter Network-SPARTAN for $PM_{2.5}$ mass concentration measurements at an urban site in Bandung, Indonesia. Intercomparison study with reference instrument Harvard Impactor showed that AirPhoton® Filter Sampler and AirPhoton® Nephelometer was a reliable combination of $PM_{2.5}$ measurement that is applicable in Bandung urban area for long term monitoring. Further study shall investigate any seasonal and diurnal pattern in the hourly $PM_{2.5}$ data and its relationship with human activities and meteorological conditions.

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This study was a part of Dr. Puji Lestari's research project with Dalhousie University, namely *Surface Particulate Matter Network (SPARTAN): A Global Network to Evaluate and Enhance Satellite-Based Estimates of Ground-level Aerosol for Global Health Applications*. The author highly appreciate above mentioned parties for financial and technical support during field samping as well as laboratory analysis.

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ROADSIDE AIR POLLUTION REDUCTION TECHNOLOGY BY ACTIVATED CARBON FIBERS

Masaaki Yoshikawa[a,*,†], Takaaki Shimohara[b], Toshihiro Kitada
[a] Osaka Gas co., ltd., [b] Kyushu University, [c] National Institute of Technology, Gifu College
[a]Osaka, [b]Fukuoka, Japan
Email: [a]yoshikaw@osakagas.co.jp, [b]shimohara@cm.kyushu-u.ac.jp, [c]kitada@gifu-nct.ac.jp
* Presenter; † Corresponding author.

Abstract: The technology against air pollution using Activated Carbon Fibers (ACF) does not use the electric power and utilizes only the natural wind. Our research group has developed the ACF unit for roadside that can remove air pollutants by parallel wind flow through slit shape structure. Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been proceeded the installation of ACF unit at the national highway where the air pollution from traffic was very severe since 2007. Observed NO_2 and NO removal at the roadside was 84% and 19% on average, respectively. The duration of ACF is enhanced by catalytic performance to oxidize NOx into $NO3^-$ ion, which can be washed out by rain fall easily. Estimated duration of ACF at the roadside is assumed for over 7 years.

Keywords: Activated Carbon Fibers, Air pollution, Roadside, NOx, Micro porous

INTRODUCTION

Activated Carbon Fibers (ACF) has been developed and manufactured by commercial scale in Japan for over 30 years [1, 2]. It has been also manufactured in China and Korea since 2000. The structure of ACF is porous fibrous carbon which has fiber diameter of 10~20 micron and has excellent performance for the speed of both adsorption and desorption. So far, ACF has been utilized for water purifier and solvent recovery equipment. Recently, a demand on the countermeasure for the air pollution in the urban area has been increased. We have developed Pitch-ACF optimized for counter-measure for the air pollution, especially for the removal of low concentration of NO and NO_2 in the atmosphere [3, 4, 5].

MATERIALS AND METHODS

For optimizing the ACF, we tested ACF listed in Table 1. The surface area of coal tar Pitch-ACF were from 500 m^2/g (A5) to 1500 m^2/g (A15), which were made by ADALL co., ltd., subsidiary of Osaka Gas. A5 was not usual brand product, which was specially produced for this study. The specific surface area and pore size was measured by ASAP2420, made by MICROMERITICS co., ltd. The mean pore size of them calculated by MP method is proportional to the specific surface area, from 0.7nm in A5 to 1.1nm in A15.

PAN-ACF was made by Toho-tenax co., ltd., which has smaller diameter of both fiber and pore size compared to the Pitch-ACF of similar specific surface area.

Adsorption tests of low concentration NOx were done in the fixed bed flow reactor of the 30mm inner diameter. 1g of ACF was set in the reactor, and flow rate of through gas was set at 300~1000ml/min which adjusted NOx concentration for 1~20ppm, temperature at 25degree C and humidity at 0~80%. NOx concentration was measured by chemical luminescence NOx meter

(ECL-88US made by YANACO co., ltd) at the inlet and outlet of the reactor.

Table 1 Properties of the tested ACF

Raw material	Brand	D_{FIBER} [a]	S_{BET} [b]	M_p [c]
Pitch	A5	16-20	500	0.7
↑	A7	16-20	700	0.8
↑	A10	16-19	1000	0.9
↑	A15	14-17	1500	1.1
PAN	FE-200	11-13	700	0.8

[a] Diameter of AC Fiber (μm), [b] Specific surface area (m^2/g),
[c] Mean micro pore size (nm)

RESULTS AND DISCUSSION

Optimization of ACF

Results of NO_2 adsorption tests were not affected by the pore size and the specific surface area, but they were affected by the relative humidity sensitively. It is considered that NO_2 can be easily adsorbed on ACF micro pore because it is condensable at room temperature. On the other hand, NO adsorption was strongly affected by the pore size and the specific surface area of ACF, as shown in Fig.1.

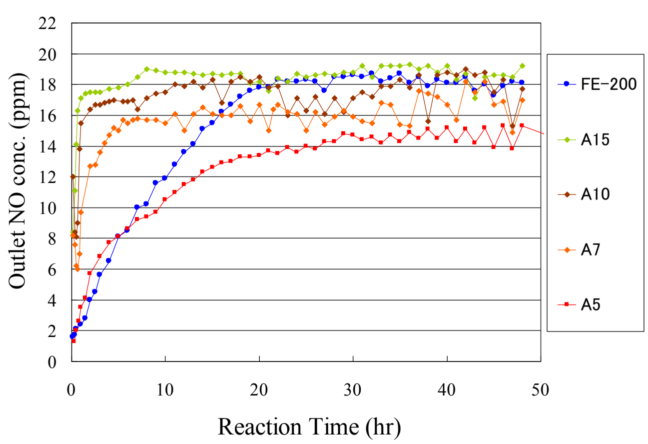

Fig. 1 Breakthrough curve of NO over ACF

In Fig.1, 20ppm NO was flown over ACF in the dry air. A15 and A10, that have larger surface area than others, showed little NO adsorption ability. In the comparison of same surface area around $700m^2/g$, PAN FE-200 showed larger NO adsorption ability than Pitch A7 in the initial stage of the adsorption. The difference between the two ACF is the mean micro pore size. So we produced Pitch-ACF of smaller pore size as FE-200 experimentally. As the result, A5 showed the highest NO adsorption ability among the tested ACF (Fig.2).

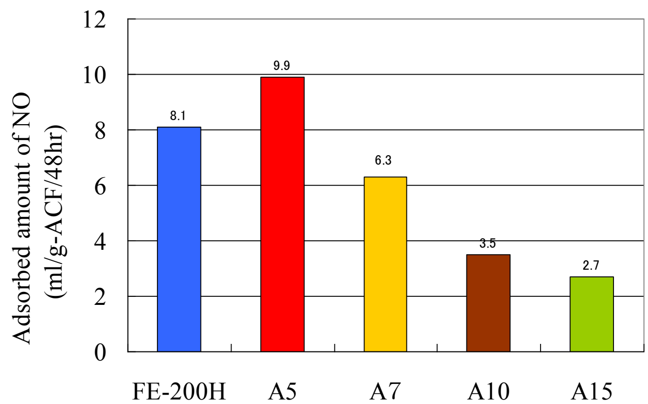

Fig.2 Adsorbed amount of NO on various ACF

Application Of ACF For NOx Removal At The Roadside

Using this ACF, the unit which can reduce the air pollution by NOx at the roadside was developed (Fig.3). Different from conventional filter unit, the ACF unit makes air pass in parallel flow. Pressure drop of ACF unit gives only 200 Pa at the wind velocity of 2 m/sec, which is one fourth of the conventional air filter (Fig.4). It is possible that by this peculiar structure, ACF unit purifies polluted air only by the natural wind without using electric powered fan.

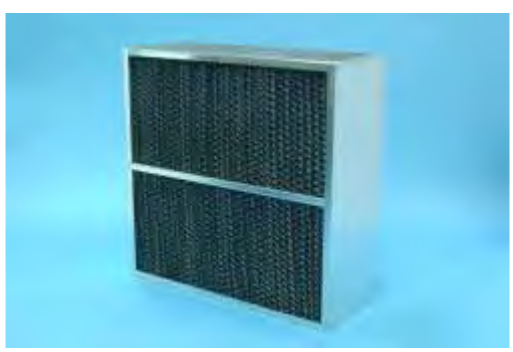

Fig. 3 ACF unit for air pollution reduction

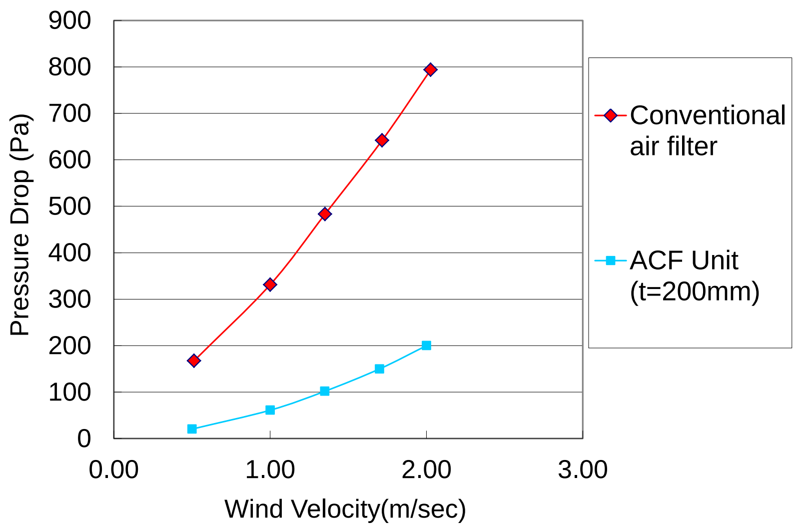

Fig. 4 Pressure drop of ACF unit compared with conventional filter

According to our fundamental study for over 15 years, Japanese MLIT started the installation of ACF unit at the roadside of national highway since 2007. The first installation of ACF was done at the route 43 in Osaka prefecture (Fig.5).

Fig. 5 Installation of ACF fence at the national highway route 43 in Osaka

The NOx removal performance of the ACF unit was measured in actual highway route 43. Fig.6 (Left) and (Right) show the NO_2 and NO removal performance respectively as a function of the natural wind velocity. NO_2 removal performance was stable against wind velocity, and 84% removal ratio was observed on average. On the other hand, the NO removal performance was relatively low, 19 % on average, and it tended to lower by the increase in the wind velocity.

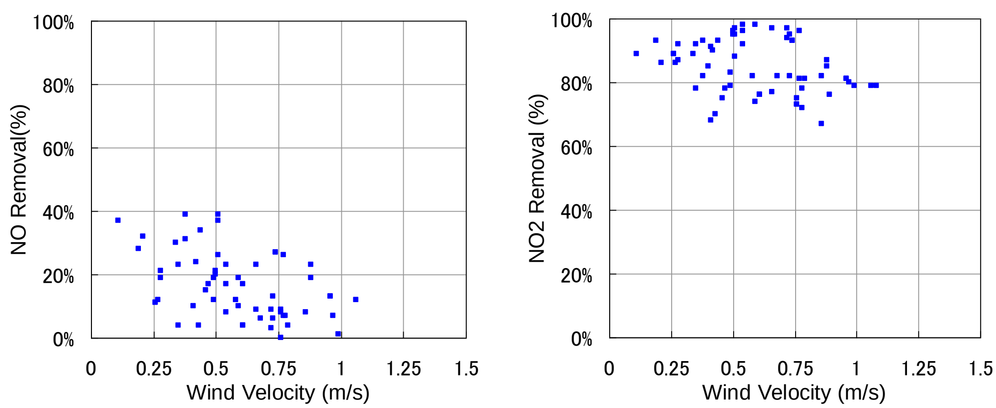

Fig.6 NOx (Left) and NO (Right) removal performance of ACF unit at the highway

According to these results, the roadside air pollution reduction system using ACF was installed at 7 places in Japan and 1 place in China. Especially, large scale of ACF fence was constructed at the national highway in Nagoya prefecture in 2014, and it greatly contributed to the air pollution reduction of the roadside environment. The reduced amount of NOx was equal to the reduction of traffic volume of 5200 large automobiles per day.

CONCLUSIONS

It is considered that Pitch-ACF A5 has the advantage in the adsorption of NO, because it has micro pore around 0.7nm on its fiber surface directly. Using this ACF, the ACF unit of parallel flow can purify NOx from polluted air by only the natural wind. The ACF unit can remove 84% of NO_2 and 19% of NO only by one time passing of wind at the highway in Japan. This technology will be also effective at the heavy traffic zone in Indonesia, such as Jakarta (Fig. 7).

Fig.7 Heavy traffic road at Jakarta, Indonesia

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DEVELOPMENT OF THE SIPHON SYSTEM PIPE-TYPE FISHWAY AND MONITORING OF FISH MIGRATION

Kiyoshi Wada [a,*,†], **Yukio Ota**[b],
[a] Department of Civil Engineering, National Institute of Technology, Gifu College, Japan
Email: wada@gif-nct.ac.jp
[b] Research Center, Nishi-Nippon Institute of Technology, Fukuoka, Japan
Email: otayukio@sage.ocn.ne.jp
*Presenter; † Corresponding author.

Abstract: In this study, the function of fishway was evaluated using preliminary data, the siphon-pipe type fish passage with cost performance and portability has been developed, and local river experiment with indigenous fish was conducted. The structure form that the flow velocity should be reduced below at the burst swimming speed of fishes was examined. As results, dissipative energy can be attenuated greatly by the form loss of joints. The calculation formula of the design flow velocity and the required number of joint was proposed. The siphon-pipe fishway was designed using this formula, and the amount of ascension of the indigenous fish by local river experiment was investigated. Although the complete range of the fishes used for the experiment permeated into the pipe, the Oikawa (Zacco platypus) ascended to exit of the fish passage for a short time, and it is the whole dominate species. This fish passage can be used for choosing fishes, as the predetermined flow velocity is changed. It was shown that the ascension difficulty of fishes is cancelled by installation of the siphon-pipe type fish passage. A siphon system pipe-type fishway have several typical characteristics, such as free from overflowing, not expensive, easy to make, transport and install, and some pipe-type fishways already works as tentative fishaways and semi-permanent fishways in Japan. Therefore, as a pipe-type fishway has high flexibility of design, siphon-pipe fish passage is effective in improving the river ecological habitat.

Keywords: Fishway design;pipe-type fishway; siphon;migration; habitat

INTRODUCTION

There are many dams and weirs not only in developed countries but also in developing countries, and some rivers have fishways to keep river condition suitable for fish. However, many dams and weirs still do not have fishways, and sometimes fishways do not work effectively.

Fishways are constructed to enable fishes to overcome obstructions such as weirs in rivers to their migrations under the condition of allowed small discharge. In other words, the fishway should be able to control the discharge precisely and to keep the proper flow field (velocity). Fishways are classified into four groups: (i)pool and weir;

(ii)steam-type; (iii) operation-type; and (iv) other-types.

In this study, a siphon system pipe-type fishway has developed by the members of Indonesian Rivers Ecosystem Conservation Project (Ir-ECO Project)[1] [2]. This fishway belongs to (iv) other-types. Moreover, the researchers precisely investigate its characteristics, namely, loss coefficient of reducer, velocity and pressure profiles in the pipe and fish behavior between reducer. The new-type fishway makes it possible that river condition can be improved.

CHARACTERISTICS OF SIPHON SYSTEM PIPE-TYPE FISHWAY

Essential Characteristics

A siphon system pipe-type fishway has some typical characteristics, and they are quite different from usual fishways. These characteristics make a pipe-type fishway suitable for not only developed countries but also many developing countries.

1) Not need overflowing: There are many weirs that often do not overflow in dry season. A pipe-type fishway is able to work even if the top of weir becomes dry.
2) Not expensive: The cost of pipe-type fishway materials is usually within some ten thousand yen.
3) Easy to made: Almost all materials are available at the shops in Padang City and Jogyakarta City in Indonesia. A pipe-type fishway can be assembled without electric tools, and it is no problem that the site of weir does not have electric power.
4) Easy to transport: All fishway parts are not heavy and can be carried with human power.
5) Easy to install: The installation of pipe-type fishway usually finishes in a few hourswith 1-2 workers, and its removal is almost the same.

The first characteristics, not need overflowing, is the most important subject from the view of technical matters. Siphon system is maybe the only way to overcome this subject. Fig.1 is the pipe-type fishway at Padang City in Indonesia, and sometimes there is no overflowing at the weir. As shown in Fig.1, it is found to easily make fishes ascend to upstream in the pipe-type fishway. The water level difference is 1.80m when the gate is opened.

Flow reduction System

A pipe-type fishway gets the suitable velocity with some reducers in the main pipe.

Figure 1. Pipe-type fishway at Parak Buruk Weir in the Kandis River

Fig.2 is the flow reduction system of pipe-type fishway, where, D_1: internal diameter of main pipe, D_2: narrow part diameter of reducer, D_3: enlarge part diameter of reducer, L: reducer interval. The loss coefficient of each reducer consists of some contraction and expansion, and it can be estimated with formula (1). The loss coefficient of each reducer can be calculated theoretically, and the number of reducers controls the velocity of main of main pipe. As the flow energy is dissipated by turbulence around the reducer inserted in pipe, total energy loss due to friction and shape is increased.

The shape energy loss dominates than friction energy loss in the pipe flow.The shape loss coefficient of pipe-type fishway is calculated with formula (2).Almost all of coefficient occurs from reducers, and the correction coefficient (□) from other parts is estimated around 5 in the formula.

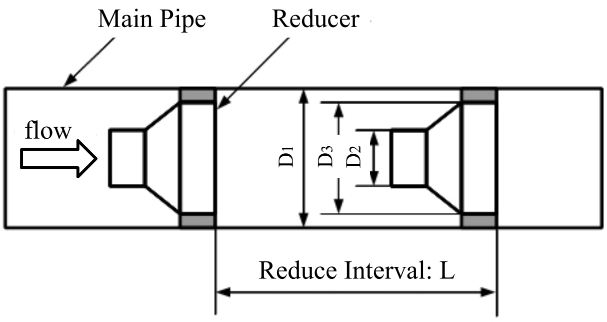


Figure 2. Flow reduction system of pipe-type fishway

$$f_r = f_{sc} + f_{ge} + f_{se} \quad (1)$$

$$f_T = N \cdot f_r + □□ \quad (2)$$

where, f_r, f_{sc}, f_{ge}, f_{se}: energy loss coefficient of each reducer, sudden contraction from D_1 to D_2, gradual expansion from D_2 to D_3, sudden expansion from D_3 to D_1 for each one, and f_T: total loss coefficient of pipe-type fishway, N: number of reducers.

Design of Pipe-type Fishway

Fig.3 shows the relationship between number of reducers and main pipe velocity of pipe-type fishway under the condition of D_1, D_2 and D_3 is 100, 50 and 75mm, respectively. In the case of the fishway at Fukano weir in Fig.4, the energy loss coefficient of each reducer is 9.73 and the water level difference is 1.60m. This fishway has 39 reducers in the pipe, and its main pipe velocity becomes 0.29 m/s and the narrow part velocity becomes 1.04 m/s.

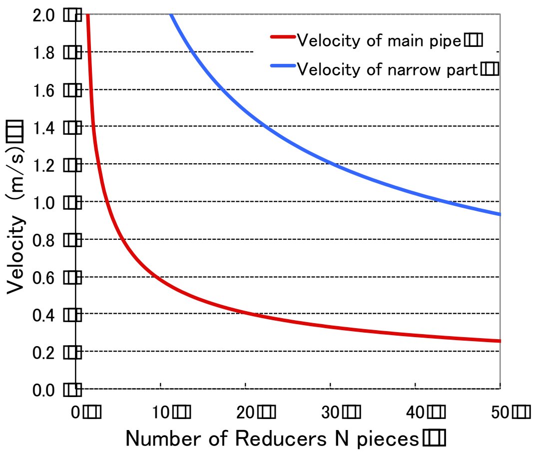


Figure 3. Main pipe velocity of pipe-type fishwayFigure 4. Install to Fukano weir in the Kii river

Pipe-type fishways consist of two models, the one is a connecting model and the other is an integrated model such as Fig.4. A connecting model is a tentative fishway, and it sometimes can be used at another weirs. Some short flexible tubes connect the inlet, several bodies and the outlet, and it is easy to change these parts. An integrated model is installed as a tentative fishway and a semi-permanent fishway. This model is tougher than connecting model, and it is easy to fix tightly to weir. The production costs of integrated model are less than connecting model, and an integrated model is the first selection of pipe-type fishway. A vertical type fishway is one of the integrated models, and it really has a vertical part in the fishway. Fig.4 is an example of vertical type fishway. As there are many square-type low weirs in Japan, vertical type fishways are very useful for these weirs.

Theoretically, the velocity of main should be less than the cruising speed (maximum sustained speed) of target fish, and the velocity of narrow part should be less than the burst speed (maximum swimming speed) of them. However, it is confirmed that the velocity of pipe-type fishway fluctuates quickly and suddenly, and fish maybe use this velocity fluctuation when they move up more easily in vertical pipe than in horizontal pipe. Empirically 0.3-0.4 m/s of main pipe velocity is suitable for many species of fish, not only swimming fish but also demersal fish.

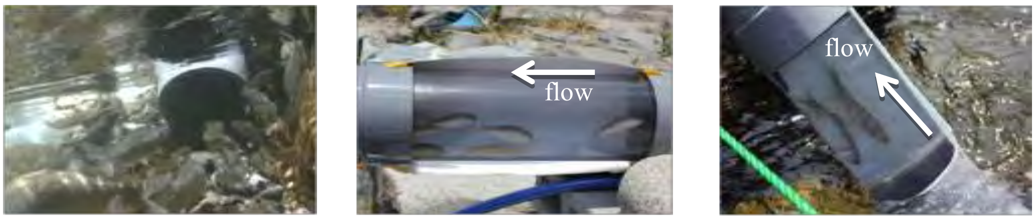
INSTALLING PIPE-TYPE FISHWAY TO RIVER AND IRRIGATION SYSTEM

Design for river with an pool-and-weirfishway

A local experiment was conducted to confirm the fish behavior to easily make fish ascend in the pipe-type fishwayinstalled on a weir in the Neo-River in Gifu Prefecture[3]. Although it is installed pool-and-weir type fishway in the river, a function is lost by damage.

Fig.5 shows that the pipe-type fishway was installed todropwork such as groundsill.As for water level differences between upper and downstream is 0.80m; the maximum height of the fishway is 1.47m. The field experiment of ascending fish was conducted approximately one hour, 19 kinds of fish and 242 individuals. Water area was secured in the fishway entrance surrounded withsandbags and nets. The experiment method released fish into the fishway entrance and observed swimming behavior using by a video camera. Fish were gathered at the fishway exit by a trap.Under the calculated condition of the low velocity is 0.30m/s and the high velocity is 1.09m/s, 22 reducers were installed in the pipe. Using the electromagnetic current meter, it was confirmed to the velocity at the entrance of fishway decreased to 0.31m/s.As shown in Fig.5, fish in the pipe started to ascend upstream after the experiment immediately.

(a) Pool-and-weir fishway (b) Assembling of the fishway (c) Installed pipe-type fishway



(d) Entrance of the fishway (e) Ascending fishes(f) Exit of the fishway

Figure 5. Installing pipe-type fishway to the Neo river with impaired fishway in

function

Design For Irrigation System Without Fishway

It was experimentally conducted that fish ascended in the pipe-type fishwayinstalled to the agricultural irrigation system in Gifu prefecture[4].Fig.6 shows that the pipe-type fishway was installed to dropwork such as diversion gate of weir. As for water level differences between upper and downstream are 1.60m. Fish were gathered at the fishway exit by a trap.Under the calculated condition of the low velocity is 0.36m/s and the high velocity is 1.30m/s, 31 reducers were installed in the pipe. Using the electromagnetic current meter, it was confirmed to the velocity at the entrance of fishway decreased to 0.36m/s. As shown in Fig.6, fish in the pipe ascend using a resting areaafter the experiment.

Figure 6. Installing pipe-type fishway to the irrigation system without fishway

RESULTS AND DISCUSSION

Fig.7 demonstrates the ratio of fish via the control sections of visible acryl pipe installed to river.As the figure, it is pointed out that ratio of strong Pale chub (*Zacco platypus*) of the swimming power increase toward the upstream from 51% to 84%.

Cruising speed (sustained speed) and burst speed (maximum swimming speed) characterize the swimming ability of fish. In general, cruising speed is 2-4 BL (body length)/s, and burst speed, 10-15 BL/s, although results of the measurement of swimming speed vary greatly according to the apparatus and criteria such as the definition of swimming time, the duration for which a fish can maintain a certain swimming speed.

Fig.8 shows the relation between the swimming speed of Ayu (*Plecoglossusaltivelis*) and the progress distance. Cruising speed and burst speed is written jointly in the figure, as the body length is calculated as 10cm. From the figure, the fish ascend towards resting area while repeating break and burst.The fish slows down in

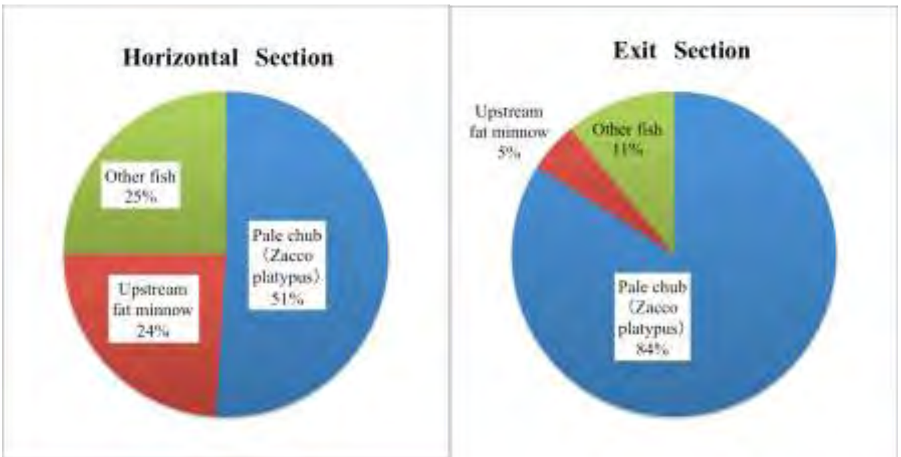


Figure 7.The ratio of fish via the control sections of visible acryl pipe

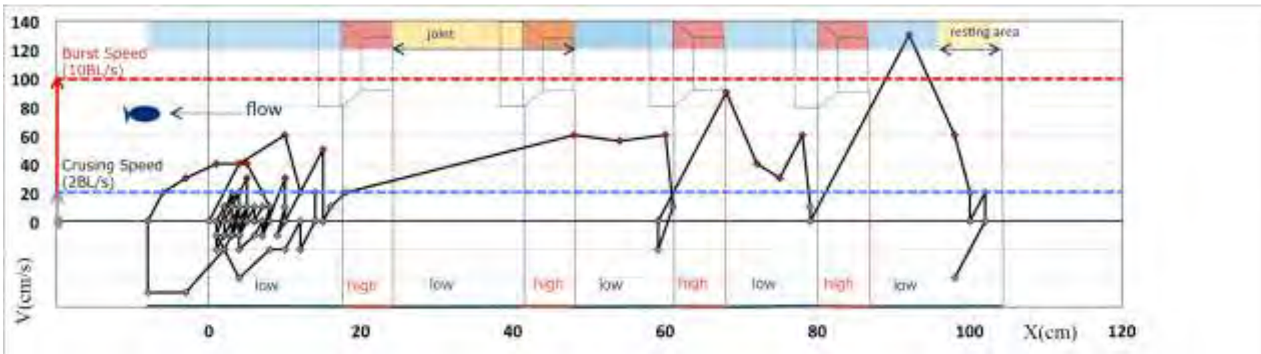


Figure 8.The relation between the swimming speed of the fish and the progress distance

enlarged part and accelerates in the narrow part from a detailed viewpoint.

According to the fish physiology, metabolism in red muscle was aerobic, while anaerobic process was confirmed in white muscle[5]. Therefore, once the white muscle was activated, accumulation of lactate occurred rapidly, and fish would be exhausted soon. To minimize the activity of white muscle, fishway should provide current velocity lower than the cruising speed at some part of any cross sections of fishway. Consequently, the fish ascend upstream through each reducerbefore arriving at bending corners. Also, it seem to the fish use gentle flow area adjacent to the mainstream skillfully and take a break outside reducer temporarily until lactic acid is broken down.

Ability or function of fish, e.g. swimming speed, has been dealt in fishway design as biological knowledge. However, tendency of behavior or preference might be more important as a life history strategy in the wild, and thus more useful for fishway design.

CONCLUSIONS

A siphon system pipe-type fishway has several typical characteristics, such as free from overflowing, not expensive, easy to make, easy to transport and to install, and some pipe-type fishways already works as tentative fishways and semi-permanent fishways in Indonesia and Japan. A pipe-type fishway has high flexibility of design, and its flow characteristics, the velocity of main pipe and reducers, are also designed with some numerical formulas. Fish in a pipe-typefishway are able to move up easily with using its flow fluctuation, and the complicated flow at the water pocket of reducers sweeps away the sediment such as sand and soil in the pipe. Actually the pipe-type fishway in the Kii-River, Fukuoka Prefecture helps a lot of fish ascend upstream every year.

ACKNOWLEDGEMENT

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THE INFLUENCE OF ECONOMIC AND DEMOGRAPHIC FACTORS TO WASTE GENERATION IN CAPITAL CITY OF JAVA AND SUMATERA

Benno Rahardyan[1], Gita Prajati[2], and Tri Padmi[2)]
Master Program of Enviromental Engineering
Faculty of Civil and Environmental Engineering, Institut Teknologi Bandung
Jl. Ganesha no 10 40132
Email: [1]gitaprajati@yahoo.co.id, [2]tripadmi@gmail.com, [3]benno.rahardyan@gmail.com

Abstracts: Population growth, industrialization, urbanization and economic growth, resulting an increase of municipal solid waste. The purposes of this study were to analyze the relationship between economic, social and demographic variable and waste generation and to identify patterns associated local waste development in Java and Sumatra. This study was to analyze the relationship between economic and demographic variabels against waste generation. Then performed khajuria and Daskalopoulus model test and also cluster, quadrantt and Klassen typology analysis to determine the pattern of characteristics and waste generation in Java and Sumatra. The test result of Daskalopoulos model was waste generation in Java and Sumatra can be explained 20.6% by consumption expenditure per category. The test result of Khajuria model was waste generation in Java and Sumatra can be explained 21.8 % by value of the total population, GDP, and illiteracy. There are three Pattern of waste generation based on the characteristics and economic activity. The first pattern is a group of cities with low waste generation that is characterized by low economic growth and port/trade and trade/plantation as economy activity. The second pattern is a group of cities with high waste generation, low economic growth and high consumption and industry/trade as economy activity. The third pattern is characterized by high waste generation, high economic growth, and high GDP and also industry/trade as economic activity.

Keywords: Waste generation, Test model, Cluster analysis, Economic activity

INTRODUCTION

Solid waste management continues to be a major challenge in urban areas throughout the world, especially in the cities of developing countries. Population growth, industrialization, urbanization and economic growth, resulted in a significant increase of the amount of municipal solid waste worldwide (Kaushal *et al*., 2012). In addition, consuming behaviour of various kinds of staples and technology results also provide a major contribution to the quantity and quality of waste generated (Jaelani *et al*. 2011).

Solid waste has shown positive correlation with economic development on a world scale (Kaushal *et al*, 2012). Solid waste produced globally in 1997 was about 0.49 billion tons with an annual growth forecast from 3.2 to 4.5% in developed countries and 2-3% in developing countries (Johari et al., 2012). Research conducted in the developing city Kowur, India showed that the solid waste in this city increased by 3274.5 kg per day compared to previous years (Bhavannarayana *et al.*, 2011). Waste management in Beijing, China shows that the economic development and population growth have increased from 2.96 million tons of waste in 2000 to 6.20 million tons in 2007, fluctuating to 6.35 million tons in 2010 (Wang and Wang, 2013). Some theories suggests that there is a direct relationship between the level income of a country with the amount of waste generated. Countries with low income levels will produce less waste than high-income countries (Hoornweg and Bhada-Tata, 2012). Indonesia belongs to the category of developing countries with mid-low levels income. Indonesia's government has a program to increase the economy. Masterplan Percepatan dan Perluasan Pembangunan Ekonomi Indonesia (MP3EI) is a roadmap that is arranged the economy's transformation to a stimulate economic activity and also increase economic growth by improving competitiveness.

Indonesia's government develops a concept to support MP3EI program, namely Koridor Ekonomi Indonesia. Government have already identified six economic corridors which covers most areas of Indonesia, specifically: East-West Sumatra Java Sea, Northern Java, Borneo, Sulawesi, East Java-Bali-Nusa Tenggara, and Maluku Islands and Papua (Ministry of Finance Republic of Indonesia, 2011).

MP3EI program has positive and negative effects. The positive impact is able to incerase economic growth and level income. While the negative impacts is increasing the amount of waste. As was mentioned earlier that economic growth is directly affect to the amount of waste generated. If the waste management system in Indonesia is not able to compensate, it can lead to health and environmental problems. Therefore, it needs a proper strategy in terms of waste management.

Model of socio-economic-environment can estimate the amount of waste in accordance with the conditions of economic, demographic, and interversi policy implemented. This model can be used as a basis for planning the capacity of the facility waste management systems (Adlina, 2013). Weng (2009) created a model of socio-economic system-environment for waste management that takes into account aspects of lifestyle changes in terms of socioeconomic, demographic, and interversi policy implemented. While Daskalopoulus *et al.* (1998) uses a variable population and living standards in a country as the main variable affecting the quantity and composition of waste generation. In addition, GIS application can also be used. This application can simplify system management, monitoring and controling during the process of collecting and transporting waste. Studies using GIS applications have been done in the city of Can Tho, Vietnam by Thanh *et al* (2009).

Research on modeling socio-economic-environmental was done by Adlina (2013) to the area of West Java. The study used three test models, which are Khajuria, Daskalopoulus and Weng test models. The results showed that the accuracy of each test this model with the original data were 90.32% for Daskalopoulus, 67.76% for

Khajuria and 68.9% for Weng. Based on this, the research is going to identify economic and demographic factors on waste generation in Java and Sumatra. Java and Sumatra was chosen because both of this area belong to the economic corridor MP3EI program.

The purpose of this study is to develop a system of environmental-economic model that can be used as a basis for planning the capacity of the facility waste management systems. The objectives of this study are to analyze the corrrelation between economic and demographic variables on waste generation in Java and Sumatra, and to identify the local patterns that are related to the development of waste in Java and Sumatra.

RESEARCH METHODOLOGY

Cities which included to the research's coverage area are Banda Aceh, Medan, Pekanbaru, Padang, Palembang, Bengkulu, Jambi, Pangkal Pinang, Tanjung Pinang, Bandar Lampung, Serang, DKI Jakarta, Bandung, Semarang, Yogyakarta, and Surabaya. Variables that used in this research are total of population, population density, consumer price index, Gross Domestic Product (GDP), population growth rate, economic growth rate, school's period, literacy rates, and people development index.
Data collect conducted in the provincial and city level. Secondary data collect focused on datas which related to the data of population, economic growth, social, and environment. Data collect conducted by getting data from relevant departments, those are BPS and Dinas Kebersihan. A statistical data processing by using statistic software from IBM SPSS Statistics 20.

The evaluation of tipology, city classification was analyzed using cluster analysis, quadrantt analysis, and classen typology analysis. Cluster analysis was analyzed based on waste generation, city's characteristic, and economic activity. After getting the cluster from those three analysis, ANNOVA analysis and discriminant was done to know the differences between the clusters. Then the results of cities's classification based on waste generation compared to the SNI.
City classification can also be done by using quadrant analysis and classen typology. Quadrantt analysis compares the relationship between population density and waste generation. Meanwhile classen typology analysis is used for covering the description of the pattern and economic growth structure of each cities. Then to find the patterns of waste generation from each cities, comparison the result of cluster analysis, quadrant analysis, and classen typology was applied.

To find the relevancy between consumer price index, Gross Domestic Product based on Constant Price, and total of population variables towaste generation, Regression Analysis was done. Test model conducted in this research as a baseline for waste management. Daskalopoulus et al. (1998) projected waste generation by linking it with consumption outcome that has been divided by the kinds of consumption. The model described in the equation below

$MSW = \beta \times RTCE_n$... **(Equation 1)**

MSW is waste generation and RTCE is related total consumption expenditures. With β as the coefficient of each variables.

Meanwhile Khajuria et al. (2010) projected waste generation based on total of population, GDP, and illiteracy. Khajuria model can be described like equation below :

$WG = \alpha + ((\beta_1 \times X_1) + (\beta_2 \times X_2) + (\beta_3 \times X_3))$.................................. **(Equation 2)**

Which WG is waste generation, x_1 is total of population, x_2 is GDP, and x_3 is illiteracy. With β as the coefficient of each variables and α is constant.

Then development of Khajuria model was done. Economic growth and illiteracy rate factors were added to linear model Khajuria, so it formed like **Equation 3.**

$WG = a + (b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5)$....................................**(Equation 3)**

which WG is waste generation, x_1 is total of population, x_2 is GDP, x_3 illiteracy rate, x_4 is school period ,and x_5 is economic growth. Meanwhile a is constant and b is coefficient of each factors. The projection of waste generation can be done based on the discriminant equation obtained from the discriminant analysis. Projection of waste generation is done every five years.

RESULTS AND DISCUSSIONS

The Evaluation of City's Typology

The city classification based on the economic activity, group of city with economic activity focused on Industry/Trade is the city with quietly high waste generation. Whereas for the group of city with economic activity that focused on trade/plantation, the production of waste generation is medium. Then group of city with economic activity that focused on Port/Trade, the production of waste generation is low. Analysis discriminant showed there are three variables that make the difference between these clusters, which are population density, consumer price index and economic growth. **Figure 1** showing the map of city classification based on the economic activity for each cities.

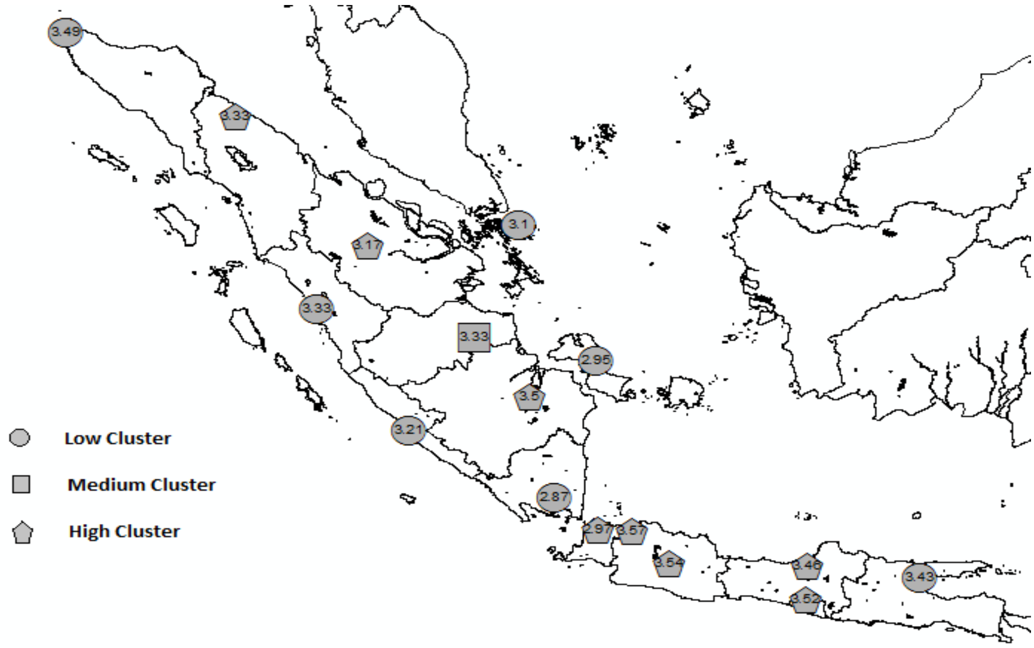

Figure 1. Map of city classification based on the economic activity.

The Classen Typology analysis like showed on **Figure 2**, obtaining the result in the form of patterns. Pattern A is fast-progressing and fast-growing regional, the city that have higher economic growth than other cities in Java and Sumatera. City that classified to pattern A have average economic growth 7.63 % and average GDP 14.67 millions. Bandung, Serang, Medan, Palembang, Tanjung Pinang, Bengkulu and Jambi are classified to this pattern. Waste generation that produced by this group of city is 3.28 l/p/d.

Pattern B is fast developing regional, which has medium economic growth. The city that classified to pattern B have average economic growth 7.11 % and average GDP 257.86 millions. DKI Jakarta and Surabaya are classified to this pattern. Average waste generation of this group of city is 3.5 l/p/d. Pattern C, quite lagging region, is a regional that has economic growth and GDP rate quietly low. The city that classified to pattern C has average economic growth 5.49 % and average GDP 8.63 millions. Yogyakarta, Banda Aceh, Pekanbaru, Bandar Lampung, Pangkal Pinang dan Padang are classified to this pattern. Average waste generation that produced by this group of city is 3.22 l/p/d.

Pattern D, growing but under pressure regional, is a regional that has high rate GDP, but the rate of economic growth is low. The city that classified to this pattern has average economic growth 6.41 % and average GDP 48.46 millions. Semarang are classified to this pattern. The average production of waste generation of this group of city is 3.45 l/p/d.

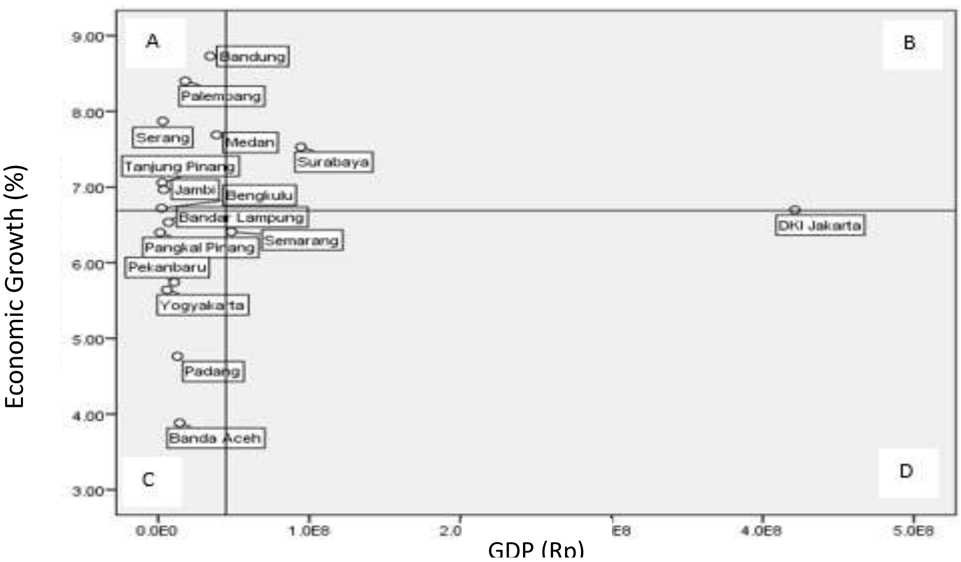

Figure 2. The classification of classen typology.

The classification based on the quadrant division of population density and waste generation can be looked at **Figure 3.** Group I is a group of city with medium waste generation (3.4 l/p/d) characterized by the medium average of population density, 2834 people/km^2 . Meanwhile group II is a group of city that have high rate waste generation (3.5 l/p/d) characterized by average population density 10984 person/km^2. Group III is a group of city that have low rate waste generation (3.04 l/p/d) characterized by the average population density 2175 person/km2. None of the sixteen cities classified into the group IV. Group IV is a group of cities that have a low waste generation and high population density.

Based on the characteristic of city, analysis cluster analyzed for two groups and three groups. Analysis cluster for two grup results showed each clusters have different characterizations. Cluster 1 is a group of city with the quietly low average of waste generation (3.24 l/p/d) characterized by average GDP 7.83 million and economic growth 6.21 %. Meanwhile for cluster 2 is a group of city with highly average of waste generation (3.44 l/p/d), characterized by GDP 40.50 million and economic growth 7.61 %. This analysis result showing the group of city with high waste generation have GDP and economic growth character that quietly high if compared to the group of city that have low waste generation.

Analysis cluster for three group have different characterizations. Cluster 1 is a group of city with the quietly low average of waste generation (3.16 l/p/d) characterized by population density 3995 people/km2 and GDP 3.8 million. Meanwhile for cluster 2 is a group of city with highly average of waste generation (3.44 l/p/d), characterized by population density 4574 people/km2 and GDP 4.50 million. Then for cluster 3 is a group of city with quietly medium waste generation (3,38 l/p/d), characterized by average of population density 2530 people/km2 and GDP 13.88 million. This analysis result showing the group of city with high waste generation have population density and GDP character that quietly high if compared to the group of city that have low waste generation.

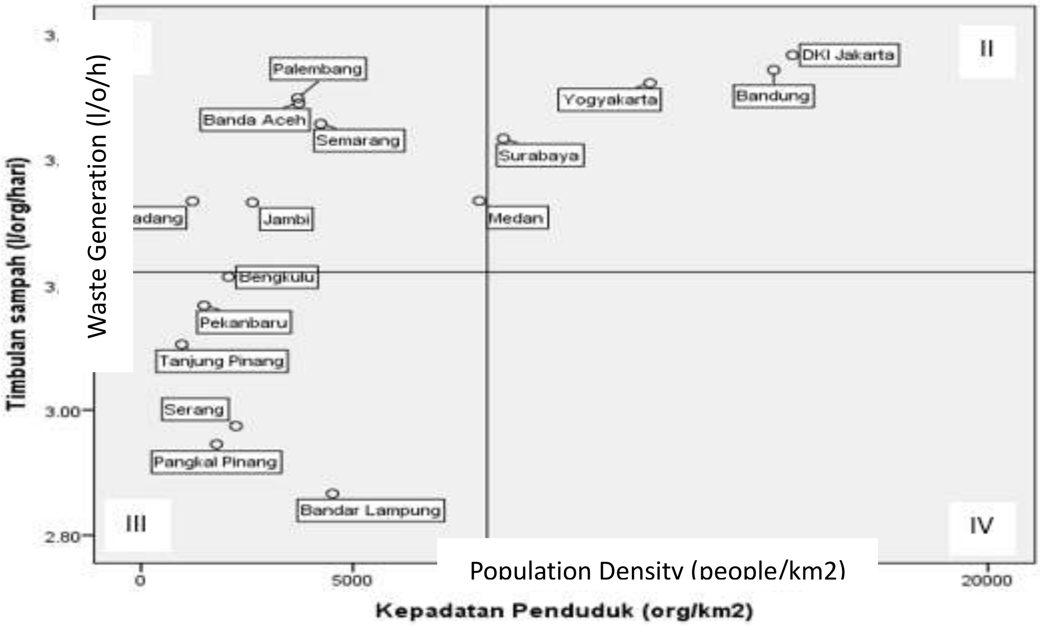

Figure 3. The classification of quadrant analysis.

By doing the comparison between cluster analysis of two groups, cluster analysis of three groups, quadrant analysis of population density and waste generation, and classen typology analysis, obtainable the characterization of each cities in Java and Sumatera. Based on the classification of waste generation cluster profile, the pattern that seen in Java and Sumatera divided into three patterns. Pattern 1 is a group of city with low rate waste generation and low economic growth. The majority of main activities from this group of city focused on Port/Trade and Trade/Agriculture. Pattern 2 is a group of city with high rate waste generation, low economic growth, and high consumption. The majority of main activities from this group of city focused on Industry/Trade. Pattern 3 is a group of city with high average waste generation, economic growth, and Gross Domestic Product. The majority of main activities from this group of city focused on Industry/Trade.

City classification based on waste generation showed that city with high population density, high total of population, and high economic growth characteristics has the waste generation that also quietly high. Meanwhile the city with population density, total of population, and economic growth that quietly low, its waste generation is also low. The differentiate variables between three clusters based on discriminant result are human development index, population growth race, and illiteracy rate. Cluster with high waste generation has the average rate of 3.5 l/p/d, cluster with medium waste generation has the average rate of 3.25 l/p/d and cluster with low waste generation has the average rate of 2.93 l/p/d. **Figure 4** shows map of city classification result based on waste generation. On the figure can be seen four cities in Java are included to the group of city with high waste generation, except Serang.

Figure 4. Map based on the cities' classification of waste generation.

The result of city classification analysis based on waste generation compared to SNI 19-3964-1994, SNI 19-3983-1995, like indicated on **Table 1.** The analysis result showed average waste generation for medium group of city was qualified with SNI 19-3983-1995. Meanwhile average waste generation of large group of city was not qualified with SNI 19-3964-1994. Waste generation in large group of city could be effected by the increasing population. It happened in Bandar Lampung. Population increased because two cities (Tanjung Karang and Teluk Betung) are united. Beside the increasing population, economic growth caused waste generation increase. Economic growth of Serang is 8.55 % and it's caused the increasing of waste generation in this city.

Table.1 The Comparison of waste generation between SNI 19-3964-1994, SNI 19-3983-1995, and analysis result.

City Classification	Total of population (person)	Waste Generation (l/p/d)		
		SNI 19-3964-1994	SNI 19-3983-1995	Analysis Result
Large	500000 – 1000000	2 – 2.5	-	3.2 ± 0.28
Medium/ Small	3000 – 500000	1.5 – 2	-	3.1 ± 0,02
Medium	100000 – 500000	-	2.75 – 3.25	3.1 ± 0.02
Small	< 100000	-	2.5 – 2.75	-

The Relation of Waste Generation to Economy and Demographic Variables

Based on regression analysis result, consumer price index is directly proportional to the waste generation. Analysis result showing that highly consumer price index of a city, so its waste generation is also quite high. Banda Aceh and Tanjung Pinang have positive regression trend, which is the progression of consumer price index will also increase the waste generation in those two cities. So it is with the relationship analysis between GDP based on constant price and waste generation. The higher GDP rate will increase the rate of waste generation. Positive regression trend happened between GDP rate and waste generation in Pekanbaru, Tanjung Pinang, and Pangkal Pinang. For analyzing the relationship between total of population and waste generation, waste generation rate is quietly increased within the increase of total of population in a regional. Exceptionally for Yogyakarta which its waste generation has decreased because of the decrease of total of population.

Test Model

Daskalopoulus model test results an equation as showed in **Equation 4.** Daskalopoulus model has R-squared 0.337. It means consumption per each category can describe waste generation in capital city of Java and sumatera by 33.7 %.

$$MSW = 7{,}517 + ((-0.003 \times RTCE_1) + (0.018 \times RTCE_2) + (-0.073 \times RTCE_3) + (0.073 \times RTCE_4) + (-0.018 \times RTCE_5) + (-0.025 \times RTCE_6)) \quad \textbf{(Equation 4)}$$

Meanwhile model test Khajuria results en equation as showed in **Equation 5**. Khajuria model has R-squared 0.219. It means total of population, GDP, and school's period can describe waste generation in capital city of Java and Sumatera by 21.9%.

$$WG = 14{,}66 + ((2.889 \times 10^{-7} \times X_1) + (-6.112 \times 10^{-9} \times X_2) +$$

$(-0.859 \times X_3))$…………..……………………………………………....(**Equation 5**)

The development of Khajuria model results an equation as showed in **Equation 6.** This development model has R-squared 0.458. It means total of population, GDP, school period, literacy rate, and economic growth can describe waste generation in capital city of Java and Sumatera by 45,8%.

$WG = 0.859 + ((2.66 \times 10^{-7} \times X_1) + (5.84 \times 10^{-9} \times X_2) + (-1.478 \times X_3) + (0.198 \times X_4) + (-0.061 \times X_5)$…………………………………………………………**(Equation 6)**

Projection of waste generation per the next five years obtained using discriminant equation as shown in **Equation 7**. The equation used to obtain a prediction cluster classification of waste generation from each city in the future. While **Figure 5** shows the increasing of waste generation per next five years.

$Z = -12.906\ X_1 + 13.793\ X_2 + -2.023\ X_3 + 1.932\ X_4 + -1.166\ X_5 + -1.559\ X_6 + -0.774\ X_7 + 2.740\ X_8 + 0.832\ X_9$ **(Equation 7)**

Where Z is discriminant score, X_1 is total population, X_2 is GDP, X_3 is consumer price index, X_4 is economic growth, X_5 is population density, X_6 is population growth, X_7 is school's period, X_8 is people development index and X_9 is literacy rate.

The increasing of waste generation per next five years can be calculated by **Equation 8. Figure 5** showed the increasing of waste generation in each capital city of Java and Sumatera.

Total waste generation = total population x average of waste generation in each cluster……………………………………………………………….…….(**Equation 8**)

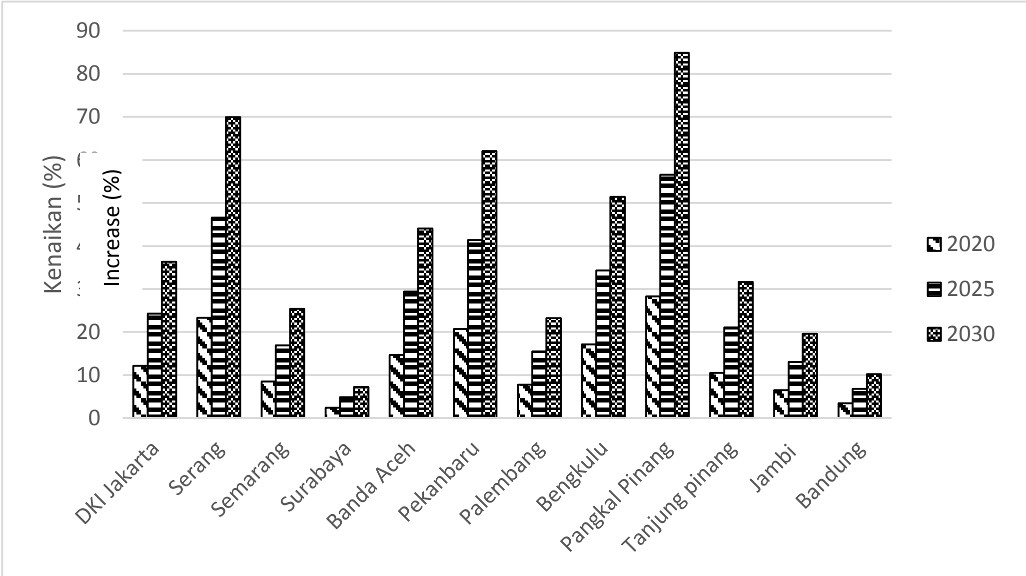

Figure 5. Increasing of waste generation per the five next years.

CONCLUSIONS

The result of city classification by doing cluster analysis, quadrant analysis, and classen typology analysis, showing there are three patterns of waste generation in 16 cities in Java and Sumatera, which are pattern 1 for low waste generation with Port/Trade and Trade/Plantation economic activity, pattern 2 for high waste generation with low economic growth and Industry/Trade economic activity. And pattern 3 for high waste generation and high economic growth and Industry/Trade economic activity.

Variables which are having effect to waste generation in 16 cities in Java and Sumatera, are economic growth, population density, Gross Domestic Product, and total of population. Daskopoulus model test that has done showing waste generation in 16 cities in Java and Sumatera only able to be explained by 33.7 % by consumption outcome in sub-category. Meanwhile, Khajuria model test, waste generation in 16 cities in Java and Sumatera can be explained by 21.9 % by Gross Domestic Product, total of population, and illiteracy.

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CARBON REDUCTION OPTIMIZATION IN WASTE TREATMENT USING DECENTRALIZED SYSTEM WITH THE APPLICATION OF A JOINT CREDIT MECHANISM

Agustina Cindy Widyanggita[1*†] and Priana Sudjono[2]
Master Programme for Environmental Engineering
Faculty of Civil and Environmental Engineering, Institut Teknologi Bandung
Jl Ganesha 10 Bandung 40132
Email: agustina.winardhi@gmail.com[1], psudjono@comices.org[2]
Presenter; † Corresponding author.

Abstract: The volume of waste generated in Bandung is increasing along with the increase of population and its activities. Through the process of natural degradation, garbage produces carbon emissions as what happened in waste treatment process. Responding to the waste problem in Bandung related to carbon emissions, it is necessary to make an optimization model to determine the best waste processing techniques for each area in Bandung which are devided by a decentralized system. Reduction in waste treatment costs are obtained from insentive which refers to the joint credit mechanism pattern, while the optimization model using linear programming will be solved using simplex method. Simulation of optimization model is run with a condition where service scope for waste is 70% with middle income people of 40% and low income people of 60%. According to mass balance concept, for 30% emission reduction target, Bandung Utara, Bandung Barat, and Bandung Selatan mostly use composting as their waste treatment with the input allocation of 90%, 99%, and 90% from the total amount of waste in each region, respectively, while Bandung Timur use sanitary landfill the 100% input of waste. When the same condition is applied but the constraint is changed into combined emission reduction for whole Bandung, the operational cost is reduced as much as 998.1 millions rupiah from initial cost. From this study, linear programming can be used for determining waste treatment plant with emissions constraints for making government's policy.
Keywords: organic waste, joint credit mechanism (JCM), optimization, linear programming

INTRODUCTION

Through the natural degradation process, organic waste emitted carbon emission, as the same with waste treatment process. Every treatment process will emit a different amount of carbon due to its technology. The more advance the technology used, the less carbon emitted, but the operational cost spent can be more expensive. In Joint Credit Mechanism (JCM) initiated by Japan there is carbon trading system where the amount of carbon reducted by Indonesia will be paid by incentive. This incentive from carbon trading can be used to reduce the operational cost for waste treatment process in Bandung City. Management of solid waste system in Bandung City are a decentralized system which mean there are several waste treatment process which are placed according to residential area division. In this research optimization will be conducted to obtain the cheapest waste treatment technology which emitt the smallest amount of carbon emission in each area of decentralized system.

The volume of solid waste generated in Bandung City raised as the population and its activity raises which become a big problem related to the lack of solid waste treatment facilities. The management of solid waste is only done by collecting and shipping the waste from TPS to the final disposal station (TPA) continuously, meanwhile the capaCity left for solid waste can only be used for 6 years ahead (Sriwuryandari dan Sembiring, 2009). In the final report of Bandung City BPLH in 2013, it is mentioned that the pilot project of solid waste management is one of the government effort to reduce the generation of solid waste which will give a long term advantage. It is also explained that the pilot project will be conducted in modular system, where certain area is determined together to applied a new management system that can reduce the investment and operational cost, increase the final disposal's lifetime, and also give working opportunity (BPLH, 2013). The average volume of wate generated in Bandung City is 3 Liter/person/day (BPLH, 2013) with the composition of kitchen waste as much as 58% (Sondari, et al., 2012). With the amount of population of 2.5 millions, so the total waste generated is 7500 m^3/day. When the amount of waste generated exceeds the final disposal capaCity, new problem will be arised that gives negative effect to the environment such as the green house gas (GHG) emission. Various solid waste treatments have been done, such as recycling organic waste to compost. Composting have a small reduction number of carbon which is 8 kg CO_2 equivalent/ton of waste, meanwhile the recycling of organic waste generated can reduce the volume of waste thrown to the final disposal which can indirectly reduce the GHG emission (Sunarto, et al., 2013). Landfill is the most expensive waste treatment after incineration with the efficiency of bolume reduction less than 50%, while the efficiency of volume reduction of incineration is greater which is higher than 50% (Minoglou, et al., 2013).

Landfill also contributes GHG emission of 3-4% from the global emission (Eggleston, et al., 2006). Green house gases emitted from solid waste sector are various, but the dominant gases that must be noticed in National GHGs Inventory are CO_2, CH_4, and N_2O. These gases included as GHG's have big potential related to global warming. Purwanto (2009) explained that the potential of global warming or global warming potential (GWP) is the radioactive effect unit of GHG which is compared to CO_2, in other words GWP is an indication of how many ton of CO_2 emitted is equal to other one ton of each GHG.

Many countries, including Indonesia has given attention toglobalwarming effect. Internationally global warming mitigation included in Kyoto Protocol which governs the obligation to reduce GHG emission related to climate change issue, Japan released a new mechanism to reduce carbon concentration worldwide which is known as Joint Credit Mechanism (Oghihara, 2013). Furthermore it is explained that in bilateral cooperation, Japan gives incentive to its partner who is able to reduce the amount of carbon in its country through project agreed by both parties. Oghihara (2013) also explained that Indonesia is legally cooperates with Japan since 2013. Emission trading process have important role in Post-Kyoto which aim to reduce GHG emission worldwide (Jaehn, et al., 2010).

To response waste issue in Bandung City, optimization model is needed to determine waste treatment method which has greatest carbon reduction with cheapest operational cost for every residential area based on decentralized system. Waste treatment method addressed for only organic waste considering this kind of waste has the greatest percentage of waste in Bandung City (BPLH, 2013). By using Intermediate Treatment Facility (ITF) in every residential area, it is hoped that the economic value, environmental quality and regional income can be raised.

RESEARCH METHOD

Decentralization of Bandung City

In this research, Bandung City is devided into 4 regions that are North Bandung, West Bandung, East Bandung, and South Bandung. Decentralization is based on administrative division where assumed that every region has 1 ITF.

Waste Generation in Each Region

Waste generation data is secondary data from 2013 in Laporan Ringkasan Eksekutif tahun 2013 (BPLH Kota Bandung, 2013). In this research assumed that the ratio of population consist of 40% intermediate income residence (IIR) and 60% low income residence (LIR) with waste generation coefficients for IIR and LIR are 0,12 kg/person/day dan 0,18 kg/person/day respectively.

Waste generation assumed 70% consider the waste management service can not reach 100% of waste because blind spot. Blind spot is area that can not be reached by waste transportation such as area without good access, area with few people which not efficient because the cost is too large compared with the waste handling. Waste generation followed **Equation 1.**

$$\boldsymbol{Waste\ Genration = Waste\ Generation\ coefficient\ x\ population} \quad \textbf{Equation (1)}$$

Open Dumping Emission

Open dumping emission calculated in term of carbon according to **Equation 2** based on EPA.

$$\boldsymbol{Carbon\ emission = Waste\ generation\ x\ biogenic\ carbon} \quad \textbf{Equation (2)}$$

where: $Carbon\ Emission =$ *open dumping emission;* $Waste\ genreation$=waste generation in tones/year*;* $biogenic\ carbon$ = organic compound carbon (kg C / ton of wet waste)

Waste Treatment Technology

Waste treatment technology which used in this research is composting, anaerobic digestion, incineration, and sanitary landfill. All technologies must be accredited by JCM or other institution which handle climate change such as UNFCCC, already applied in Japan, have known efficiency value, specialize to treat food waste (FW), and suitable for Bandung City by considering the economic, field availability, accessibility, and the efficiency aspects.

Emission of Waste Treatment Alternatives

Every waste treatment technology emitted different amount of emission. All of the emission, either carbondioxide, carbon,or methane emission will be converted to equivalent carbon emission (C-eq). Carbon emission for composting, anaerobic digestion refer to Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), while carbon emission for incineration and sanitary landfill refer to Emission Inverntory Guidebook (EEA, 2013) and EPA's Waste Reduction Model (WARM, 2015), respectively.

Carbon Reduction Emission

Carbon reduction emission is the amount of carbon that can be reduced using alternative waste treatment compared to the amount of carbon emitted by open dumping. The calculation of carbon emission reduction follows **Equation 3**.

$$\%eff = \frac{Carbon\ emission(open\ dumping) - Carbon\ emission(alternative)}{Carbon\ emission(open\ dumping)} x100 \qquad \textbf{Equation(3)}$$

Alternative Treatment Cost

Waste treatment alternatives cost is secondary data from Peraturan Menteri Pekerjaan Umum which can be seen in **Table 1.**

Table 1 Waste Treatment Alternatives Cost

Facilities	Investment Cost (Rp)	Operational Cost (Rp/ton of waste)
Insenerator (IF)	225 million - 3.3 billion/ ton of waste	400 - 600 thousand
Composting (CM)	500 million - 2.4 billion/ ton of waste / day	80 - 200 thousand
Anaerobic Digestion (AD)	660 million - 2.64 billion / ton of waste/ day	125 - 250 thousand

Source: Lampiran IV Peraturan Menteri Pekerjaan Umum No.3 Tahun 2013

Policy Related to Carbon Emission

Carbon emission reduction target according to Peraturan Presiden RI Nomor 61 Tahun 2001 about National Action Mitigation of Green House Gases is 26% on 2020 from Bussiness As Usual (BAU) scenario. If it is related with JCM, carbon emission reduction targeted by Japan for developing country is only 3%. (DNPI, 2013).

Model Development

Waste management system used in this research can be seen on **Figure 1.** It is assumed that every ITF consists of composting facility, anerobic digester, incineration facility, and sanitary landfill. Based on waste management system on **Figure 1**, it can be formulated from decision, objective function, and constraint variables.

Mathematic model begin by determine variable, constraints, and objective of system model. The n measured relation $(r_1, r_2, \ldots, r_n)$ will be stated by decision variable where each value is determined. Decision variable can be expressed in the ammount of carbon emitted by each source. In this research, amount of carbon reduced by each waste treatment defined in form of carbon emitted by related treatment. There are 16 decision variables (x_{ij}) on this optimization model. Those values are multiplication product of 4 decentralized areas and 4 kinds of waste treatment technologies.

Critical step in building mathematical model is when making the objective function. Quantitative measurement development is needed from relative relation showed by every formulated object. Because of that it is not needed to put every unnecessary detail or factor that predicted to give same response to all considered alternative treatment. The optimized variable in this model is total cost for waste management system and emitted carbon in each system. Objective function in optimization model is to minimize total cost of waste management system.

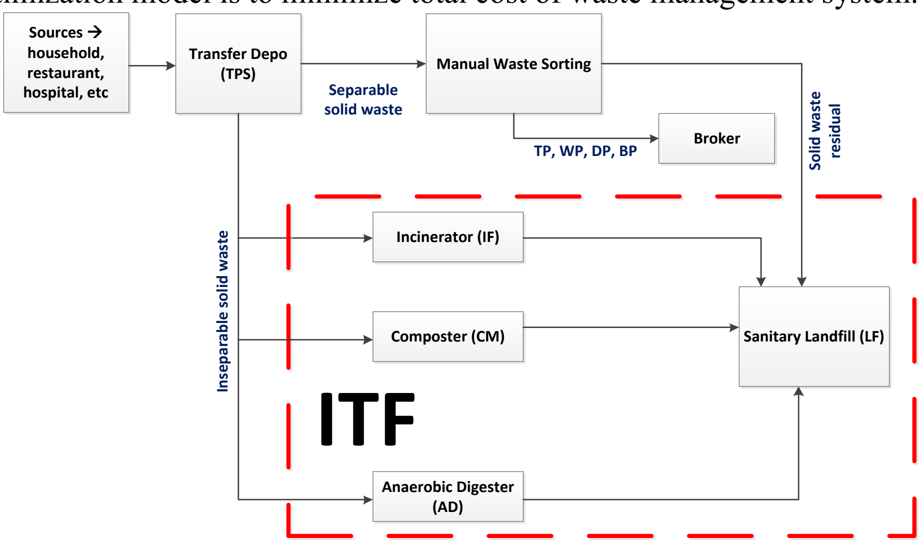

Figure 1 Sistem Pengelolaan Sampah di ITF

The main constraint in this optimization model is elaborated in **Equation 4**.

$$\sum_{j=1}^{4} X_{i,j} = 1\text{, with } i = 1 \text{ to } 4 \qquad \textbf{Equation(4)}$$

That mass balance equation shows that waste can be allocated in various waste treatments, but the sum of each waste fraction inputted in the treatment plant must be equal to the total mass of each component.

Research Area

Study area in this research is Bandung City which consists of 4 administrative regions.

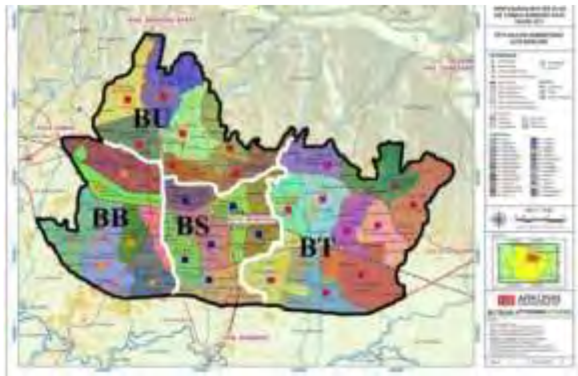

Figure 2 Regions Division (Laporan Ringkasan Eksekutif BPLH Kota Bandung, 2013)

The division of administrative region can be seen in **Figure 2** which consists of 4 region and 30 districts of Bandung City. Waste generation prediction in 2015 for every region of Bandung City is shown in **Table 2.** The predicted waste generation will be used for calculating the baseline emissions for the next 5 predicted years.

Table 2 Predicted Waste Generation in 2015

Area of Bandung	Predicted Waste Generation (FW) in 2015 (ton/year)
Bandung Utara (BU)	38727.34 ≈ 38700
Bandung Barat (BB)	45220.09 ≈ 45200
Bandung Timur (BT)	47273.73 ≈ 47300
Bandung Selatan (BS)	33008.63 ≈ 33000

RESULTS AND DISCUSSIONS

Condition of Each Area

From **Table 3**, it can be seen that incineration emitted lowest carbon of other waste treatment technologies. Considering that, incineration has a good potential as Bandung waste treatment technology, but the cost needed is relatively more expensive than others (see **Table 4**).

Table 3 Emission Carbon from Location (i) Using (j) Technology

Carbon Emission ($EM_{i,j}$) (ton C-eq/year)	**Location (i)**			
Treatment Technology (j)	BU (1)	BB (2)	BT (3)	BS (4)
Composting (1)	1858.912	2170.564	2269.139	1584.414
AnaeDig (2)	464.728	542.6411	567.2848	396.1036
Incineration (3)	1.74273	2.034904	2.127318	1.485388
Sanitary LF (4)	774.5467	904.4018	945.4747	660.1727

Moreover not every area has good economic value for using incinerator which should be built in densely populated area. For relatively low populated area, usage of incineration technologies needed more cost than sanitary landfill, about 51.42 times more expensive.

Table 4 Operational Cost for Each Source (i) Using (j) Technology

	Operational Cost ($C_{i,j}$) (millions Rp/ton FW)		
Treatment (j)	**2015**	**2020**	**2025**
Composting (1)	0.483	3.495	7.743
AnaeDig (2)	0.646	4.681	10.363
Incineration (3)	1.725	5.850	19.843
Sanitary LF (4)	0.115	0.384	0.521

All of the calculation conducted in the model use open dumping as the baseline. Suggest the government apllied policy for carbon emission reduction of 20%, so the maximum emission permitted from all waste treatment is 80% from total carbon emission (see **Table 5**).

Table 5 Open Dumping (As Baseline)

Location (i)	**FW (ton/year)**	**Carbon Emission (ton C-eq/year)**
NB	38727.34 ≈ 38700	4260.01 ≈ 4260
WB	45220.09 ≈ 45200	4974.21 ≈ 4970
EB	47273.73 ≈ 47300	5200.11 ≈ 5200
SB	33008.63 ≈ 33000	3630.95 ≈ 3630
TOTAL	≈ 164200	≈ 18060

Mathematical Formulation

Waste management allocated to several kind of technology according to the needs. Based on that it is needed to find the best proportion of each allocation of treatment. By using cost efficient $C_{i,j}$ from **Table 3** and decision variable $X_{i,j}$, an objective function of total cost can be formulated (**Equation 5**).

$$Z_{cost} = \sum_i^m \sum_j^n (C_{i,j}) x (X_{i,j})$$

Equation(5)

where: m= the amount of emission sources; n=the amount of technology; i=index for emission sources; j=index of technology; Z=cost for

To obtain the objective function of Z in **Equation 5**, variable decision $X_{i,j}$ need to be solved using linear system with constraints as follow (**Equation 6** and **Equation 7**):

$\sum_j^n (X_{i,j}) = 1 \; for \; each \; region \; with \; i = 1 \; to \; 4$ **Equation(6)**

$\sum_i^m \sum_j^n \left[(EM_{i,j}) x (X_{i,j}) \right] \leq (1 - \%Red) x Total \; C \; Emission$

Equation(7)

Where: m=the amount of emission sources; n=the amount of technology; i=index for emission sources; j=index of technology; %Red is the percentage of emission reduction according to the policy applied; Total C emission=total carbon emission from open dumping

Determining Suitable Technologies for Each Region

Every waste treatment technologies have their own needs. As an example, not every region can be used for landfill site. When it is raining, runoff spreadings from a higher area will gives bigger spreading effect then those in flat areas. Other consideration is about the land availability. Area with smaller residential dense is more feasible for sanitary landfill site with the hope that negative impact in that area can be minimalized. Based on spatial pattern plan map of Bandung for 2011- 2031 (Bappeda, 2012) in **Figure 3**, it can be seen that North Bandung and East Bandung is the most feasible areas for sanitary landfill site, but due to its topograph, the elevation in North Bandung is relatively high so it is not suitable as sanitary landfill site. Because of that, it is determined that East Bandung is choosen as the location for sanitary landfill site.

Figure 3 Spatial Pattern Plan Map of Bandung for 2011 – 2031 (BAPPEDA, 2011)

One of the considerations for choosing incineration site is the cost efficiency problem. If the incinerator used is a mass burn incinerator in modular combuster type with a capacity of 130 ton of waste/day, so it is better if the amount of waste generated has the same amount of the incinerator capacity because if the amount of waste generated is much more smaller than the treatment capacity, operational cost needed will be higher. According to that problem, only West Bandung and East Bandung area which can give higher economic efficiency with the amount of waste generation of 123.84 ton/day and 129.59 ton/day, respectively. Other consideration is population density. Areas with higher population representate a condition where land availability is not much. According to that, incineration will be used in West and East Bandung. Biological waste treatment can be done in aerobic condition with composting or anerobic condition using biodigestion. The problem here is the final product of its treatment which depends on waste composition. To obtain good quality of liquid fertilizer, biological treatment process must be mixed with animal feces. It is related to the anaerobic bacteria needed to activate substrate from

FW. According to this consideration, better to locate biodigester and composter site near farms so animal feceses can be transferred to composting or biodigestion plant without spending much money. If it is assumed that liuid fertilizer and compost produced will be used for city garden, so from **Figure 3**, green open space and gardens can be founded in every area in Bandung City. According to all of the considerations before, it is determined to use biodigester and composter in every area of Bandung City.

Simulation Results For 2020

After the condition of waste for 2015 is known already, prediction of optimization for waste allocation in 2020 is conducted in two different conditions. Simulation result gives graph shown in **Figure 4.**

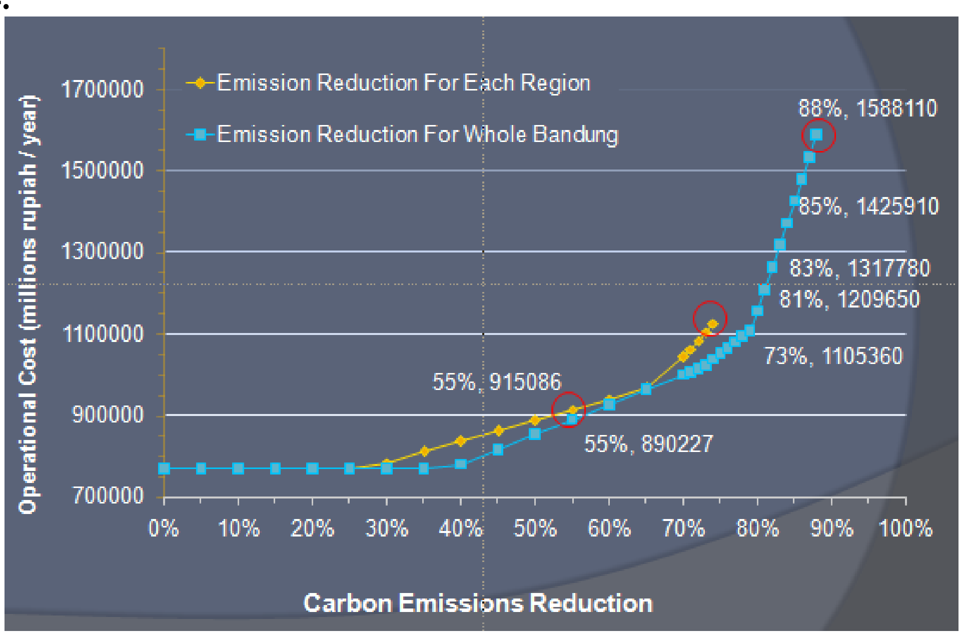

Figure 4 Comparison of Operational Cost in Both Situations

The first situation is conditioned that every region have its own emission reduction target, while the second situation is conditioned that Bandung City has a certain emission reduction and reduction target in each regions are neglected. It can be seen in **Figure 4** that by the presence of carbon trading (see the red line), operational cost of waste treatment in Bandung City became cheaper than before (see the blue line). **Figure 4** also shows the maximum reduction that can be achieved from each condition where the maximum target reduction for combined emission constraint is higher than the other one which is 88%.

Allocation of Waste to Be Treated

Figure 5 shows the allocation of waste (ton of FW/year) in Bandung Utara to be treated using each kind of treatments. The allocation of waste to be treated in Bandung Utara for target reduction of 30% using emission constraints for each region is as follows: X_{11}=64784.88, X_{12}=6415.09, X_{21}=78191.16, X_{22}=8.861468, X_{23} until X_{33} is zero, X_{34}=93100, X_{41}=55052.15, X_{42}=5747.831

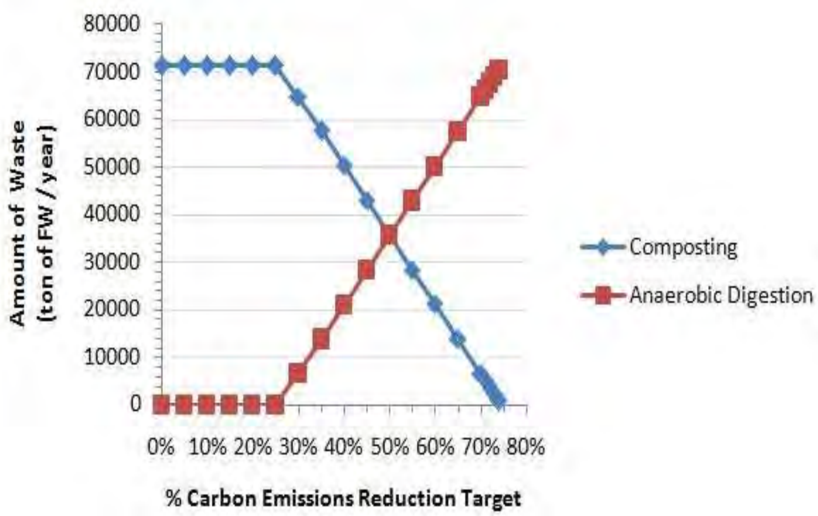

Figure 5 Allocation of Waste to Be Treated in Bandung Utara

Three Phases of Simulation Results

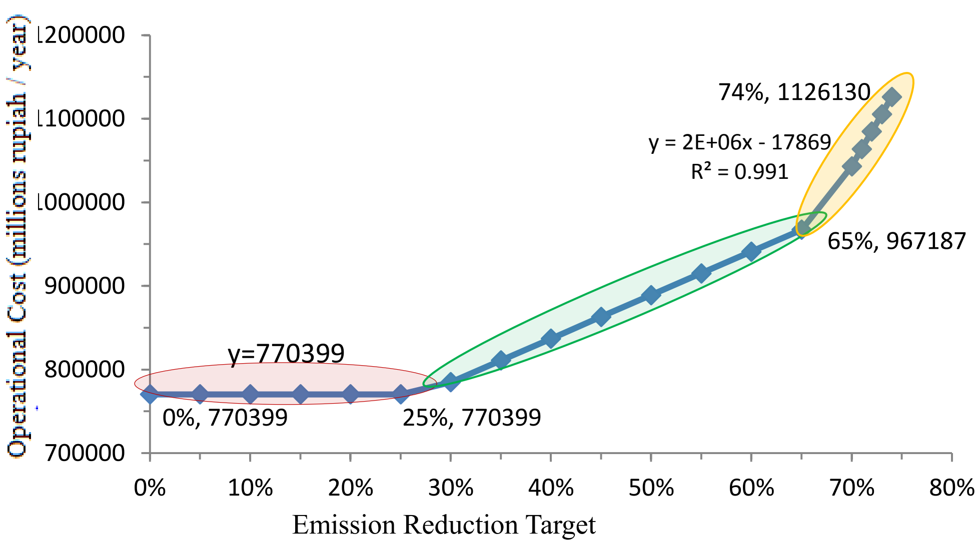

Figure 6 Phases of Simulation in 2020

Figure 6 shows the simulation results in 2020 using separated constraint for emission for each region. There are three phases of simulation results that can be seen in **Figure 6**. First is the constant phase between target reductions of 0% to 25% which consists of the cheapest waste treatment plant in each region. In this phase the realized emission reduction is below target emissions. The second phase occurred when the target for emission reduction is higher than 25% up to 65% where several regions of Bandung City started to use their second cheapest waste treatment plant to meet the reduction target. Bandung Utara and Bandung Selatan started to use Anaerobic Digester. These conditions also occurred for phase three, but it happened in Bandung Timur only which used Inceneration facility to meet the target reduction.

CONCLUSION AND SUGGESTION

Biodigester and composter will be used in every region, sanitary landfill will be used in East Bandung, and incinerator will be used in East Bandung and West Bandung.

Allocation of optimal waste fraction input for each waste treatment in every region for 2020 with emission reduction target of 30% are as follows, x_{11} = 0.9099, x_{12} = 0.0900997, x_{21} = 0.999887, x_{22} = 0.000113318, x_{23} = 0, x_{31} = 0, x_{32} = 0, x_{33} = 0, x_{34} = 1, x_{41} = 0.905463, x_{42} = 0.0945367 with the total operational cost of 784835 millions rupiah.

Carbon trading system application can reduce the operational cost for Bandung City as much as 14436 millions rupiah/year.

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DEGRADATION OF DEGRADABLE PLASTICS ON SEVERAL SOLID AND LIQUID MEDIA

Emenda Sembiring[1*,†] ,Yufienda Novitasari[2]
Environmental Engineering Study Program, Faculty of Civil and Environmental Engineering
Institut Teknologi Bandung
emenda@ftsl.itb.ac.id[1] and yufienda.novitasari@gmail.com[2]
* Presenter; † Corresponding author.

Abstract: Plastics on the market are usually made by synthetic polymers that are difficult to decompose in nature. To reduce the impact of plastic waste, nowadays biodegradable and degradable plastics have been introduced into the market. The availability of degradable plastics on the market attracts local government in Bandung to use degradable plastics for waste storage especially on the road side. Therefore, this study evaluates the end life of degradable plastics in solid and liquid media: soil, waste, composting and water. Two types of plastic materials, @Ecoplas and @Oxium are investigated. @Ecoplas is made from natural materials, such as starch, so it can be degraded biologically. @Oxium is made from additional addictive substance that is mixed into pure plastic raw materials in order to speed up the oxidation process. The plastics were inserted into the soil and waste media for 90 days, composting media for 50 days, anaerobic condition for 21 days, and the river media for 21 days. To confirm the degradability, a series of measures was conducted by measuring the weight and tensile strength. Scanning Electron Microscopy (SEM) test was also conducted to see the morphology of plastics during the experiments. The average of weight loss for @Ecoplas was up to 31% and for @Oxium was up to 20% during 90 days in waste media, whereas, in the soil the average weight loss for @Ecoplas and @Oxium was up to 33% and 28% during 21 days consecutively. For the tensile strength test, @Ecoplas has decreased 25-27% and @Oxium has decreased 16-17% in soil and waste media.

Keywords: biodegradable plastics, degradable plastics, degradability, solid media, liquid media

INTRODUCTION

In the past, plastic polymeric materials have been designed to resist degradation. However, with mounting environmental and legislative pressure to reduce plastic and packaging wastes, there has been an increased demand for biodegradable polymers that can decompose in the environment. In Bandung, there are two types of degradable plastics which are commercially available, biodegradable and degradable plastics, for example with the brands @Ecoplas and @Oxium. @Ecoplas is one of the new brand of biodegradable plastics. Biodegradable plastics are plastics that can be degraded with the help of microorganisms into environmentally friendly compounds, carbon dioxide(CO_2), water(H_2O) and biomass. @Oxium is one of the brand from additive that is mixed into pure plastic raw materials in order to speed up the oxidation process.

Are degradable plastics (DP) or biodegradable plastics (BP) can be the answer to solve the environmental pressure caused by conventional plastics? To find the answer, the need to know how DP or BP degrades in the environment is important. Then, a decision on to promote the BP or DP can be justified. Therefore, this study objective is to determine the level of degradation of plastic @Ecoplas and @Oxium. The study was conducted on six media degradation testing, the soil media, waste media, composting media, anaerobic condition, and river media. The media and condition were chosen based on the possibility of end life of plastics.

LITERATUR REVIEW

When biodegradable plastics started entering the market, there were a series of misconceptions about the term degradable and biodegradable. Many plastics entered the market with biodegradable labeling, but only disintegrated and did not completely biodegrade. These plastics have been commercially available since 1990 and can be produced either from plant origins, such as strach or by bacteria. Therefore, in order to avoid misconceptions, several standards in the area of degradable as well as biodegradable plastics have been developed by national standards bodies including USA (ASTM), the International Organization for Standardization (ISO) and others (Mohee et al., 2008).

As per the ASTM standard D5988-03, biodegradability of plastic materials has been defined as the capability of undergoing decomposition into carbon dioxide, methane, water, inorganic compounds or biomass predominantly by the enzymatic action of microorganisms. The standard requires 60-90% decomposition of the plastic within 60-180 days in composting environment. Degradable plastic is defined as a plastic designed to underdo a significant change in its chemical structure under specific environmental conditions, resulting in a loss of some properties that may vary as measured by standard test methods appropriate to the plastics and the application over period of time that determines its classification.

Figure 1 indicates how degradation differs from biodegradation.The degradable stage stops at the fragmentation of polymers. This occurs by the action of heat, moisture, sunlight and/or enzymes that shorten and weaken the polymerchains resulting infragmentation residues and cross-linking to create more intractable persistent residues. It is only if the fragmentsare consumed by microorganisms as food and an energy source that the plastic polymer is said to be biodegradable.

Degradable vs Biodegradation

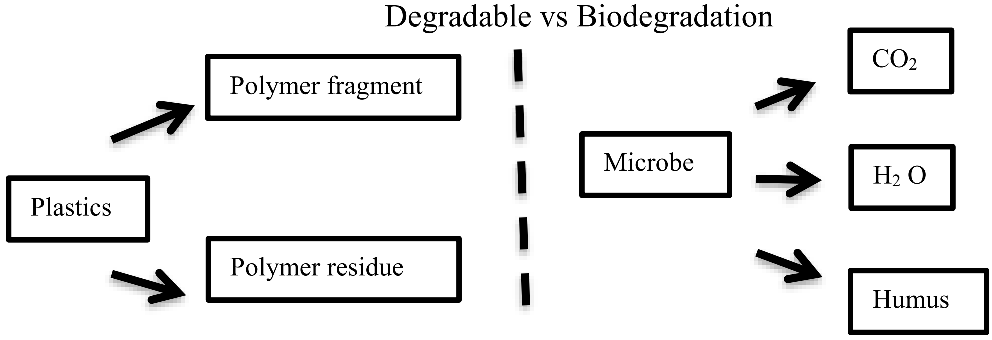


Figure 1 Degradation versus biodegradation process

MATERIAL AND METHODS

Types of plastics that were sampled in this research are @Ecoplas and @Oxium. @Ecoplas is a biodegradable plastic film samples which are made from a mixture polyethylene with starch. This plastic has a thick 20µm. @Oxium is degradable plastic which are made from a mixture polyethylene with additives added. This plastic has a thick 30µm.

Two types of controls are used namely positive and negative controls. A filter paper is used as positive control. A positive control is a specimen that can be degradaed completely. Negative control came from conventional plastics on the market, HDPE (High Density Polyethylene). A negative control is a specimen that can't degraded along this test.

a. Determination of biodegradability under soil media

Soil media which were applied in this study was a soil without compost or nutrient added. In this condition, the soil media were dropped into the reactor, size 1x1x1 m. The samples plastic of @Ecoplas, @Oxium and HDPE as a negative control were inserted into the reactor which already contains the soil. These samples were inserted on three different heights, 30 cm, 60 cm and 90 cm from the bottom. The study was carried out at the media for 90 days and sampling once every seven days. The soil parameters used for monitoring were moisture content, pH and temperature.

b. Determination of bioderadability under waste media

In this condition, the piles of waste were derived from TPS *Caringin* and the experiments were conducted at the Sarimukti landfill. The piles of waste were droped into the size 2x1x1m. The samples plastic of @Ecoplas, @Oxium and HDPE as a negative control were inserted into the piles of waste. These samples were inserted on three different heights, 30 cm, 60 cm and 90 cm from the bottom. The study was carried out at the media for 90 days and sampling once every seven days. The waste parameters used for monitoring were moisture content, volatile solids, pH and temperature

c. Determination of biodegradability under composting media

A reactor, 60x50x120 cm was used for aerobic composting. The composting materials consisted of 25.5 kg of kitchen waste, 30 kg of yard waste, 2.5 kg of paper and 8.2 kg of water. The carbon-to-nitrogen ratio of the mix was 27.9, where the carbon content was determined based on the ash percentage and the nitrogen content by the Kjeldahl method.

The moisture content was adjusted to 55% by the addition of water. The sample plastics of @Ecoplas, @Oxium, HDPE and filter paper, 0.5 g each, were cut into sizes 0.5 x 0.5 cm and were placed in 17.5 mm -18.0 mm bags. These bags were then inserted within the compost pile at different positions, 40 and 60 cm from the bottom.. The biodegradation of these test samples were determined through mass loss analysis. The composting parameters used for monitoring were moisture content, volatile solids content, pH and temperature.

d. Determination of biodegradability under anaerobic conditions

This part of the study was performed to investigate the biodegradability potential of degradable/biodegradable plastic under an anaerobic medium (sludge) as per ASTM D5526-94d test method to determine anaerobic biodegradation of plastic materials under accelerated landfill conditions (Figure 2). The samples plastic of @Ecoplas, @Oxium, HDPE and filter paper, I gram each were cut finely to film sizes of 0.5 x 0.5 mm as specified in ASTM D5526-94d. The inoculum was an anaerobic sludge obtained from the *Bojongsoang* waste water treatment plant where effluents of domestic waste from Bandung city were treated. This investigation consisted of thoroughly mixing the plastic and cellulose filter paper samples by using stirrer with constant spin for 2 hours. The samples were analyzed in dulicate and one set was assessed without addition of any plastics.

Figure 2 Experimental set-up under anaerobic condition

e. *Determination of biodegradability under river water sample*

River water sample which were used in this study came from Cikapundung river. In this condition, Cikapundung River water sample was then dropped into the reactor, size 60x40x50 cm.The samples plastic of @Ecoplas, @Oxium and HDPE as a negative control were inserted into the reactor. The study was carried out at the media for 21 days and sampling once every seven days. The water parameters used for monitoring were Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO) and alkalinity.

RESULTS AND DISCUSSION

a. Degradability test under soil media

The percentage of plastic degradation can be calculated as follows:

$$\% \, Plastic\ Degradation : \frac{(weight\ of\ plastic\ at\ the\ beginning - weight\ of\ the\ plastic\ at\ the\ end)}{weight\ of\ plastic\ at\ the\ beginning} x100\%$$

Table 1 Percent Degradation of Plastics on Soil Media

Sample	Height (from the bottom)	Weight T_0(gram)	Weight T_{90}(gram)	% Degradation
HDPE	30 cm	0.1162	0.1123	3.350
	60 cm	0.1122	0.1121	0.080
	90 cm	0.1168	0.1167	0.085
@Ecoplas	30 cm	0.2911	0.1962	32.60
	60 cm	0.2875	0.1941	32.48
	90 cm	0.2825	0.1886	33.23
@Oxium	30 cm	0.3720	0.3021	18.79
	60 cm	0.3750	0.2830	24.53
	90 cm	0.3880	0.2780	28.35

It can be seen from Table 1, the percent degradation of HDPE only 0.08 to 3.35 %. It shows how HDPE very slowly decompose in nature compare to other plastics. The sample pastic of HDPE will not be degraded at its optimum time for only 90 days. According to the results of percentage degradation for @Ecoplas, it can be seen that the weight of plastic at height of 30 cm, 60 cm and 90 cm were not too different significantly. At height of 30 cm from the bottom, plastic degraded 32.6 %, at height of 60 cm from the bottom, plastic degraded 32.48 % and at height of 90 cm from the bottom, it degraded 33.23 %.

The results of percent degradation for @Oxium were different. It can be seen that the weight of @Oxium at height of 30 cm from the bottom had the smallest percent degradation, 18.79 % , whereas at a height of 60 cm from the bottom the sample plastic had a percent degradadation 24.53 % and the highest degradation occurs at a height of 90 cm from the bottom, 28.35 %. According to Mohee et al., (2008), @Oxium was an Oxo-degradable type, where the type of plastic will degrade well when there is the influence of specific environmental conditions, such as sunlight and moisture.

b. Degradability test under waste media

After being tested for 90 days, at the beginning the temperatur of the piles of waste was 34^oC and at the end the temperature was 29^oC. The moisture content in this experiments was about 50-60%. According to Damanhuri and Padmi (2010), the moisture content of municipal waste in Indonesia is about 60%. It happened because the waste composition was dominated by organic materials. In this experiments, pH value stands at 5.9-6.2. According to Tchobanoglous et al., (1993), a stable pH in the digester to degrade organic material is 7. If the pH value is far above the 7 there will be a loss of osmotic pressure on microorganism, while the pH value is too low will cause decomplectation of major ions from minerals and organic matter.

Table 2 Percent Degradation of Plastics on Waste Media

Sample	Height from the bottom	Weight T_0 (gram)	Weight T_{90} (gram)	% Degradation
@Ecoplas	30 cm	0.2890	0,2010	30,44
	60 cm	0.2921	02010	31.18
	90 cm	0.2955	0.2200	31.11
@Oxium	30 cm	0.3660	0.3210	12.29
	60 cm	0.3680	0.3020	17.93
	90 cm	0.3620	0.2880	20.44
HDPE	30 cm	0.1140	0.1130	0.870
	60 cm	0.1120	0.1090	2.670
	90 cm	0.1130	0.1120	0.880

It can be seen from Table 2, the percentage degradation of HDPE only 0.8 to 0.88 %. For @Ecoplas, it can be seen that the weight of plastic at height of 30 cm, 60 cm and 90 cm were not too different significantly. At a height of 30 cm from bottom, plastic degraded 30.44 %, at height of 60 cm from the bottom, plastic degraded 31.18 % and at height of 90 cm from bottom, it degraded 31.11%. The result of percent degradation for @Oxium was significantly different. It can be seen that the weight of @Oxium at height of 30 cm from the bottom had the smallest percent degradation, 12.29% , whereas at a height of 60 cm from the bottom the sample plastic had a percent degradadation 17.93 % and the highest degradation occurs at a height of 90 cm from the bottom, which is20.44% .

c. *Degradability test under composting media*

On composting media there are several parameters that must be evaluated to determine that compost was mature and stable. The parameters are temperature, moisture content, pH, volatile content, and C/N ratio. In this study the compos reaches a stable condition after 50 days. The average initial temperature of the compost pile was 28^oC. The mean peak temperature obtained was 50^oC on day 14. This gave an indication of the active decomposition phase consisting of high microbial activity in the organic matter. It should be noted that the temperature of the pile remained above 50^oC for about 3 days. There was an abrupt decrease in temperature after day 6 due to the end of the active decomposition phase, as a result of depletion in the amount of readily available organic matter for microorganisms or limiting amounts of one of the reactants. The temperature started to stabilize after day 20. The initial average moisture content of the pile was 52%, which increased to 60% on day 25 to reach a maximum of 62% on day 30. This increase was due to the decomposition process. Thereafter, a gradual decrease in moisture was noted, indicating water utilization by the microorganisms during the breakdown process. The moisture content decreased to about 55% on day 45, at which point it stabilized due to the absence of microbial activity and the initiation of compost maturation. Variation in volatile solids within the compost pile provides an indication of biological degradation over time. The volatile solids content decreased from 77% on day 1 to 62% on day 14, indicating that decomposition was taking place. An overall decrease of 45% in volatile solids content was obtained after 40 days of composting. At no time during the composting period did the pH go beyond the optimal pH range (6.2–8.5), implying that the conditions within the pile were always favorable for microbialactivity. The pH increased from 6 on day 1 to 8.5 on day 50. This indicated that microbial activity occurred effectively. The trends followed by the parameters indicated effective microbial activity; in other words, test samples were under an effective composting environment for successful and unbiased biodegradation to take place. Table 3 shows the percent degradation before and after composting.

Table 3 Percent Degradation of Plastics on Composting Media

Sample	Height from the bottom	Weight T_0(gram)	Weight T_{50}(gram)	% Degradation
@Ecoplas	30 cm	0.0519	0.0411	20.80
	60 cm	0.0512	0.0401	21.67
@Oxium	30 cm	0.0511	0.0468	8.410
	60 cm	0.0508	0.0442	12.99
HDPE	30 cm	0.0511	0.0510	0.190
	60 cm	0.0512	0.0510	0.390
Filter Paper	30 cm	00510	0.0000	100.0
	60 cm	0.0514	0.0041	92.02

There was no distinguishable cellulose filter paper left after 50 days of composting, implying that it was fully biodegraded (100%) and that the conditions required for biodegradation to occur in a composting environment were present. The weight of the @Oxium decreased by 8.41% at height of 30 cm from the bottom, and 12.99% at height of 60 cm from the bottom, implying that they did not fully degrade within the 50-day period and required more time for complete biodegradation as can be confirmed by the ISO 14852, which states that @Ecoplas degraded to about 20.8% at 30 cm from the bottom and 21.67 at 60 cm from the bottom after a period of 50 days under an aerobic composting (Table 3).

d. Degradability test under anaerobic media

For the anaerobic environment, biodegradability was determined in terms of biogas production. Figure 3 shows the cumulative variation in the volume of methane generated from anaerobic sludge IPAL Bojongsoang and Figure 4 from Sarimukti landfill soil during anaerobic digestion. A high rate of methane gas production was noted for filter paper and Ecoplas (a cumulative amount of 162 ml and 98 ml, respectively) until day 21 indicating high microbial activity, which correlated to the decrease in volatile solids. Figure 5 shows cumulative carbon dioxide from inoculum of anaerobic sludge IPAL Bojongsoang which were 34.32 mg for filter paper and 12.98 mg for Ecoplas, 4.27 mg for Oxium and 3.74 mg for HDPE. Figure 6 shows cumulative carbon dioxide from inoculum of Sarimukti lanfill soil which were 30.8 mg for filter paper, 9.94 mg for Ecoplas, 4.92 mg for Oxium and 3.34 mg for HDPE. Table 4 shows degradation of plastics on anaerobic conditions.

Table 4 Degradation of Plastics on anaerobic conditions

Media	Plastics	T_0 (gram)	T_{21} (gram)	% Degradation
Anaerobic Sludge WWTP Bojongsoang	@Ecoplas	1.089	0.872	19.92
	@Oxium	1.120	1.080	3.570
	HDPE	1,087	1.085	0.180
	Filter paper	1.023	0.012	98.82
Sarimukti Landfill Soil	@Ecoplas	1.018	0.843	17.19
	@Oxium	1.120	1.083	3.300
	HDPE	1.087	1.080	0.640
	Filter paper	1.023	0.102	90.02

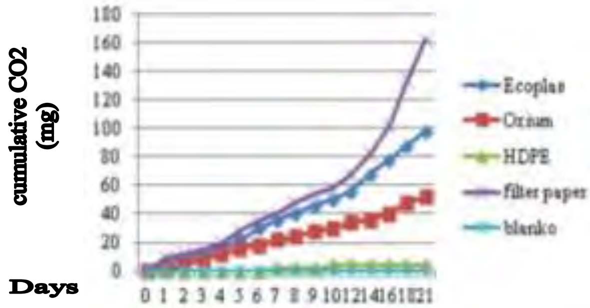


Figure 3 Cumulative of Methane on Anaerobic Sludge IPAL Bojongsoang

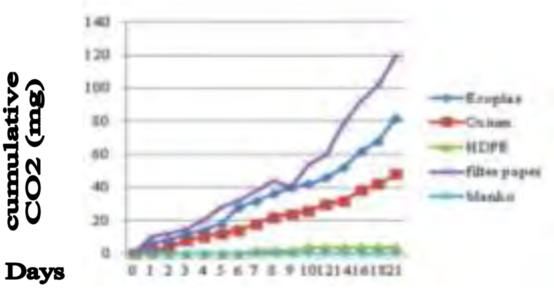


Figure 4 Cumulative of Methane on Sarimukti Landfill Soil

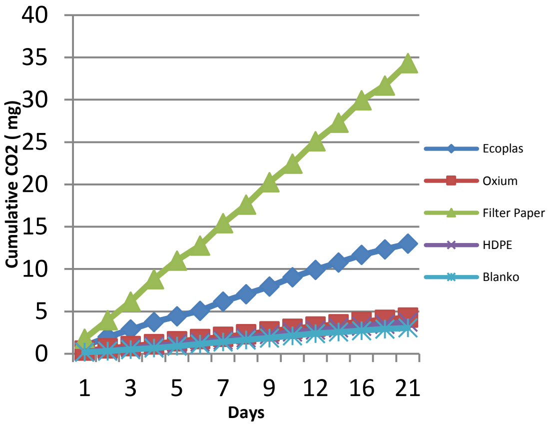


Figure 5 Cumulative of Carbon Dioxide on Anaerobic Sludge IPAL Bojongsoang

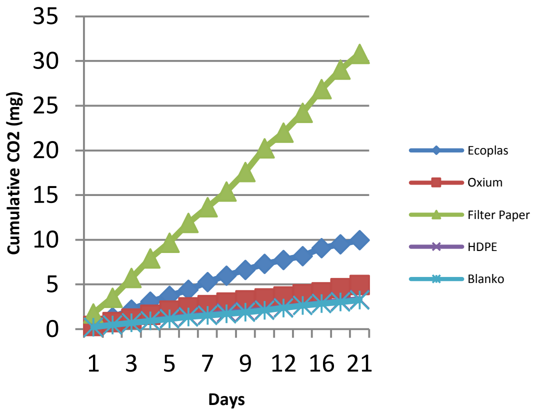


Figure 6 Cumulative of Carbon Dioxide on Sarimukti Landfill Soil

e. Degradability test under river media

The percentage weight loss that occurs in the river media is insignificant. This was because the testing method was done in batch conditions. According to research by Yunar (2011), if the testing method was done directly in the river for 6 weeks, then the @Ecoplas could be degraded100%. This was because in the river condition there were not only microorganisms, but also macro-organisms, such as fish, snails and other macro-organisms that could degraded the plastics. Table 5 showns the percent degradation of river media.

Table 5 Percent Degradation of Plastics on River Media

Sample	T (0) (gram)	T (7) (gram)	T (14) (gram)	T (21) (gram)	%degradation
@Ecoplas	0.2871	0.2820	0.2710	0.2320	19.19
@Oxium	0.3522	0.3500	0.3510	0.3170	9.990
HDPE	0.1342	0.1340	0.1339	0.1340	0.150

f. *Tensile Strength Test*

Tensile strength test performed in this study refers to the standard ASTM-D638. After the observation in several media such as soil media, waste media and the river water sample media, tensile strength test results that occur are shown in Table 6.

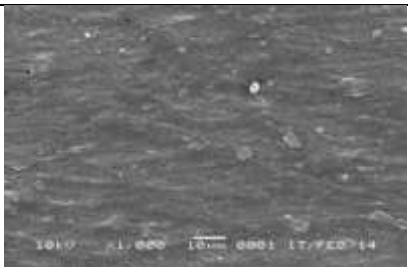
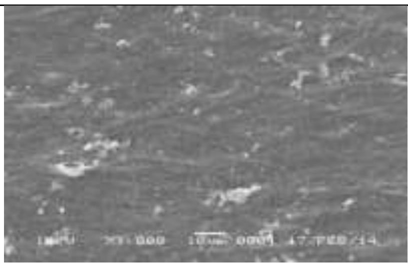
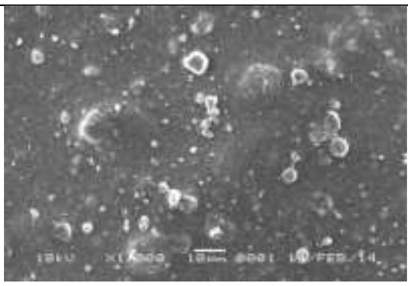
Table 6 Results of Tensile Strength Test

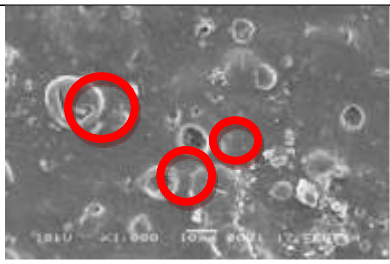
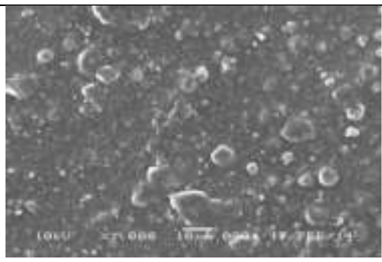
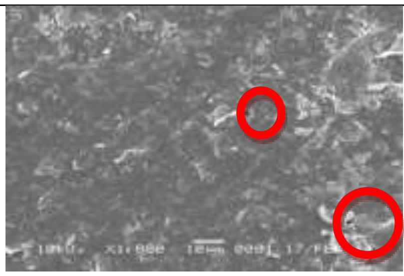
Sample	Media	Days	Tensile Strength Test (MPa)
@Ecoplas	Without Media	0	93.200
@Oxium			120.62
HDPE			134.52
@Ecoplas	Soil	90	70.200
@Oxium			100.62
HDPE			134.28
@Ecoplas	Waste	90	68.400
@Oxium			100.42
HDPE			133.88
@Ecoplas	River	21	88.820
@Oxium			112.62
HDPE			134.62

It can be seen from Table 6 that reduction value of tensile strength test happened in @Ecoplas and @Oxium. The reduced of tensile strength value because the constituent materials of plastic were degraded by microorganisms conditions that change the mechanical property of plastics, so that the value of tensile strength test also declined.

g. *Scanning Electron Microscopy (SEM) Test*

The SEM test in this experiments performed at a magnification of 1000X. The resulte of this SEM test were shown in Fig. 7, Fig. 8, Fig 9, Fig.10, Fig.11, Fig.12.

Sample	Media	Figure of SEM Test
HDPE	Soil Media T(0)	 **Figure 7 HDPE Sample on Soil Media T (0)**
HDPE	Soil Media T(90)	 **Figure 8 HDPE Sample on Soil Media T (90)**
@Ecoplas	Without Media T(0)	 **Figure 9 @Ecoplas on Soil Media T(0)**

Sample	Media	Figure of SEM Test
@Ecoplas	Soil Media T(90)	 **Figure 10@Ecoplas on Soil Media T(90)**
@Oxium	Without Media T(0)	 **Figure 11 @Oxium on Soil Media T(0)**
@Oxium	Soil Media T(90)	 **Figure 12 @Oxium Sample on Soil Media T(90)**

These are example of morphology plastics type @Ecoplas, @Oxium and HDPE before and after being tested on soil media for 90 days. It can be seen from Figure 7 and Figure.8, that there were no differences about HDPE Plastics before and after experiment. But for @Ecoplas and @Oxium, there were differences about before and after being tested. It can be seen from fig.9 and fig.12 that there were holes in @Ecoplas and @Oxium after being inserted on soil media for 90 days.

CONCLUSIONS

Biodegradable plastics degrade more than degradable plastics. No correlation of biodegradable plastics with the position of samples in the media. There is a correlation between degradable plastics with the position of samples in the media. The biodegradable and degradable plastics weight reduction occurs more in waste landfill than in soil and aquatic water

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CHANGES IN SOIL CHARACTERISTICS UNDER SARIMUKTI LANDFILL, WEST BANDUNG REGENCY

Febrian Hadinata[1,*] †, Benno Rahardyan[2], Enri Damanhuri[3]
[1] Doctoral Program of Environmental Engineering Institut Teknologi Bandung
[2,3] Faculty of Civil and Environmental Engineering Institut Teknologi Bandung
Jl. Ganesha No. 10, Bandung, Indonesia
Email:, febrian.hadinata@yahoo.co.id, benno@ftsl.itb.ac.id[3], and enridamahuri@gmail.com
[*]Presenter; † Corresponding author.

Abstract: The volume of landfill leachate in Indonesia is quite high, due to the closure of waste is not done on a daily basis. And if the liner layer is not available or is not working properly, then the leachate will go directly to the bottom soil layer. Characteristics of the soil at the base of the landfill may be subject to change due to seepage of leachate from rubbish on it. This study examines changes in the physical characteristics of the soil under the landfill, which include; plasticity index, grain size analysis and the specific gravity. Sampling was conducted at the landfill Sarimukti, West Bandung regency. Samples were taken to look at the possibility of changes in soil characteristics, by comparing karakteristk ground under the landfill (6 samples) and outside the landfill (2 samples). From the results, it can be concluded that there is no significant difference between the Specific Gravity ground under the landfill and outside the landfill, there is no difference between the grain size distribution of the soil beneath and outside the landfill, while the Plasticity Index land under landfill higher than in outside the landfill, so it has the ability to absorb water and develop higher shrinkage

Keywords: infiltration, landfill, leachate, physical characteristics, soil

PRELIMINARY

Due to the operational costs are low, almost all of Indonesia's waste dumped into landfills, by open dumping. UU no. 18/2008 on waste management make development activities and rehabilitation of landfill became rampant in Indonesia. Within the scope of the design, the geotechnical characteristics become very important in the design and maintenance of landfills. Leuwigajah landslide in landfill case in 2005 that killed 147 people realize that the landfill is an engineering structure that must be considered from the aspect of the stability of the embankment.

This study is a preliminary study, which analyzes the differences in physical characteristics of the soil under the landfill and outside the landfill, at the same location, to see the possibility of change in the characteristics of the soil due to seepage of leachate.

As an initial assessment to determine whether the physical characteristics of the soil changes due to infiltrated by leachate, conducted sampling in zone 1 and zone 2 TPA Sarimukti, West Bandung regency. Samples taken at the heel landfill that has a depth of about 3 meters. TPA Sarimukti overall area is 25 hectares, with a large percentage of landfill by 60% of the total area of the landfill. Hopefully this research can provide initial information for further research to determine the geotechnical behavior of landfill in Indonesia.

LITERATURE REVIEW

Open dumping landfill, without liner, allowing leachate to easily pass through the soil strata. This may have an impact on changes in soil properties. Milad, ZA (2014) conducted an experiment on two types of soil; muddy sand and claly sand beneath Al-Jahra Landfill, Kuwait. Results from shear and consolidation on solid ground specimens that interact with leachate showed a greater influence on the properties of clayly sand rather than the loamy sand. Zupanc (2010) mentions that the leachate at the landfill significantly increases the available water capacity of up to 52%.

Meryl George and K.S. Beena (2011) presents the results of a study of various geotechnical characteristics (limit of consistency, shear strength and hydraulic conductivity) in soil contaminated leachate. The results show that garbage leachate contamination increases soil permeability and shear. However, consistency limits of soil decreased as a result of leachate contamination.

METHODOLOGY

Sampling was conducted in Sarimukti Landfill, West Bandung regency. Samples were taken to look at possible changes to the basic soil characteristics, by comparing the characteristics of the soil under and outside the landfill. The sampling is done under zone 1 and zone 2 TPA Sarimukti. From each sampling point, 3 samples were taken to test the characteristics of the soil in the laboratory, at different depths, sample depth specified on; (a) 0 - 1m, (b) 1-2 m and (c) 2-3 m beneath a layer of trash, in zone 1 and zone 2 TPA Sarimukti. For comparison, the native land inside Sarimukti landfill area that is outside the zone of landfills were also taken. Figure 1 shows the depth of soil sampling (disturbed) for laboratory tests.

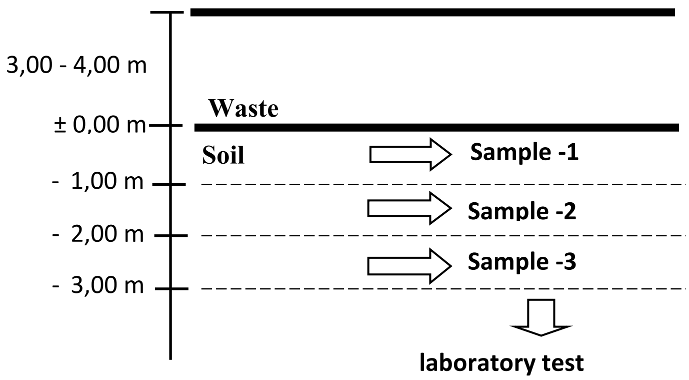

Fig 1. Soil sampling under landfill.

Physical properties testing conducted is the water content (ω), specific gravity (Gs), sieve analysis, hydrometer analysis, liquid limit and plastic limit.

RESULTS AND DISCUSSION

Sampling

Sampling was conducted on March 22, 2015, when the current in sunny conditions, sampling is done at three points, including; one point below the zone-1, one point below the zone-2 and one other point in the area that is not under the landfill site. Table 1 and Figure 2 shows the location of the sampling

Table 1. Sampling Location

Location	Coordinate	Sampel Depth [1)]
Zona 1 TPA Sarimukti	6°47'53.75" S 107°20'58.17" T	± 0 - 1 meter
		± 1 - 2 meter
		± 2 - 3 meter
Zona 2 TPA Sarimukti	6°47'56.50" S 107°20'57.74" T	± 0 - 1 meter
		± 1 - 2 meter
		± 2 - 3 meter
Area bukit	6°47'51.43" S 107°20'54.59"T	± 0 - 2 meter
		± 2 - 4 meter

Note: [1)] of the boundary between the waste layer and soil layer

Fig 2. Sampling (disturbed); (a) subgrade soil under zone 1, (b) soil outside the zone of landfills.

For the purposes of laboratory analysis, of any depth, take as much as ± 50 kg of soil samples (in disturbed conditions). The sample is introduced into a sample bag, and then inserted into the sample box, and sent to the laboratory of Soil Mechanics. Samples taken are disturbed samples that require treatment prior to laboratory testing. Soil samples were dried at room temperature, after dried, crushed soil samples with a wooden bat slowly to separate the grains of soil. Soil samples through sieve No. 04. taken for further testing

Specific Gravity Test Results

Table 2 shows the test results of soil sample specific gravity, of the six samples under landfills, and the two samples were not under landfills. The sixth sample was assumed as a random sampling under the landfill area. Of the six samples that were under the landfill area, obtained a mean of Specific Gavity (Gs) by 2.56, with a standard deviation of 0.021. Meanwhile, from the two samples taken from an area that is not under landfills, gained an average of Gs of 2.55. To prove whether the Gs value of soil that is under landfills, equal with Gs of soil that is not under the landfill, then the t test (one sample), with H0: mean Gs ground under the landfill = 2.55, and Ha: Gs mean ground under the landfill ≠ 2.55. T hitung obtained by 1.11, and with a confidence level of 95%, and the number of samples (n) as 6 pieces, obtained t table value of 2.571. Due t hitung smaller than t tabel, then H0 is accepted, which means there is no significant difference between Gs of soil under the landfill with a value of 2.55 (Gs of soil in the area outside the landfiill).

Table 2. Specific Gravity Test Results

Kode Sampel	Spesific Gravity
Under Zona-1	
S1.1.1	2,58
S1.1.2	2,58
S1.1.3	2,56
Under Zona-2	
S1.2.1	2,53
S1.2.2	2,55
S1.2.3	2,54
Average (under landfill)	**2,56**
Outside landfill	
S1.3.1	2,55
S1.3.2	2,55
Average (outside landfill)	**2,55**

Particle Size Distribution

The sample is spread and dried to air dry conditions. Wooden hammer used to break up clots without destroying the grain samples that had been air dried. Samples were filtered separately with a filter 4 (him. 4.67), and a 200 gram sample through sieve no. 4 is used for the analysis of grain size distribution. The smallest is 200 sieve sieve with a diameter of 0.075 cm. Granules through sieve no. 200 tested further in hydrometer analysis. Figure 3 shows the grain size distribution of the eight samples

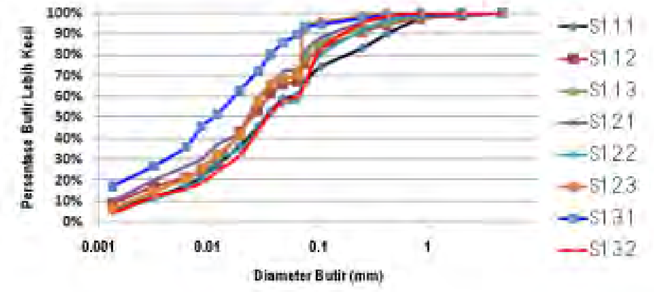

Fig 3. Grain size distribution of soil samples

Atterberg Limits Test Results

Atterberg divide the land into four basic condition, solid, semi-solid, and liquid plastic, which form the boundary change from one condition to another condition known as Atterberg limits. Soil samples were taken to test Atterberg limits of samples sieve no. 30. Table 3 shows the test results of Atterberg limits.

Table 3 Test Results of Atterberg Limits

Sample Code	Liquid Limit (LL)	Plastis Limit (PL)	Plasticity Index (IP)
S1.1.1	74,91%	35,98%	38,92%
S1.1.2	78,98%	39,35%	39,63%
S1.1.3	78,02%	40,48%	37,54%
S1.2.1	75,22%	36,01%	39,21%
S1.2.2	68,55%	33,98%	34,57%
S1.2.3	73,19%	36,12%	37,07%
S1.3.1	70,98%	39,05%	31,93%
S1.3.2	84,12%	36,67%	47,45%

Of the six samples under the landfill area, obtained a mean plasticity index (IP) amounted to 37.82%, with a standard deviation of 1.714%. Meanwhile, from the two samples taken from an area outside the landfill, only taken on samples S1.3.1 IP value as a comparison (by 31.93%), this is because the value of R2 in the test results (liquid limit) S.1.3.2 quite small (R2 = 0.414). To prove whether the IP of soil under the landfill equal with IP value outside landfill, the t test (one sample) is done, with H0: IP of soil under the landfill = 31.93%, and Ha: IP of soil under landfill ≠ 31.93%. Tcount obtained at 8,42, and with a confidence level of 95%, and the number of samples (n) as 6 pieces, obtained t table value of 2.571. Due tcount greater than t table, then H0 is accepted, which means there are significant differences between the IP of soil below the landfill with a value of 31.93% (IP of soil outside the landfiill area).

CONCLUSION

From these results, it can be concluded that:

- ✓ There are no significant differences between the Specific Gravity (Gs) of soil under the landfill with a value of 2.55 (Gs of soil outside of the landfill).
- ✓ There is no difference between grain size distribution of the soil under and outside the landfill area.
- ✓ Plasticity Index of soil under landfill higher than the outside of the landfill area, so it has the ability to absorb water and shrinkage level of the soil is increased.

In general, it can be concluded that there is no difference between granular soil under and outside the landfill. However, an increase in the value of plasticity index, which should be a concern. Soil with high plasticity, making shrinkage of the soil becomes high, and movement due to shrinkage of this land can damage structures contained in it, such as layers of liner and leachate collection system.

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RELATIONSHIP POPULATION DENSITY OF AQUATIC SEDIMENT MACROZOOBENTHOS TO RIVER WATER QUALITY PARAMETERS

(Case Study: Citarum Upstream, Subdistrict Kertasari, Bandung Regency)

Barti Setiani Muntalif [1*†], Nurul Chasanah[2] and Mohammad Faiz Faza[3]
Master Program of Environmental Engineering
Faculty of Civil and Environmental Engineering, Institut Teknologi Bandung,
Jl. Ganesha No. 10 Bandung 40132
Email: [1]barti_setiani@yahoo.com and [2]mohammad.faiz19@gmail.com
* Presenter; † Corresponding author.

Abstract: The increase in anthropogenic activities that occur along the Citarum river basin upstream segment, District Kertasari, Bandung regency, have a negative impact on water quality of the river with the presence of input waste into the water body which is the remainder of the result of human activity, and also cause disruption to the aquatic biota that live in it. The purpose of this study was to determine the relationship of the changes conditions of water and sediment parameters on macrozoobenthos populations. The results showed that based on the Pearson correlation analysis are known parameters COD, TOC and silt have the highest correlation value of the macrozoobenthos population density of 0.966, 0.865 and 0.576. In addition, with the use of PCA analysis known that water temperature, TSS, turbidity, TOC, COD, BOD and water pH is a major component of water parameters that affect the density of macrozoobenthos. Whereas, for the parameters of sediment obtained that parameter silt substrat, clay substrat, total phosphate sediment and gravel that affect the density of macrozoobenthos. The results also showed that based on biotic index (BMWP-ASPT) water conditions were in polluted condition of mild to severe, and from the pollution index (IP) shows the light polluted conditions.

Keywords: Citarum upstream, macrozoobenthos population density, water quality, correlation

INTRODUCTION

The increase in anthropogenic activities in Citarum has a negative impact on water quality of the river. In the upstream segment CRB has a lot of land use around the river as a residential location, industry, agriculture and livestock. Even in areas close to the Citarum river springs located in Situ Cisanti, has seen the disposal of waste from livestock activities are discharged through the sewers that flow into water bodies subsidiary of Citarum River (Cita Citarum, 2011). As a result of the increase in the load of waste that goes into the water body, besides a decline in water quality, also lead to the disruption of aquatic biota that live in it (Ishaq and Khan, 2013).

One of the biotic components waters often studied the impact of anthropogenic activity in the river is macrozoobenthos. Aquatic biota is an important component in the biological assay (bioassessment) in order to evaluate the overall quality of water resources, ecological functions, as well as the specific influence of anthropogenic activities. Disruption that occurred in the biota due to contamination toxic pollutants may be physiological disorders, such as increased respiration, defect morphology, and there is a larger scale ecological balance disturbance (Sudarso, 2009). Chopra et al. (2012) says that the river has brought the role of industrial waste, urban sewage, fertilizer runoff from agriculture and water carried by the current, and one organism to be affected from such pollution is macrozoobenthos. Research has been done by Muntalif et al. (2008), shows that there has been a decline in water quality in the upper Citarum river flowing along with the flow in the downstream direction that passes through residential areas, dairy farming and agriculture, which contributes to advise the burden of residual waste community activity results in a stream.

This study was conducted to determine the distribution of macrozoobenthos populations that occur along the Citarum River upstream of the conditions that have not been polluted waters up polluted waters, which include population density, species composition and keanekeragaman types of macrozoobenthos. The results of this study are expected to be useful as information for the parties concerned in decision-making according to the conditions existing in the Citarum River management efforts for the welfare of the population and the sustainability of both the living biota in the Citarum River and the people whose lives depend in flow Citarum River.

METHODOLOGY

The study was conducted in the upper reaches from Mount Wayang Citarum River up to Wangisagara village with 7 specified sampling locations , where the station 1 to 4 with the surrounding natural conditions and station 5 to 7 to ambient conditions there has been human activity. The measurement of physical and chemical parameters of water conducted in situ and in the laboratory. For the measurement of the parameters in the laboratory, water samples taken by the composite sampling method + 2 liters from each sampling location, then water samples are stored in a cool box. Water parameters to be measured is the flow velocity, turbidity, brightness, TDS, TSS, temperature, DO, BOD, COD, pH, total N and total P.

Macrozoobenthos Sampling was conducted using random sampling using a Surber net with a mesh size of 500 lm. Then do the preservation of the macrozoobenthos samples with administration of 4% formalin solution. Sediment sampling as much as + 500 grams each sampling location. Sediment samples then will be analyzed to determine the distribution of sediment particles, total organic carbon content (%), total nitrogen (%), and phosphate (mg / kg).

Then proceed with the analysis of data begins, to the calculation the number of population density of macrozoobenthos. Furthermore, the calculation of the value of diversity index (H ') in each station. The use of biotic index (BMWP-ASPT) to determine the quality of the waters (Mandaville, 2002) as well as the pollution index (IP) as a comparison (Decree LH, 2003). Pearson correlation analysis is used to predict the relationship between the parameters of water, sediment and sediment particle distribution of the biological parameters. The test is used to determine the relationship between the parameters of water, sediment and sediment particle distribution (% gravel,% sand,% silt and% clay) on the abundance of macrozoobenthos. Principle Component Analysis or principal component analysis to determine the relationship between the density of macrozoobenthos with water and sediment quality parameters in the upstream Citarum River. The calculation of the statistical analysis performed using SPSS software ver. 20:00

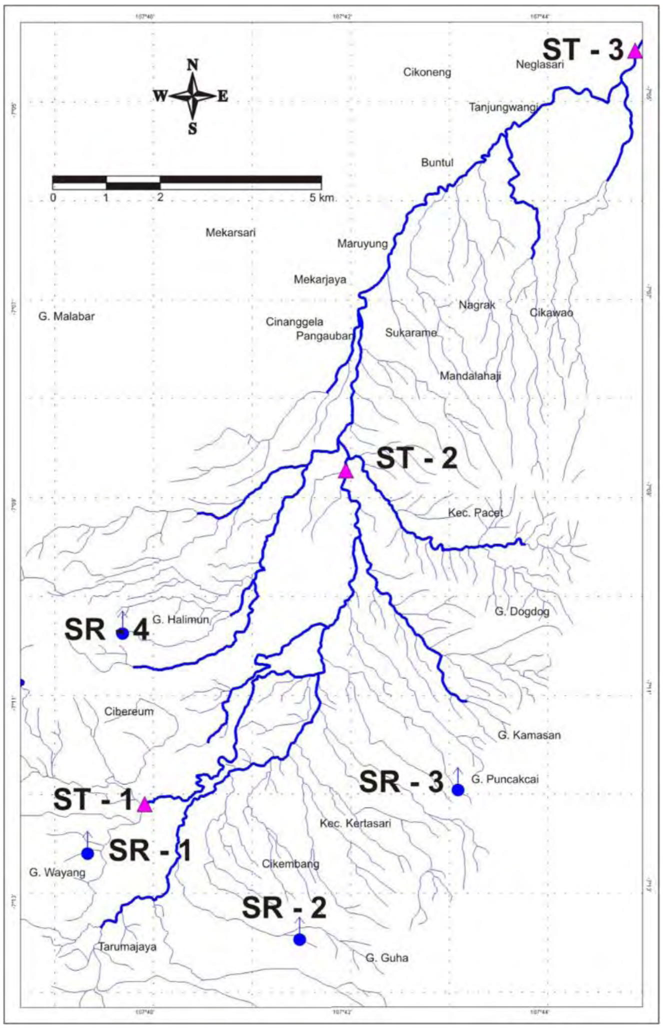

Figure 1. Sampling Site Map

RESULTS AND DISCUSSION

Overview of Sampling Stations

Sampling stations were determined as refference site with conditions that have not been disturbed by 4 points located in 4 different Citarum river basin located in Gunung Wayang, Gunung Guha, Gunung Puncakcae and Gunung Halimun. Conditions surrounding the sampling station still crowded with riparian vegetation. In addition, those sampling stations have relatively similar physical characteristics, in terms of water depth, substrate type and width of the river water. The water depth of four stations ranges from 3 cm to 5 cm, and the width of the river ranges from 14 cm to 4 meters. Station 4 has the lowest vegetation density of 3 other stations. It can affect the water temperature caused by higher light intensity. Type substrate of bottom river of the four stations is almost similar which is dominated by gravel and sand.

The other sampling station determined based on the utilization of the different areas around the river, such as livestock and agricultural area (station 5), housing (station 6) and sand mining (station 7). The depth of water from the three stations ranged from 43 cm to 70 cm, with the deepest is located at station 7. The width of the river water ranged from 5.5 m to

17 meters, where the station 7 with the largest width of the river water. The water temperature was measured range between 22,2 °C to 22,7 °C. The narrow temperature range around the river due to similar conditions with lack of riparian vegetation that grows around the river flow. Substrate types were observed in the different stations with two other stations, namely rocky and sandy, while the other station types of substrates such as hard rock and muddy.

Physical And Chemical Parameters River Water Bodies

Here is the result of the measurement of physical and chemical parameters of the river waters

Table 1. Physical and Chemical Parameter Water

Parameter	Satuan	Stasiun													
		1		2		3		4		5		6		7	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II
Temperature	ºC	19,8	20,3	16,4	16,4	18,1	17,6	20,7	24,5	22,3	22,4	22,2	24	22,7	26,1
Turbidity	NTU	15,4	16,7	13,7	10,2	22,7	3,3	34,3	53,2	126	29,2	90,1	32,1	76,3	21,6
Current Velocity	m/s	1,08	0,2	1,2	0,2	0,4	0,3	2,1	0,2	0,5	0,4	1,2	0,4	0,9	0,5
TDS	mg/L	167	221	94	32	41	21	81	7	123	183	93	123	112	106
TSS	mg/L	<1	10	11	16	<1	15	<1	29	225	38	106	34	93	23
pH	--	7,8	7,46	7,4	6,2	7,2	7,13	8	7,76	8,1	7,6	8,45	8,16	8,3	7,8
DO	mg/L	7,88	7,30	8,09	8,12	8,01	6,97	7,87	7,58	7,5	7,84	6,8	7,97	8,12	7,87
COD	mg/L	11,2	7,57	22,3	7,57	11,2	7,57	11,2	30,4	89,3	53,2	11,2	15,2	27,9	38
BOD	mg/L	-	4,66	-	4,58	-	4,54	-	13,68	-	24,67	-	7,26	-	18,48
Total P	mg/L	0,11	0,35	0,05	0,15	0,05	0,03	0,04	0,55	<0,01	0,83	0,06	0,26	0,07	<0,01
NTK	mg/l	0,87	1,63	0,87	2,71	2,36	2,17	2,95	2,71	2,66	8,66	3,55	3,79	2,36	2,17
TOC	mg/L	2,87	2,87	0,8	2,87	1,31	0,8	1,83	0,8	5,45	4,42	5,45	2,35	2,87	5,45

Based on **Table 1** known that there were some chemical parameters with different concentrations significantly between refference site stations (stations 1-4) to the station with the flow of the river is polluted (stations 5-7), including the temperature, TSS, turbidity, total N, COD and conductivity. Water temperature measured at 5-7 stations ranged between 22.2 to 22.7 C. The high temperature at the station compared with 1-4 stations, because riparian vegetation through which the river flows is minimal so that the penetration of sunlight can be easily into the waters of the river. According to Whitehead *et al.* (2009), an increase in water temperature will affect the chemical reactions and is associated with a reduction in water quality and ecological status of freshwater. The high level of TSS concentration at 5-7 stations caused by particulate inputs from the riparian areas that have changed function into open land, such as agriculture, residential, traditional sand mining and ranching. Similarly, the turbidity values were higher than the station realitf 1-4. The difference in turbidity value is presumably due to differences in flow velocity in each section of the river. The effect of a slower flow causes the accumulation of material suspended solids greater.

In addition, at 5-7 stations there was an increase nitrogen concentration (NTK). Presumably the increase was because the number of inputs of organic matter that comes from agricultural areas due to the use of nitrogen fertilizer around the river carried away by runoff water. Moreover, domestic waste from human settlements and farms also contribute to the increase of the nitrogen concentration. The highest COD concentration is located at station 5 with an average concentration of 89.3 mg / L. High COD value at the station at this location due to the load input of organic material has a large enough from settlement, a dairy farm and agriculture around the river, it is similar with the statement of Al-Shami *et al.* (2011) that the high value of COD in water is caused by a number of contaminants that enter the waters, especially organic pollutants from household waste, industrial, rice fields and aquaculture.

Distribution of Sediment Particles

The main factor that determines the spread of macrozoobenthos is aquatic sediments in the form of sand, clay and silt gravel and rocks, the composition determines the type of makrozoobenthos. Here is the result of sediment particle distribution subsrat sample stream.

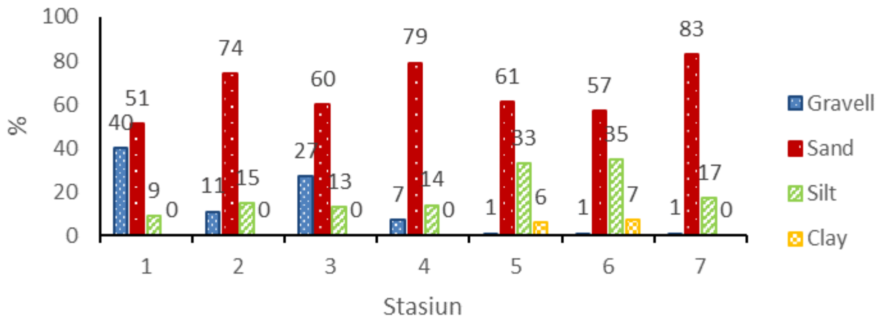

Figure 2. **Distribution of Sediment Particles**

Based on **Figure 2**, it is known that the highest percentage of fractions at each station is sand. The percentage of sand fraction is highest at Station 7 in the amount of 83%, while the lowest was in station 1 is 51%. Sediment type is one factor that determines the spread of the type of benthos. The results of the sediment fraction and texture of sand fraction showed the greatest presentation compared to other sediment particle size. Nybakken (1992) stated that the sand has a nutrient and water holding capacity that is not too good but good infiltration and aeration. The number of benthos that live in the sand substrate showed that sediment type is fairly well correlated to the water circulation that regulates moisture and supplies oxygen and nutrients.

In addition, the results of measurements of organic matter content in the sediment in the waters of the Upper Citarum River showed that organic C content ranged from 33.85% - 47.63%, with the lowest percentage found in station 6 and the highest at station 2. For the total content N (NTK) ranged from 1.03% - 1.22%, the lowest percentage found in station 4 and highest at station 2. For the phosphate content ranged from 316.42 mg / Kg - 1002.19 mg / kg, with the lowest content found on three stations and highest at station 5.

Macrozoobenthos

Based on observations of macrozoobenthos in the upstream flow Citarum River Kertasari District, Bandung Regency in 2 times of sampling, was found 87 genera, which is 68 genera of the class Insecta, 3 genera of the class Hirudinae, 3 genera of the class Oligochaeta, 5 genera of the class Gastropoda, 5 genera of the class Malacostraca, one genus of the class Bivalvia, 1 genus of Adenophorea class and one genus of Diplopoda class. In **Figure 3** are known that from twice sampling, the most species of macrozoobenthos were found in station 1 with 32 genera, meanwhile in station 6 only found the least about 12 genera. The lack genera found in Station 6 is affected by the condition of the river waters are dominated by rocky substrate, so that only certain types of macrozoobenthos are able to live on the substrate.

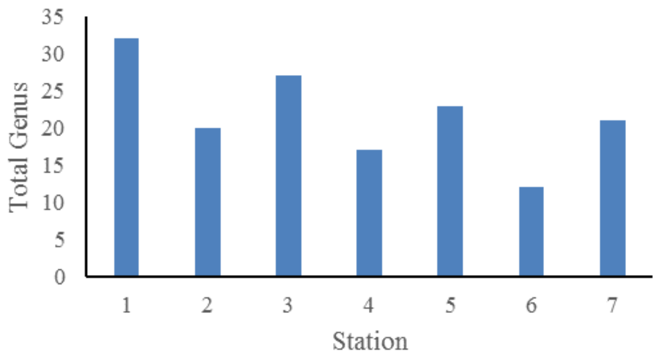

Figure 3. Number of Species Macrozoobenthos

The most species of macrozoobenthos were found at station 1 indicates that water conditions at the station can be said to be in good condition, so it can support the life of the various species of aquatic biota. Meanwhile, the least were found at station 6, describing the condition of the water is bad, because it is only able to support life in some kind of macrozoobenthos were tolerant to the water conditions.

Based on **Figure 4**, shows that the highest population is macrozoobenthos at station 5 and station 7. A large number of species found at station 1 does not show the number of higher population density. Another case with the five stations that have the highest population density among the six other stations. That is because there are two species of macrozoobenthos that dominates at the station, that *Chironomus* and *Polypedilum*. Both species are known to go into the family Chironomidae, which the family is known to have the ability to adapt to the condition of waters with high pollution levels. In addition, it is also supported by the ability to form colonies, increase the chances of reproducing are higher than with other species of family (Zaha and Mazumdar, 2013).

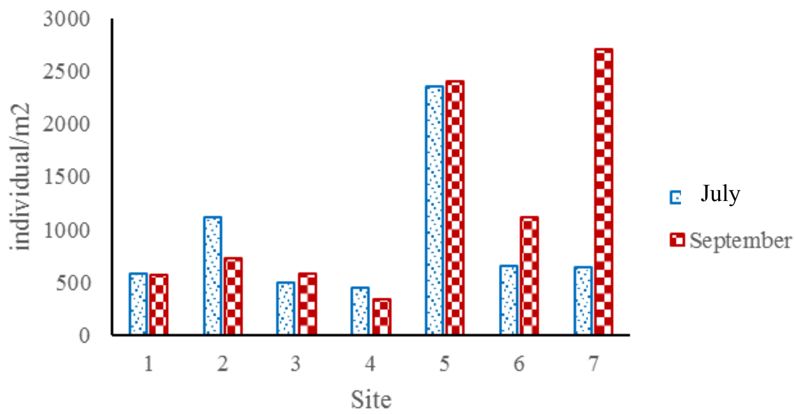

Figure 4. Population Density of Macrozoobenthos

The highest diversity index (H ') value, was found at station 1, that is equal to 2.48. This value is influenced by many different species was found and the population density of each species. Known in advance that station 1 is the station with the largest genus that found of 32 genus. In addition, there were no genus dominating the population density, which is population density of each genus is almost evenly. As with the stations 6 and 7, which has a diversity index value of 0.49 and 0.4. There was a genus of the family Chironomidae who have abundant population density compared to other genus, and also the amount of genus are found relatively few, which is only 12 genera.

River Water Quality Assessment

Biotic indices used in the assessment of water quality status Citarum River upstream, District Kertasari, Bandung Regency is an index Biological Monitoring Working Party-Average Score Per Taxon. Based on the value of ASPT, Citarum River upstream have ASPT values range between 2.91 to 5.86. It shows that the condition of river water into the level of light pollution to heavy pollution. Lowest index value was obtained at station 5 by 2.91. The low value of the biotic index because there is genus with a low scoring rate, which comes from the family Chironomidae, Hirudinae, Oligochaeta and Gastropoda. The family belongs to the group of macrozoobenthos that kind of cosmopolitan or can adapt to various environmental conditions (Zeybek et al. 2014).

Pollution Index (IP) obtained from the seven stations ranged from 1.62 to 4.13. The highest IP value obtained at station 5 and the lowest at station 3. The high value of IP at station 5 is because there is some water parameters that exceed water quality standards, such as BOD and COD. Sewage that comes from around the waters had a major contribution to the concentration of these two parameters, especially the waste that comes from a dairy farm. However, the value of IP is still included in the group lightly polluted.

Relationship Between Biological Parameters to Water and Sediment Parameters

Based on Pearson correlation analysis between the diversity of macrozoobenthos to water and sediment parameters within two sampling times (Table 2 and Table 3) was obtained parameters with the highest positive correlation value was the total phosphate (+0.33), TDS (+0.78) and substrate gravel (+0.91), while the parameters with the highest negative correlation value is pH (-0.75), DO (-0.5) and the sand substrate (-0.69).

At the first sampling, it is known that the total phosphate is the parameter with the highest positive correlation value. However, when viewed from the significance value which is more than 0.05 can be said that these parameters haven't significant relationship to diversity of macrozoobenthos. Another case in the second sampling, TDS is known as the parameter with the highest correlation value, has a significance which is less than 0.05, so it can be said that these parameters have a significant and strong relationship to diversity of macrozoobenthos. Correlation value of gravel whether on the first and second sampling is the highest, and the significance value of 0.05 so that it can be said that the relationship between the diversity of macrozoobenthos to gravel parameters are very strong and significant.

Table 2. Results of Pearson Correlation Analysis Betweem Diversity of Macrozoobenthos to Water Parameters

	Flow	Temperature	TDS	TSS	pH	DO	Turbidity	NTK	P	COD	TOC	BOD
Diversity (1)	-0,14	-0,57	0,02	-0,42	-0,75	0,31	-0,54	-0,54	0,33	-0,17	-0,34	
sig. (1)	0,77	0,18	0,96	0,36	0,05	0,50	0,22	0,21	0,47	0,72	0,45	
Diversity (2)	-0,06	-0,08	0,78	-0,38	0,17	-0,50	-0,19	-0,05	0,23	-0,14	0,10	-0,12
sig. (2)	0,89	0,86	0,04	0,41	0,71	0,25	0,68	0,92	0,63	0,77	0,83	0,80

Table 3. Results of Pearson Correlation Analysis Betweem Diversity of Macrozoobenthos to Sediment Parameters

	C-Organic	NTK	Phosfat	pH	Gravel	Sand	Silt	Clay
Diversity (1)	0,34	0,01	-0,56	0,12	0,91	-0,64	-0,50	-0,34
sig. (1)	0,45	0,98	0,19	0,80	0,01	0,12	0,25	0,45
Diversity (2)	0,67	-0,63	0,70	-0,32	0,73	-0,69	-0,25	-0,06
sig. (2)	0,10	0,13	0,08	0,48	0,06	0,09	0,59	0,90

Pearson correlation analysis between population density of macrozoobenthos to water and sediment parameters was obtained parameters with the highest positive correlation values, which is COD (+0.96), TOC (+0.89) and mud substrates (+0.58), while the parameters with values The highest negative correlation is the total phosphate (-0.69), pH (-0.85) and gravel substrate (-0.59).

Correlation value, either COD or TOC, to population density of macrozoobenthos showed a very strong relationship, and the significance of each value of less than 0.05 can be considered as a significant relationship. In addition, the negative correlation value of pH sediment have a very strong relationship to population density of macrozoobenthos and the significance value of 0.05 resulted in a significant relationship.

Table 4. Results of Pearson Correlation Analysis Betweem Density of Macrozoobenthos to Water Parameters

	Flow	Temperature	TDS	TSS	pH	DO	Turbidity	NTK	P	COD	TOC	BOD
Density (1)	-0,43	0,21	0,27	0,81	0,12	-0,19	0,66	0,02	-0,69	0,97	0,50	-
sig. (1)	0,34	0,66	0,56	0,03	0,79	0,69	0,11	0,98	0,09	0,00	0,25	-
Density (2)	0,62	0,52	0,40	0,47	0,30	0,43	0,01	0,52	0,11	0,77	0,90	0,80
sig. (2)	0,14	0,24	0,37	0,28	0,51	0,33	0,99	0,23	0,82	0,04	0,01	0,03

Table 5. Results of Pearson Correlation Analysis Betweem Density of Macrozoobenthos to Sediment Parameters

	C-Organic	NTK	Phosfat	pH	Gravel	Sand	Silt	Clay
Density (1)	0,18	0,25	0,48	-0,85	-0,38	-0,13	0,58	0,54
sig. (1)	0,70	0,59	0,27	0,02	0,40	0,78	0,18	0,21
Density (2)	-0,03	-0,54	-0,36	0,32	-0,59	0,27	0,49	0,36
sig. (2)	0,95	0,22	0,43	0,49	0,17	0,56	0,26	0,43

To determine the most influential environment parameters between population density of macrozoobenthos to the water and sediment parameters used statistical analysis such as Principle Component Analysis (PCA) to reduce the variables into several factors. The percentage of the form factor representing each independent variable can be seen from the value of communality.

The results of PCA analysis of water parameters in July showed that only one factor was formed fromfour water parameters. Based on **Table 6** shows that the turbidity and TOC is a variable that has the highest communality value of 4 parameters. For variable turbiditya, was obtained a value of 0.962. It shows about 96.2% turbidity variable can be explained by factor formed. For variable TOC, was obtained a value of 0.883. It shows about 88.3% TOC variable can be explained by formed factor.

Table 6. Communality Value of Water Parameters (July) on Formed Factor

Communalities

	Initial	Extraction
Suhu	1,000	,764
TSS	1,000	,877
Kekeruhan	1,000	,962
TOC	1,000	,883

Extraction Method: Principal Component Analysis.

The results of PCA analysis of water parameters in September showed that the water of 5 variable parameters only formed one factor. Based on **Table 7** is known that the BOD and COD variable is the variable with the highest commonality value with the formed factor. For BOD variables, was obtained a value of 0.789. It shows about 78.9% BOD variable can be explained by formed factor. For COD variables, was obtained a value of 0.818. It shows about 81.8% COD variable can be explained by formed factor.

Table 7. Communality Value of Water Parameters (September) on Formed Factor

Communalities

	Initial	Extraction
Suhu	1,000	,762
COD	1,000	,818
BOD	1,000	,789
pH	1,000	,567
TSS	1,000	,726

Extraction Method: Principal Component Analysis.

The results of PCA analysis of sediment parameters in July indicates that from 5 variable of sediment parameters were only formed one factor. Based on **Table 8** is known that variable silt and clay is the variable with the highest commonality value to the formed factor. For variable silt, was obtained a value of 0.966. It shows about 96.6% mud variable can be explained by factors that are formed. For variable clay, was obtained a value of 0.968. It shows about 96.8% TOC variable can be explained by factors that are formed.

Tabel 8. Communality Value of Sediment Parameters (July) on Formed Factor

Communalities

	Initial	Extraction
COrganik	1,000	,541
pHsedimen	1,000	,416
Lumpur	1,000	,966
Liat	1,000	,968

Extraction Method: Principal Component Analysis.

The results of PCA analysis of sediment parameters in September showed that from 4 variable of sedimen parameters were only formed one factor. Based on **Table 9** it is known that the total phosphate and gravel variable is the variable with the highest commonality value do the formed factor. For variable total phosphate, bas obtained a value of 0.897. It shows about 89.7% of total variable phosphate can be explained by factors that are formed. For variable gravel, was obtained a value of 0.829. It shows about 82.9% gravel variable can be explained by factors that are formed.

Tabel 9. Communality Value of Sediment Parameters (September) on Formed Factor

Communalities

	Initial	Extraction
COrganik	1,000	,632
Psedimen	1,000	,897
Kerikil	1,000	,829
Lumpur	1,000	,592

Extraction Method: Principal Component Analysis.

CONCLUSION

Based on Pearson correlation analysis known that COD and TOC has the highest positive correlation values to a population density of +0.966 and +0.895 macrozoobenthos, whereas for sediment sludge parameters have the highest correlation value of +0.576. In addition, total phosphate and TDS parameters have positive correlation value to diversity of macrozoobenthos of 0.33 and 0.78, while for the gravel and sediment parameters phosphate has the highest correlation value of +0.91 and +0.696. Environmental parameters that most influence on the population density of macrozoobenthos, based on the analysis of PCA are water temperature, TSS, turbidity, TOC, COD, BOD and water pH. Whereas, for the parameters of sediment obtained that parameter silt substrat, clay substrat, total phosphate sediment and gravel that affect the density of macrozoobenthos.Conditions waters assessed from biotic index BMWP-ASPT in 6 stations were in lightly to moderate polluted, except in station 5 with heavily polluted conditions, whereas if assessed from pollution index (IP) those 7 station were in lightly polluted state.

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FROM MDGS TO SDGS: WHAT WILL IT TAKE? TOWARDS SUSTAINABLE AND SAFE WATER SUPPLY FOR ALL

Anindrya Nastiti
Environmental Management Technology
Faculty of Civil and Environmental Engineering, Institut Teknologi Bandung,
Jl. Ganeca 10 Bandung
Email: anindrya@tl.itb.ac.id
*Presenter; † Corresponding author.

Abstracts: This paper reviews the history of international water supply policy from the early 1980s to the Sustainable Development Goals.Strives to achieve universal access to water and improving service quality, SDG water framework demands for a more complex monitoring framework and both generalized and localized target. This paper serves as an advocacy tool as that demand attention to the problems of service quality in water sector, as well as reflective tool to make sure that we are going to the right direction towards sustainable access of safe water for all.

Keywords: Water supply policy, MDGs, SDGs, sustainable water supply

THE INTERNATIONAL WATER SUPPLY POLICY: FROM TIME TO TIME

As the foundation of human life, water had been a major subject in international agenda. The notion of human rights to water was addressed in one of the earliest international water conventions in 1977. The resolutions of United Nation Water Conference held in Mar del Plata, Argentina, explicitly states that all people, regardless of their stage of development and socio-economic condition, are entitled to the rights to have access to drinking water in quantities and of a quality equal to their basic need. This event also initiated a new era for international cooperation for improved water supply in developing countries (Black, 1998).

The launching of International Drinking Water Supply and Sanitation Decade (1981-1990) or the first Water Decade boosted resources allocated for the sector with its grand slogan: “Water and Sanitation for All”. At that time, only one person in five had access to clean water. This decade, countries were committed for the universal access or providing water for all by 1990 with priority to the poor and less privileged, and water scarce areas. During the Decade, low-cost water and sanitation technologies gained its popularity. Nevertheless, with the emphasis on hardware without thinking as much for the local cultural context, the maintenance of the technology by local community, or the software, many projects were not sustained for a longer period. The Hand Pump Project (1981-1991), a joint program of UNDP and World Bank, focusing on study of availability and maintenance of hand pump systems not only initiated software importance by developing community based maintenance for hand pumps, but also instigated multi-donors cooperation. Although the Decade has not triumphed in accomplishing its quantitative objective, it had been successful, at least, as learning experiences and binding commitment for larger resource allocation for water supply and emerging sector attentiveness and practicable strategies and models in regard to system sustainability (Black, 1998; Christmas

& de Rooy, 1991).

While the debate on water in the 1980s was largely focused on water and sanitation as adjuncts to public health, in the 1990s the scope of the debate dramatically expanded and the wider focus became the management and use of water as part of environmental protection and sustainable development. Post the first Water Decade, the Global Consultation on Safe Water and Sanitation was held in New Delhi, India in 1990. Not only implied equity issues by downgrading the previous commitment of 'water for all', to 'some for all rather than more for some', this consultation also highlighted institutions by advising to shift the role of government from provider to enabler and community based management of water. This event was followed by the UNDP symposium in Delft in 1991, sensing the urgency for management of water resources in integrated manner due to competing interests among water user sectors and the importance of capacity building towards sustainable water supply projects.

The recognition of growing scarcity to water, among other natural resources, was emphasized also in the Rio Conference of 1992, leading to the adoption of Agenda 21, a wide-ranging blue print for actions in achieving sustainable development. In the same year, the International Conference on Water and the Environment was held in Dublin. The four guiding principles of this conference deal with holistic, participatory, and gender-sensitive approach in managing water as finite and vulnerable resource, as well as the controversial notion of recognizing water as economic goods. The implication of such idea, as Black (1998) emphasized, that not only the quality of the water, but economic indicators, i.e. willingness to pay, shall be considered important in determining a success water supply provision. This milestones probably marked the rise of Integrated Water Resource Management (IWRM) and private sector participation in the issue of water.

Although the Dublin's fourth principles recognized that access to water at an affordable price is a human rights, it had been facing resistance since post-Rio Ministerial meeting on water and sanitation in Noordwijk in the Netherlands in 1994 due to fears that economic concerns will overcome social, ecological, and religious concerns. Debates over water pricing –cost-recovery basis or pro-poor basis- reached consensus that pricing should be determined based on the level of service provided with cross-subsidy from higher volume to very low volume consumers (DFID, 2001). Since then, a number of overlapping and complementary approaches in water management have been put in to tests: appropriate technology, private sector involvement, reduction of subsidies, decentralization of decision-making to the lowest appropriate administrative level, user participation in services, reform of institutions and regulatory frameworks, and cost recovery and pricing.

At the United Nations Millennium Summit in September 2000, the largest-ever gathering of world leaders adopted the Millennium Declaration; from the Declaration emerged the Millennium Development Goals, an integrated set of time-bound targets for extending the benefits of globalization to the world's poorest citizens. Target 7C MDGs, is to halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation. The international communities further recognized that the water target is the key to achieve other MDGs targets through improving economic opportunities that break the vicious cycle of poverty, enhancing school participation for children, improving health and well-being, and ensuring sustainable-life supporting ecosystem.

In regards to the required major efforts to extend water service for those who still unserved, in December 2003, the United Nations General Assembly, in resolution A/RES/58/217, proclaimed the period 2005-2015 International Decade for Action 'Water for Life'. The decade officially started on World Water Day, March 22, 2005. The primary goal of the 'Water for Life' Decade is to promote efforts to fulfil international commitments made on water and water-related issues by 2015. Focus is on furthering cooperation at all levels. The challenge of the Decade is to focus attention on action-oriented activities and policies that ensure the long-term sustainable management of water resources, in terms of both quantity and quality, and include measures to improve sanitation. Achieving the goals of the 'Water for Life' Decade requires sustained commitment, cooperation and investment on the part of all stakeholders from 2005 to 2015 and far beyond. The water for life decade had been celebrated every year on March 25, as World's Water Day, on different focuses, ranging from financing, water and cities, to human right of water.

On 28 July 2010, through Resolution 64/292, the United Nations General Assembly explicitly recognized the human right to water and sanitation and acknowledged that clean drinking water and sanitation are essential to the realization of all human rights. The Assembly recognized the right of every human being to have access to sufficient water for personal and domestic uses (between 50 and 100 liters of water per person per day), which must be safe, acceptable and affordable (water costs should not exceed 3 per cent of household income), and physically accessible (the water source has to be within 1,000 meters of the home and collection time should not exceed 30 minutes). The Resolution calls upon States and international organizations to provide financial resources, help capacity-building and technology transfer to help countries, in particular developing countries, to provide safe, clean, accessible and affordable drinking water and sanitation for all.

WHAT HAVE WE ACHIEVED?

The Millennium Development Goals (MDGs) have served as a shared framework for global action and cooperation on human development. Fashioned as a universal vision with the target date of 2015, the key features of MDGs are: visionary; concrete, simple, clear, time-bounded common goals; and focus to specific targets. Its emphasis on human development had shifted policy attention well beyond the economic growth objectives that dominated the previous agendas (UN, 2012). Not only it had risen proportions of supports to sectors included in the targets, the MDGs had also been successful in tying the knots of international dialogue and cooperation and invaluable for the advocacy and campaigns for improvement (Manning, 2010). Being useful in setting priorities in global and national level on specific development gains (General Assembly of United Nations, 2012), it also helps to focus actions at all levels (UN, 2012). Another externality that the MDGs brought is that its robust statistical indicators had helped governments to focus on results and galvanized the strengthening of international and national statistical system for policy design and monitoring (UN, 2012).

As the official United Nations mechanism for monitoring the MDG targets for safe drinking water and basic sanitation, the Joint Monitoring Programme (JMP) use the proportion of population using an improved drinking-water source as indicator in measuring progress. The data collected and disseminated by the JMP at global, regional, and national level form the basis for informed-decision making by key policymakers and program managers in the sector.A remarkable progress were made since the declaration of MDGs.

According to UN, the world has met the target of halving the proportion of people without access to improved sources of water, five years ahead of schedule. Between 1990 and 2012, 2.3 billion people gained access to improved drinking water sources, but in 2012, 748 million people remained without access. The 2014 report of Joint Monitoring Programme stated that there was a 13 percent increase of the global population in regard to access to improved drinking water sources; from 76 percent in 1990 to 98 percent in 2012; the number was more striking in developing regions: 60 percent increase within 12 years (WHO/UNICEF, 2014). While the target 7c has been achieved prior to the final deadline of 2015, according to UN, progress has been uneven within and across countries.

ARE WE COUNTING WHAT COUNTS?

The emphasis on statistical indicators may provide a robust approach in measuring progress that is internationally comparable, but it has reduced the complexity of poverty and development problems to the bare bones. Therefore, some dispute that the targets were not adequately formulated for it leave out the demographic challenges and the magnitude of certain social problems (UN, 2012). For example, Onda et al. (2012) indicated that despite astonishing increase in coverage, an additional 1.2 billion people still use water from sources or systems with significant sanitary risks. But some critics contend that governments and donors have picked off the low hanging fruit by only reaching the most accessible people: those who benefited the most, were the ones that were ‘better-off’ (Bruce, 2010). It perhaps has a glint of truth in it since the inequity within subnational, urban-rural, intra-urban, and quintiles persist and sometimes have increased (WHO/UNICEF, 2014).

Clasen (2012) has perfectly captures how MDG water target claim exaggerates achievement. Although MDG water target explicitly states to halve proportion without access to ‘safe’ (indicating quality) and sustainable ‘drinking water’ (indicating the point of use, not water sources), the Inter-Agency and Expert Group on MDG Indicators decided to rely on an existing system of reporting on water and sanitation that was never designed to capture the core components of the MDG water target (United Nations, 2003, in Clasen, 2012).

According to JMP, 89 percent of the developing world’s population have access to improved water sources and drinking water target were met by 116 countries worldwide (WHO/UNICEF, 2014). Statistically speaking, the achievement in water supply sector is remarkable; but the philosophy in providing water for the people is not only for the survival; formally proclaimed as basic human rights, water means to protect people’s health, to uphold their dignity, maintain their quality of life, and in broader framework, to serve as a pre-requisite towards a sustainable development. Such functions are represented on the elements of access: the equity, safety, quantity, continuity, and affordability of water supply. The facts that whether an acceptable quality, sufficient quantities, affordable and a reliable water is available for each and every household that were counted as having access to improved water sources, are unheard of in official statistics.

This problem of water supply provision is also value-laden. In the management of public utility and natural resources, no single policy problem are value-neutral and the scholarly findings are often improper and ineffective on their uses. The emphasis on availability of technology in measuring access to water are proven to have many pitfalls, particularly when it does not account for the perspective of users and motivation of providers. The water supply and sanitation sector does not lacking of types of technology that can safely eliminate pathogenic and hazardous substance from the water and distribute it to the hands of consumers. Nevertheless, there were many cases when such technologies fail to bring the expected impact to the targeted society. For example, in the urban water system, it is often the variables of 'water' and 'capital' are accounted for. Meanwhile, the effect on power relation to the distribution of water supply service in municipalities is often excluded from the equation. That sometimes explains why the poor residents live near the main pipe network are discounted from receiving excellent service, why illegal provision thrives, and why even the 'appropriate' technologies does not appropriate in a sustainable manner.

In the attempt on solving a policy problem, a framing technique is necessary to determines which facts are relevant and at the same time, it gives meaning to a situation. In Indonesia, for example, there is a variety on the definition of access. BAPPENAS (2012) included households using bottled water combined with improved water in their estimate as '*improved*' despite the motivation of users to use mixed water source at home; they further revise the number of households with access to improved water from 42.75 percent to 55.04 percent. But households using both borehole and bottled water can also be classified as 'unimproved' since, perhaps, the ground water is unfit for drinking nor does it provide a continuous supply of water in the dry season.

The households' strategy on using mixed water source proposes a problem on framing. The use of mixed water source behaviour may be driven by the deficiency in the provision system; people are forced to cope with the poor performance of water provision system, signalling that the area of concern needs attention in the water policy agenda. Such behaviours are never accounted for in the frame of monitoring; people are either having access to improved water or unimproved water; the statistics reports were always consist of the two category, improved and unimproved. Never there were a mixed between improved water, combination of improved and unimproved, or improved water with a certain treatment at the point of use (such as boiling, filtering, or applying disinfectant in household scale).

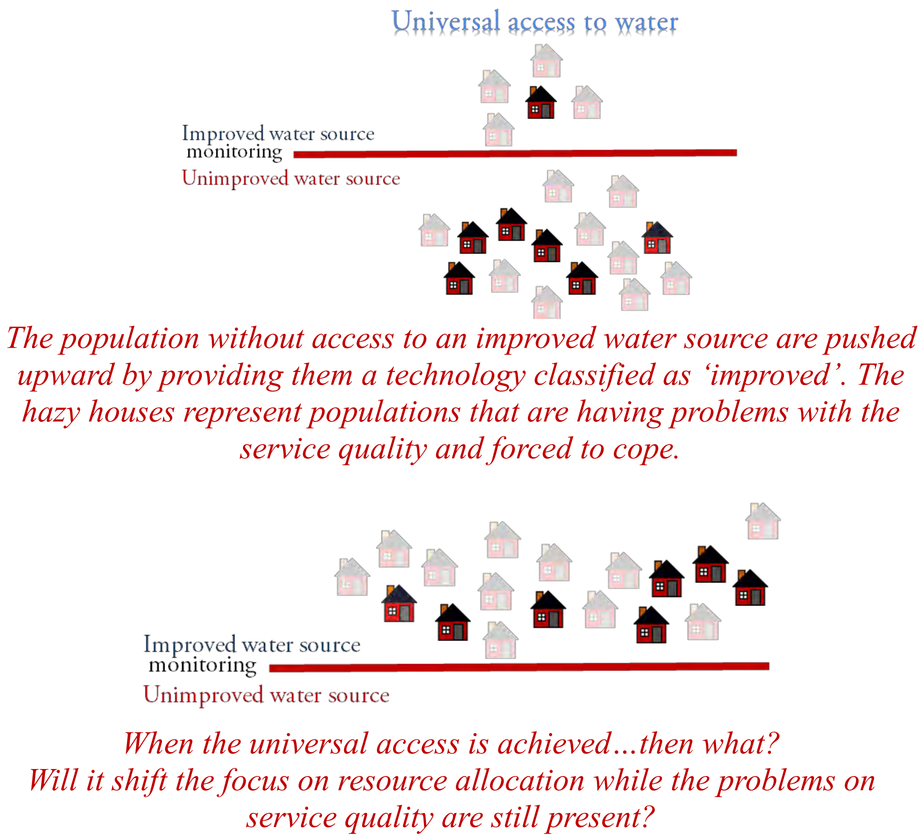

Figure 1. The pitfall on relying on access to water as the sole monitoring indicator in the contextual target

A common catch phrase of 'if you cannot measure it, you cannot manage it' had become too familiar in the management of public utility and natural resources. In his book, Stone (1997) had highlighted the dominance of 'counting' in measuring problems. He stated that by counting begins with categorization: deciding which things are included and which are excluded, which requires value judgment; "every number is a political claim about where to draw the line" (Stone, 1997, pp 167). He further asserted that measuring implies that actions must be done as a response.

Hauled into the political domain, counting and measuring is exactly the problem of framing; Stone implies that measurement can be a doubled-edge sword, sometimes you want it to be 'good' and you want it to be 'poor'. In water supply sector, local governments desperately need to be 'good' to make a good rapport e.g. to secure political position; for example, local governments tend to polish their report on the coverage of access to water. Meanwhile, some other frantically needs their performance to be 'poor' in order to be eligible in benefiting from a grant scheme. Thus, the ambiguity nature of number trigger free interpretations.

THE WAY FORWARD

As the MDGs expires, the outcome document of the 2010 High-level Plenary Meeting of the General Assembly on the MDGs requested the Secretary-General to initiate dialogue on a post-2015 development agenda. Critics have argued that the shortcomings that MDGs faced could have been avoided if a more inclusive consultation process had taken place in formulating it, in which such a process could have more meaning to country context (UN, 2012).

At the September 2010 MDG Summit, UN Member States initiated steps towards advancing the development agenda beyond 2015 and a process of open, inclusive consultations on the post-2015 agenda. The set of eleven global thematic consultations and national consultations in over 60 countries is facilitated by the United Nations Development Group and involves partnership with multiple stakeholders. The two bottom lines agreed during this renewal of commitments are as follow. *First*, the future framework will be built upon commitments already made. An MDG format of concrete, time-bounded, quantitative, and measurable goals, targets, and indicators that implies a clear framework and easy to communicate will be preserved, but will be disaggregated by sex, age, and geography. *Second*, the framework will be global in nature and universally applicable to all countries. Nevertheless, there will be a sufficient space for national policy design and adaptation to local setting to avoid one-fits-all solution while respecting international standards. Different national circumstances, capacities, and priorities will be taken into account; and this will be best achieved through participatory processes. (UN, 2012, General Assembly of the United Nations, 2012).

In water sector, post-2015 agenda, the SDGs (Sustainable Development Goals), highlight the key role of water, sanitation, and hygiene (WASH) in development framework. Water Aid (2013) emphasizes the critical linkages between WASH and a broad range of human development goals – including health, education, gender equality, environmental sustainability and employment. It shows the positive impact that improvements in WASH has on these goals, and conversely how poor WASH holds back their progress.

It is agreed that in post-2015 era, water related framework should be: (1) **integrated**, by reflecting integrated nature of factors affecting development, stronger focus on cross-sectoral and stakeholders integration, integrated programs reflecting the complex reality of people's lives, also integrated with other areas of poverty reduction, crosscutting nature of water resources that address on water's horizontal nexus with other sectors; (2) **Focus on equity**, targeting poor and marginalized groups and neglected areas of development, shall be reflected also in monitoring framework that focus on accountability of Member States in addressing inequity; (3**) Water as human rights,**any future development framework must reflect this reality and create incentives and accountability for progressive realisation of the human right to water and sanitation, (4) **Leave room for flexibility for adaptation** to local contexts, needs, and priorities. (WaterAid, 2013; The Post 2015 Water Thematic Consultation Report, 2013).

Water Aid (2013) specifies a target date of 2030 for achieving universal access to safe water, sanitation and hygiene globally in households, schools and health facilities, and ensure that water, sanitation and hygiene targets and indicators focus explicitly on reducing inequalities, by targeting poor and disadvantaged people as a priority, and on improving the sustainability of services to secure lasting benefits.

CLOSING REMARKS

Despite the triumph of MDGs, some critics argue that what had been the strengths of MDGs can also be perceived as its weaknesses: its focus on certain fields shifts attention from other important development elements; its shared common vision undervalues countries' contexts and differences in baseline conditions and became the 'one-size-fits-all solution (UN, 2012). Strives to achieve universal access to water and improving service quality, SDG water framework demands for a more complex monitoring framework and both generalized and localized target. This paper serves as an advocacy tool as that demand attention to the problems of service quality in water sector, as well as reflective tool to make sure that we are going to the right direction towards sustainable access of safe water for all.

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GOVERNMENT SUPPORT TOWARDS COMMUNITY TO WASTEWATER MANAGEMENT IN URBAN SLUM AREA (CASE STUDY: METROPOLITAN BANDUNG AREA)

Iendra Sofyan[1*†], Prayatni Soewondo[2], Tresna Darmawan Kunaefi[3], and Marisa Handajani[5]
Faculty of Civil and Environmental Engineering, Institut Teknologi Bandung
Ganesha 10 Bandung 40132
Email: iendra@hotmail.com[1]
Presenter; † Corresponding author.

Abstract: Sanitation is one of the development aspects which are mankind basic necessity. Government support plays an important role in santitation achievement. One of sanitation development policy in Indonesia refers to community needs (demand driven) rather than achieving technical target (supply driven). The development pattern has positioned community to play a major role in development process and become an active participant in facility planning, construction, utilization and maintenance. This research is intended to explore importance factor for community in sanitation management. Research location is in Greater Bandung Area which is West Java Province capital area. In the area without government intervention, among ten requested importance factors, the financial factor becomes a major importance factor that had to be improved, nevertheless community participation, environmental and social impacts factors are satisfied important factors. On the contrary, in area with government intervention there are other factors appear than those mentioned factors which are institution and technology.This indicates government socialization and empowerment effort has opened community perception that sanitation management needs legitimate institution and suitable alternative technology.

Keywords: government, community, sanitation, slum area

INTRODUCTION

The majority of urban households and businesses in Indonesia use septic tanks for wastewater disposal, and the use of water-flush toiletsis common. About 14 percent of urban dwellers still practice open defecation (Aus Aid, 2013). Indonesia Statistic Bureau (BPS) data stated that proper sanitation achievement is increasing from 51,19% in 2009 to 60,31% in 2013, while Millennium Development Goals (MDGs) target stated that 62,41% proper sanitation in Indonesia (RPJMN, 2010/2014) has been updated to 100% in 2019 (RPJMN, 2014/2019). In West Java Province, which has the largest population in Indonesia, sanitation service in 2013 is 64% and in 2015 is aimed to reach 70% (RPJMD, 2013/2018).This coverage is significantly lower than in otherEast Asian countries despite Indonesia having experiencedsignificant economic growth in recent years, surpassing manyof its neighboring countries.

Development Policy

Government support contributes in santitation achievement and as for the challenges towards sanitation are low political priority, low allocated budget, low human resources and lack of readiness in implementation. Beginning in 2000, the central government, coordinatedby BAPPENAS,embarked on a series of initiatives to reformwater supply and sanitation sector policies. Thesere forms were aligned with decentralization which devolvedresponsibility for sanitation to the local government.Indonesian government effort and policy is confirmed by initiatinga National Program for Human Settlement Sanitation Development Acceleration (PPSP). In this scheme, development acceleration will concern to sanitation including wastewater management. The following achieved establishment of the Acceleration of Urban Sanitation DevelopmentProgram (PPSP) to assist local governments incomprehensive citywide sanitation planning through thepreparation of City Sanitation Strategies (SSK). As of mid-2012, 240 cities and regencies have prepared SSKs, and 330of the 496 local governments in Indonesia are expected tocomplete them by 2014.

Inclusion in the 2010-2014 Medium Term Development Plan of sanitation targets: (a) Indonesia to be 100 percent Open Defecation Free; (b) 10 percent of the total population to be using off –site wastewater management systems; and (c) 90 percent of the population to have improved on-site or shared facilities. Both on-site and off-site system refers to the government's strategy to encounter the challeges in sanitation.As on site system improvement, decentralization system then become one alternative in domestic wastewater management to accelerate covering service which manage wastewater close to the source (Wilderer and Schreff, 2000). Development pattern is conducted by involving various stakeholder, community as users in particular, focusing active community participation to initiate and to take responsibility for constructing sanitation facility, empowering community and dedicated to low income inhabitants (Dayal et al., 2000).Government Regulation No.23/2014 stated that community participation should be encourage to help the Government's development programme. The West Java Provincial Government also stated about the importance of community participation in their local policy known as "Jabar Masagi". Essentially community based decentralization system is both technical and economically appropriate for low income society (Paterson et al, 2007).Technical government implemented system is per group decentralization or communal instead of centralized system. A total of approximately 1700 decentralized wastewatertreatment systems (DEWATS) constructed countrywidewith another 4,000 DEWATS systems planned to be implemented by 2015. On the other hand, centralized sewerage systems planned for an additional five cities such that 32 million people or 15 percent of the population in 16 cities will be covered by centralized sewerage systems (Aus Aid, 2013).

Institution

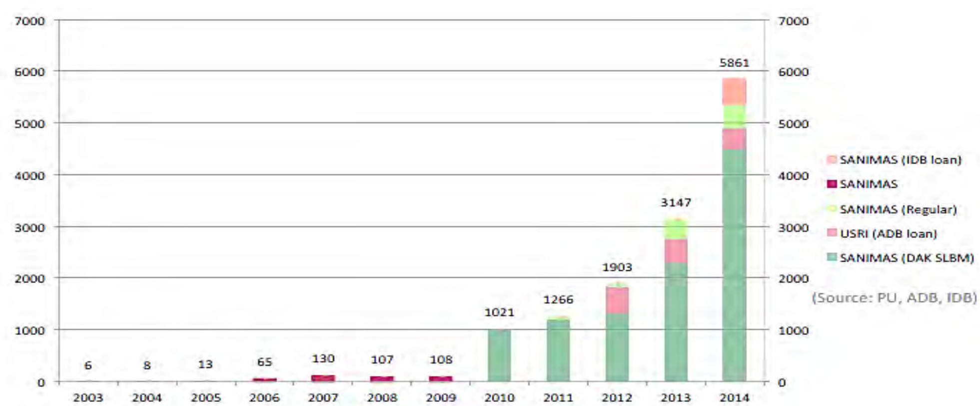
Well managed institution is required to execute abovementioned programs. Cooperation among sectors both technical and non technical sectors are then realized in sanitation development particularly in institutional aspect (Mara et al, 2010). In Uganda for example, water and sanitation are managed by central government inter department covering ministry of education, health, water and environment (Isunju et al, 2011). In Indonesia, BAPPENAS initiate working groups for water and sanitation (Pokja AMPL) then since 2007 focusing on sanitation through sanitation development technical team (TTPS) that involve nine ministries/institutions incorporated in Pokja AMPL, which are Ministry of Home Affair, Ministry of Health, Ministry of Public Works, Ministry of Housing, Ministry of Finance, Ministry of Industry, Ministry of Environment and Central Statistic Bureau. This team is also created in both provincial and city/regency government.The Association of Cities and Districts Concerned aboutSanitation in

Indonesia (AKKOPSI, established in 2011) nowcomprises over 200 cities. Members of AKKOPSI have committedto allocating at least 2 percentof their budget tosanitation in the future.

Financial

Related to financial policy aspect, low political priority and institutional capacity create less government attention to invest in sanitation than in other sectors (Cumming, 2008). Increasing financial support since 2003 as shown in Tabel 1, moreover in significant amount after regional autonomous era, both national (APBN) and provincial/local (APBD) budget, sanitation still has less allocated budget than water (WSP, 2009). Low allocated budget, below 2% in average, leads to useless sanitation facilities due to small operational and maintenance budget (WSP, 2009).

Table 1.Financial Support in Sanitation



Sustainable Sanitation Facility

Wastewater treatment system is integrated off-site and on-site system also involving legal, finance, institution and administration waste water infrastructure system (Permen PU, 2013). Table 2 shows often used sanitation facilities in Indonesia.

Table 2. Categories of Sanitation Facility di Indonesia

Category	**On-site System**	**Hybrid : Community Based**	**Off-site System**
Sub-division	- Communal - Individual	- Communal Septic Tank - Communal wastewater treatment unit - MCK++	- Medium: Decentralization - Centralized
Water flow	Not required	Required for flushing	Required for flushing
Transport system	No piping system	Area piping system	Conventional piping system/

Category	On-site System	Hybrid : Community Based	Off-site System
			sanitary/simple
Treatment system	Collected in septic tank	Septic Tank/ABR+filter. MCK++: digester+ABR+filter	Anaerobic, aerobic or lagoon system
Final disposal	Fecal Sludge Treatment Facility(IPLT)		Fecal sludge treatment in wastewater treatment facility (IPAL)
Note: MCK : MandiCuciKakus, *ABR : Anaerobic Buffled Reactor*			

Source: ADB & WB, 2013

Individual sanitation provision in slum area is unfeasible due to high density and poverty (Schouten andMathenge, 2010), also for centralized sewerage system because of high cost, large water consumption and irregular housing pattern shall complicate piping network. In urban slum area the only feasible system is communal on-site system which is appropriate for limited land (Katukiza et al, 2012). This communal system or septic system is commonly used for individual house or also known as decentralized wastewater treatment system (DEWATS) that technically and economically possible for low income inhabitants (BORDA,1998; Paterson et al, 2007; Libralato et al, 2012).This system is appropriate for area without direct connection to centralized wastewater piping system, essentially used to handle black and grey water naturally in septic tank and disposal field. Decentralization management system needs intensive attention from professional experts and researchers considering its water consumption, pollution control, water recycling and also cost efficient and effectiveness (Butler and Mac-Cormick, 1996).

According to Mara et al (2007), the utilization stages in sustainable sanitation are community health, operation and maintenance capability, environmental sustainable and proper institution. Sanitation is close related with fecal management and treatment (Parkinson et al, 2008) that means management institution is emphasized. Carden et al (2009) define sustainability is accuracy in maintenance and long term system sustainability. Bracken et al (2004) conclude that sustainable sanitation system shall result human health protection, minimize environmental degradation or declining natural resources. This system is technical, economical and socially acceptable.

Sustainable sanitation from technology aspect standpoint is environmental and locally sustainable with contribute to health improvement and environmental protection also technically accepted by user (Darrow, 1993). Operational sustainable technology is a facility to remove pathogen materials from wastewater, protecting groundwater, least cost implementation, operation and maintenance also functional without high quality materials (Howard et al, 2003).

Summary for determining factors in community based sanitation development are shown in Table 3 below.

Table 3. Sustainability Determining Factors

No	Determining Factor	Defenition
1.	Institution	Institutional role in sanitation development both for government and community
2.	Regulation	Regulation role in sanitation management
3.	Financial	Financial support for sanitation handling
4.	Community Involvement	Community involvement in sanitation management
5.	Technology	Applicated technology type and performance
6.	Private sector role	Private sector involvement in sanitation management
7.	Culture	Attention to cultural role including local wisdom
8.	Gender	Housewife role in sanitation management
9.	Social Impact	Attention to social impact including community social life (religion, behavior, trust)
10.	Environmental Impact	Attention to surrounding environmental impact

Community Participation

Participation is community voluntary attitude to help out development program successfully instead of people mobilization process (Bryant et al, 1987). Since community takes over bigger responsibility, the participation wills succeed even more (Wellington, 2009). In terms of development, UN defines participation as active and meaningful involvement from inhabitants in various levels, which are:

1. Decision making process to stimulate community purposes and resource allocation to achieve them;
2. Program implementation and voluntary conduct projects;
3. Program or project result utilization.

Essentially, sanitation system needs to adjust with community requirements instead of community adaptating with sanitation system(DellstromRosenquist, 2005). Four important main factors are (Schouten andMathenge, 2010):

1. Field situation, each location will have different case;
2. Financial, affordable by community in both construction and operation and maintenance;
3. Technology, simple operation and maintenance also environmentally safe; Participation, main role in implementation.

METHODOLOGY

This research design is conclusive descriptive refer to explaining one or more characteristic of structured and specific variables both for secondary data and observation result to help out decide, evaluate and provide the best optionto solve problem. Quantitative analysis shall be used (Firdaus, 2012). Research purpose is to identify determining factors for sustainable sanitation in urban slum area.

This research is conducted in to different handling locations/areas that result to different respondent understanding, Location 1 is slum area without government program while Location 2 is slum area with government program (SANIMAS/SLBM). Research is conducted by questionnaire distribution to communities in both locations, those results then compared and analyzed to obtain conclusion.

Location 1

Research location is Greater Bandung Area urban slum area. This location is selected based on several planning documents which are City/Regency Spatial Plan (RTRW) and Environmental Health Risk Assessment (EHRA) study.Selection criteria will refer to:

1. Population density. Ideal population density is 75 people/Ha (WHO, 2010), this research is focused in district and villagewith density over 75 person/Ha.
2. Stated as slum area in RTRW or other documents.
3. Prone Sanitation Area, according to Environmental Health Risk Assessment (EHRA) study which conducted by City/Regency by series of activities in Urban Sanitation Acceleration Development Program (PPSP) to describe sanitation condition.
4. Urban area characteristic.

Research Location 1 is described in following Table 4.

Table 4.Research Location 1

Bandung City	Cimahi City	West Bandung Regency	Bandung Regency
1.Kel. Sekejati 2.Kel. Braga 3.Kel. Andir 4.Kel. Cigondewah	1. Kel. Cigugur Tengah 2. Kel. Leuwigajah 3. Kel. Melong 4. Kel. Cibeureum	1.Kel. Padalarang 2.Kel. Ngamprah	1. Kel. DayeuhKolot 2. Kel. Rancaekek

Location 2

Research is conducted to community based sanitation development program granted areas in Bandung Metropolitan particularly in urban area, commonly known as SANIMAS and SLBM. From entire 69 locations, there is 47 locations situated in urban area.

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):

(Equation5)

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

RESULTS AND DISCUSSION

Sanitation Facility

Housing profile in Bandung City slum area is mostly owned or inhabited, but often rented as well. Inhabited house generally have private toilets while rented house use shared toilets (WSUP, 2011).Schematic on-site wastewater treatment system in Indonesia is shown on Figure 1.

Although slum area communities have private toilet, the quality should be observed further as shown in below Figure 2, but the quality of facility is doubtful. TheMinistry of Health issued the good sanitation criteria which are no water and soil pollution, bugs free, odorless, used safely and comfortable, easy to clean and paying attention to aesthetics. Toilets facility and materials are also important, for instance the wall and floor. Good floor should be dark, well isolated to avoid cockroach and other small insects, easy to clean and dry, good slope and non slippery. While the wall should be light, soundproof, isolated, having door and aesthetics.

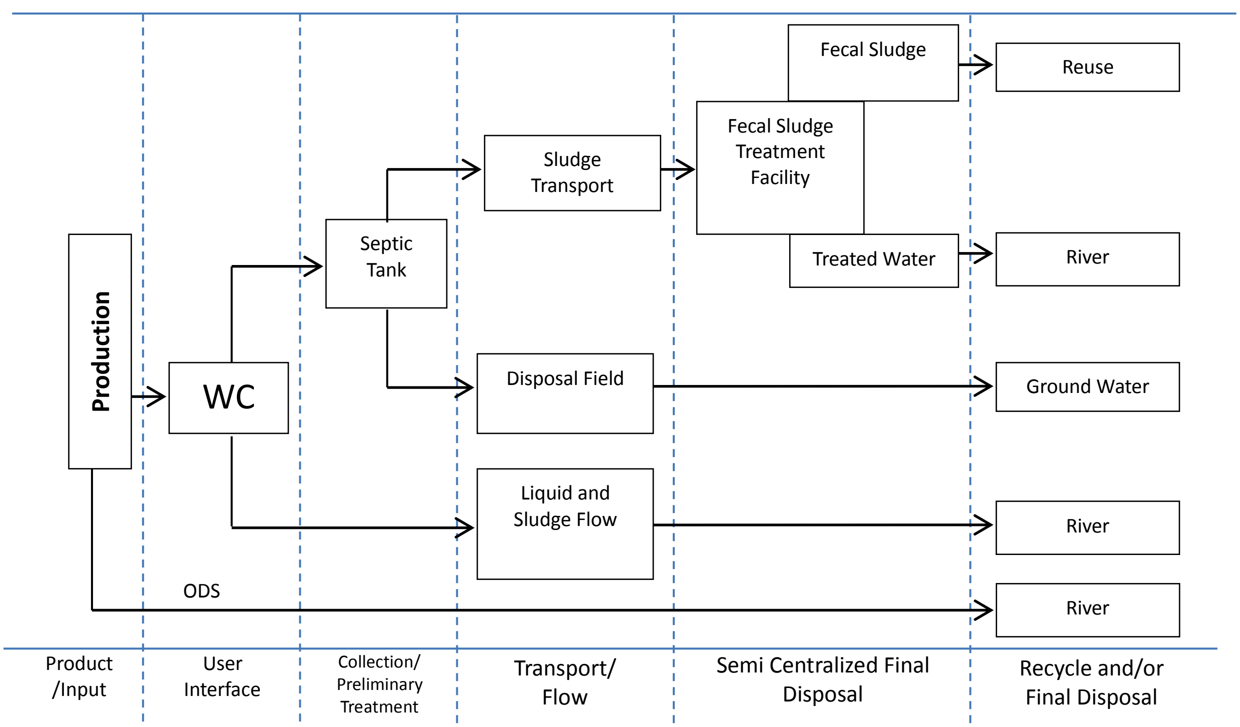


Figure1. Schematic On-site Domestic Wastewater Flow System

The same figure also explain fecal sludge collection facility that using septic tank for only 45-57%. Similar with the toilets, septic tank collection and treatment quality is also doubtful. Other inhabitants flow the sludge directly to the river or through open channel network then to the river without prior treatment as shown in above Figure 1. This network should be modified to a better piping network that equipped with communal treatment facility.

Available private toilets in each house signify that required technology is communal distribution and treatment. Hence government attempts to involve in providing sanitation facility particularly community based or decentralized communal treatment system.

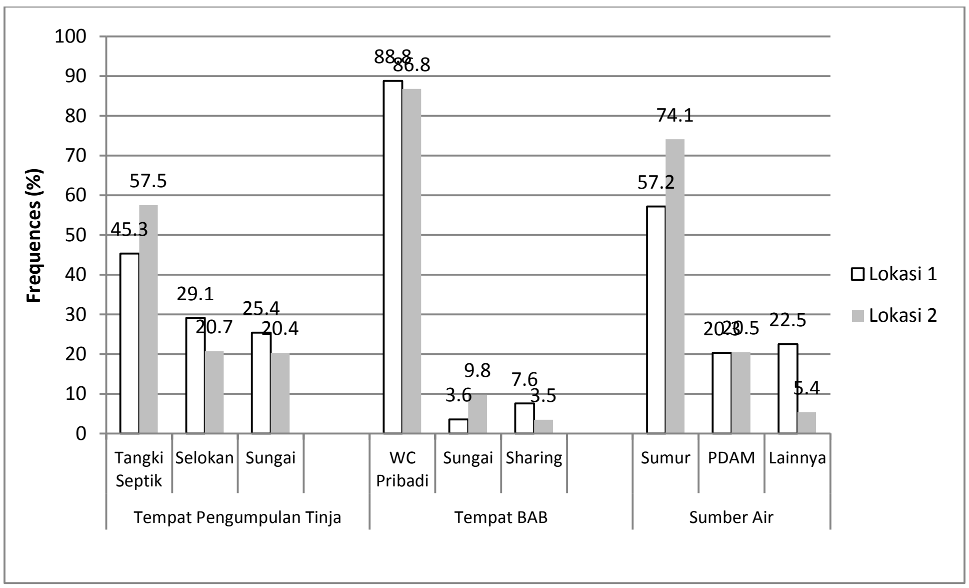


Figure 2.Sanitation Facility and Water Source Illustration

Importance Factors for Development Success and Sustainable

As explained above, Indonesian government efforts to achieve sanitation service target are implemented through decentralization system to the community that means sanitation management is conducted by the community while government acts as a facilitator. However, community readiness to implement this concept needs further study especially for the required factors. Next discussion isidentification results for sanitation management importance factors in urban slum area. The keywords are development achievement and sustainable.

Importance factors identification results in Location 1 and 2 are shown in following Table 5. There are different survey results to 10 importance factors in sanitation management in both locations. Importance considered factors in both locations are finance, community involvement, social and environmental impacts, however in Location 2 (supported by government program) other factors show up which are technology and institution.

Table 5. Importance Factors Comparison in Location 1 and 2

Quadrant	Research Result Stage 1	Research Result Stage 2
Quadrant I (important factor, not satisfied yet)	V3. Cost	V3. Cost V5. Technology
Quadrant II (important factor, satisfied)	V4. Community Involvement V9. Social Impact V10. Environmental Impact	V1. Institution V4. Community Involvement V9. Social Impact V10. Environmental Impact
Quadrant III (unimportant factor, not satisfied)	V1. Institution V2. Regulation V5. Technology V6. Private Sector	V2. Regulation V6. Private Sector V7. Cultural Role V8. Gender Role
Quadrant IV (unimportant factors, satisfied)	V7. Cultural Role V8. Gender Role	

Note:
Stage 1: Location without government program
Stage 2: Location with government program

Financial factor that comes up in both locations reflects community characteristic in slum area. As discussed above, inhabitants income in slum area generally below regional minimum wage (UMR), consequently main necessity shall be more prioritized than sanitation which least financed by any available fund. Government financial supports are much expected by community as no support experienced yet.

Technology factor arise in Location 2 which illustrate government intervention result through community empowerment in sanitation development. Previous community understanding that domestic wastewater should be disposed or treated by septic tank only, has improved by understand that technology have important role in sanitation management.

Institution as managers working place has important role in decentralization system, this factor arise in Location 2 as a result from government program to prepare community in sanitation management particularly for well structured community organization. Community has understood that by their limited time and power, a well coordinated group/institution is required to achieve success and sustainable developed facility.

Social and environmental impact and community involvement factors are considered as important factors in both locations. It means that community has understood basically that well managed sanitation is required to avoid negative social and environmental impacts. Community has involved in sanitation management in both locations, either individual in Location 1 or group involvement in Location 2.

CONCLUSION

Based on survey result, analyzed data and discussion, could be concluded that sanitation facilities are dominated by private toilets both in slum areas with and without government program. This means community has a role to provide their defecation facility independently by any available condition. Septic tank is used by part of inhabitants while other directly flows to the nature. However septic tank maintenance still poor, therefore the quality should be improved by communal or shared septic tank which is suitable to slum area physical and social condition.

Community understanding to sanitation is relatively good, particularly by government program that involve the community, starting from preparation, plan, construction and maintenance stage. Generated positive impact is increasing community understanding in sanitation management including the importance of institution and technology in addition to financial, community involvement, social and environmental impact.

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STUDY OF SOCIO-ECONOMIC AND ENVIRONMENT IMPACTS OF INCONVENTIONAL TIN MINING (A CASE STUDY: BANGKA BARAT DISTRICT OF BANGKA BELITUNG PROVINCE)

Fahrika Erwana[1], Kania Dewi[2] and Benno Rahardyan[3]
[1,2,3]Program Magister Teknik Lingkungan, Institut Teknologi Bandung
Jl. Ganesha 10 Bandung 40132
Email : fahrika.erwana59@gmail.com[1], kaniadewi@ftsl.ac.id[2]andbenno@ftsl.itb.ac.id[3]

Abstract: This study is a measurement and evaluation of the impact of unconventional tin mining on the social and economic conditions, as well as the environmental damage caused by tin mining in the district of West Bangka of Bangka Belitung province. Data were obtained from questionnaires, observation, and literature review. Firstly, questionnaire need to be tested its validity and reliability before continued to assess awareness and perception. In addition there will be path analysis to observe the influence of variables to perception of social, economic and environment impacts. The study involved 400 randomly selected respondents in the two sub districts in the District of West Bangka, they are Mentokand Jebus. Observation result showed that the unconventional tin mining gives negative impact on the environment and social conditions, but it gives a positive impact on the economic conditions. Based on path analysis, variables of awareness, participation, expectation and support unconventional tin mining have significant effect to perception of social, economic and environment impacts.

Keywords: Unconventional tin mining, validity, reliability, path analysis

INTRODUCTION

Bangka Island is largest tin producer in Indonesia. From Bangka island area 1.29405 million ha, amount 27.56% of the island's land area is a Tin Mining Authorization. PT. Tambang Timah (a subsidiary of PT. Timah Tbk) control land area of 321 577 ha and PT. Kobatin 35 063 ha (Bappeda Bangka 2000). Beside the two companies, Tin Mining Authorization also be given to private companies. Until mid-2007, the number reached 101 .(Dinas Pertambangan Provinsi Kepulauan Bangka Belitung 2007).

In addition there are a number of other private smelters and traditional miners called unconventional mining (TI) which mines spread over land and sea of Babel. Tin mining issues began to emerge since the number of IT is increasing every year.

Mining activities throughout the world, have contributed both positively and negatively on the economic and social aspects of the communities in the mining areas. Visible positive contribution in the form of increased income, employment increase, intense migration and population growth and the provision and maintenance of social facilities. But besides a positive contribution, mining also includes the negative impact of land degradation, increasing levels of crime, the loss of agricultural land and cultural heritage, health hazards and inflation. (Onwuka, et al., 2013).

The studies about the impacts of mining activities on the environment and social and economic community have been doneby Kitula (2004), Petkova (2009), Samuel et al (2012), Ocholla et al (2013), Onwuka, et al (2013), Sati (2014). But until now the method of the study is still growing. Some studies are very specific to certain types of mining materials and a location on a geographic scale. Only a few studies have used statistical analysis in the study.

The purpose of this study was to determine the awareness of the public about the environmental impact of tin mining in Bangka Barat. In addition, this study also aims to determine the public perception of the impact of social and environmental economic society due to unconventional tin mining in Bangka Barat.

Ths study is based on the hypothesis that the mining activities have a significant impact on the socio-economic and environmental. (Kitula, 2005).

This study reviews both negative and positive impacts of unconventional tin mining. Policies and strategies for the management of post-mining region should sustainability three main dimensions of ecology, economic and social. It is necessary to study the impact of research on unconventional tin mining on the environment and socio-economic communities in West Bangka.

METHODOLOGY

In this study describes the data that has been obtained from the questionnaire, observation, interview and literature study.

The variables of this study are:

a. The variable impact on the physical and chemical properties of the environment.
   1) Environmental degradation (damage) as a result of tin mining open pit methods.
   2) Environmental pollution due to mining activities.
b. The variable impact on the social and economic conditions
   1) Public awareness of the environmental impacts.
   2) Public perception of the social, economic and environmental consequences of tin mining activities.
   3) The willingness of the public to participate in environmental management as a result of unconventional mining.
   4) Expectations for unconventional mining community.

Data collection is obtained by questionnaires, observations and literature study.

Stages of data analysis consists of:

Test Validity and Reliability Questionnaire

Validity and reliability test aims to determine whether the questionnaires valid and accurate to measure the public's awareness and perception. Validity analysis using item-total correlation formula. Item statement or question declared invalid if it has a coefficient of r count larger than the standard r coefficient (can be obtained from table r). r value standard in This study involves 400 respondents with a significance level of 5%. Ifr correlation value is greater than the table, the questionnaire can be said to be valid.

To test the reliability coefficient it is obtained or $r_{calculation}$ consulted with r_{table}in the significant level of 5%. The test results said to be reliable if $r_{calculation} > r_{table}$ and otherwise said to be reliable if or $r_{calculation} < r_{table}$

Data Analysis to determine the public awareness against environmental impacts and the public perception of the impact of mining activities on the social and economic conditions and the environment were analyzed quantitatively by scoring method (Dedek Apriyanto, 2012). Awareness assessment carried out with weights with a Likert scale, such as Strongly Disagree (STS) = 1, Disagree (TS) = 2, Neutral (N) = 3, Agree (S) = 4, and 5 = Strongly Agree.

Path Analysis

Path analysis is a way to study direct and indirect effects number of variables that are hypothesized as a cause variable to result variable.

Discriminant Analysis

Discriminant analysis is a statistical analysis technique which has uses to classify the object of several groups. Grouping with discriminant analysis is the case because there is the influence of one or more other variables that are independent variables. Linear combination of these variables will establish a discriminant function (Tatham et. al.,1998).

RESULT AND DISCUSSION

Research samples were taken from is two districts namely: Mentok and Jebus and the community who are randomly selected. **Figure 1** presents the distribution of respondents in the Mentok and Jebus.

Figure 1. Respondents Distribution Map

Inconventional Tin Mining Impacts on the Environment

In this study, public awareness of the environmental impact has two questions, namely the question of pollution (Q1), damage (Q2). Distribution of consciousness or awareness of the environmental impact can be seen in **Figure 2.**

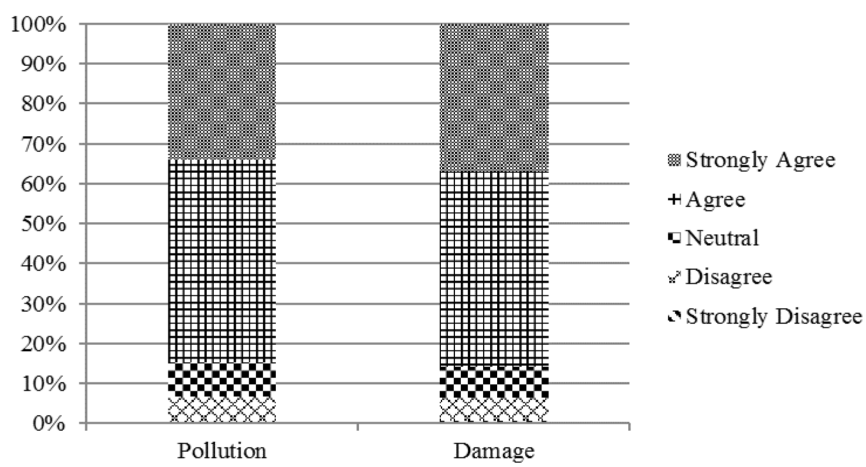

Figure 2. Awareness of the environmental impacts

Based on Likert scoring, the percentage of awareness of the environmental impact in the form of pollution is 82% and the damage is 83%. So that public awareness of the environmental impact is very high.

Results of a survey on public perception of the environmental impact has 8 questions, namely the question of water pollution (Q13), soil contamination (Q14), air pollution (Q15), changes in the landscape (Q16), noise nuisance (Q17), health problems (Q18) and comfort disruption (Q19) can be seen in **Figure 3**.

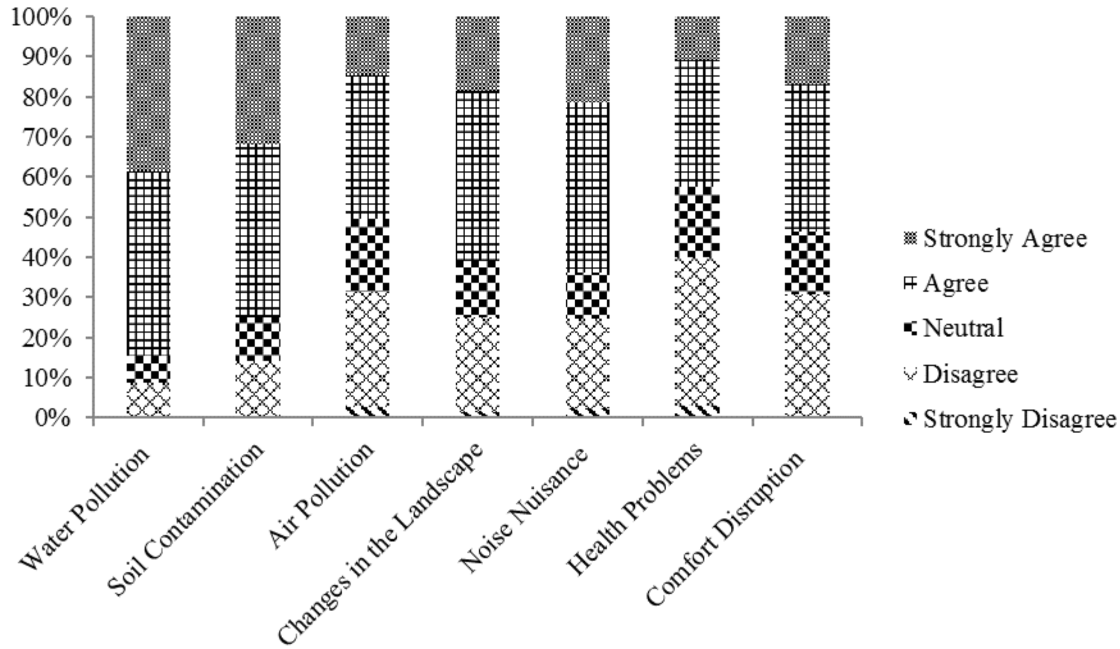

Figure 3. Perception of The Environmental Impacts

Based on Likert scoring, the percentage of perceptions of environmental impacts such as water pollution, soil pollution, air pollution, landscape change, increased noise, health problems and comfort disruption each by 83%, 78%, 66%, 71% , 72%, 62% and 68%. It means the public perception of the environmental impact is negative.

Inconventional Tin Mining Impacts on Socio-Economic Conditions

a. Perceptions of Social Impact

Public perception of the social impacts has five questions they are presence of immigrants (Q3), conflict (Q4), the level of crime (Q5), social jealousy (Q6), and changes in social conditions (Q7). Distribution of public perceptions of the social impacts can be seen in **Figure 4**.

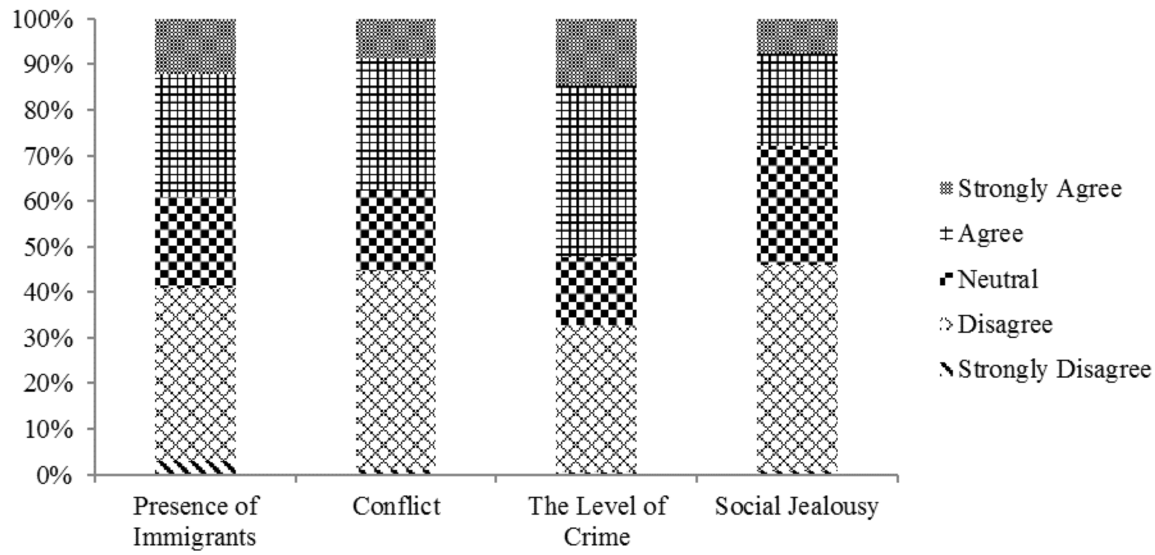

Figure 4. Perception of The Social Impacts

Based on Likert scoring, the percentage of the perception of social impact in the form of the presence of migrants, conflicts, increased crime rates and social jealousy, respectively 61%, 60%, 67% and 58%. It means the public perception of the social impact of such conflicts and jealousy categorized neutral. While the public perception of the social impact in the form of the presence of immigrants and the increase in crime rate negative categorized.

b. Perceptions of Economic Impacts

Public perception of the economic impact has five attributes questions that income increase in (Q8), job opportunities (Q9), business opportunities (Q10), land compensation (Q11), and changes in economic conditions (Q12). Distribution of public perceptions of the social impact of this can be seen in **Figure 5.**

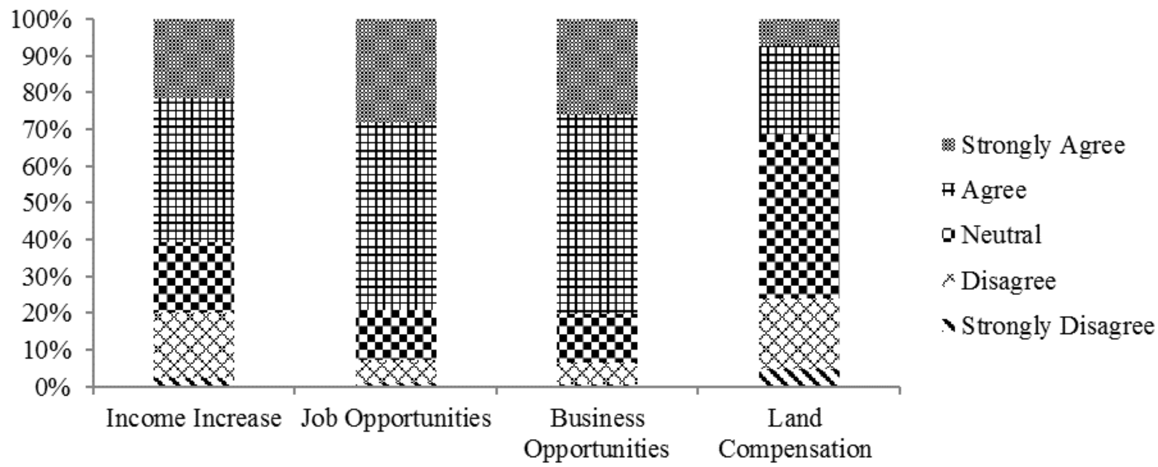

Figure 5. Perception of The Economic Impacts

Based on Likert scoring, the percentage of the perception of the economic impact of increased income, employment, business opportunities and land compensation, respectively 72%, 80%, 80% and 62%. It means the public perception of social impact is positive.

Willingness to Participate in Managing Environment Impacts of Inconventional Tin Mining

Composition of the public's willingness to participate in managing environment impacts of un conventional tin mining can be seen in **Figure 6**.

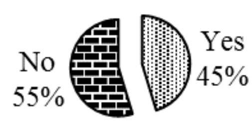

Figure 6. Willingness To Participate In In Managing Environment Impacts Of Unconventional Tin Mining

If expectation compared to willingness to participate, those who are dissatisfied with the unconventional mining, are not willing to participate in environmental management. It means people are not willing to participate in environmental management because in conventional tin mining didn't meet their expectations. **Figure 7.** shows the relationship both aspects.

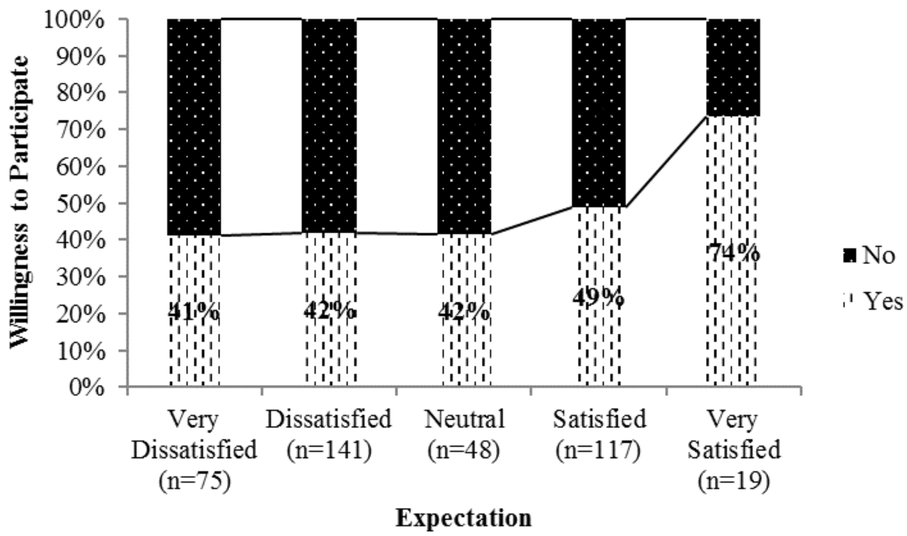

Figure 7. Expectations Willingness To Participate

Supporting for The Existance of Inconventional Tin Mining

People support for the inconventional tin mining can be seen at **Figure 8**.

Figure 8. People Support For Inconventional Tin Mining

Base on the **Figure 8**, can be seen that some respondents (53%) are not supporting inconventional tin mining.

If we compared between respondent support for inconventional mining and environtment pollution awareness, those who have awareness of environment impacts not supporting inconventional tin mining that cause environtment pollution (**Figure 9**).

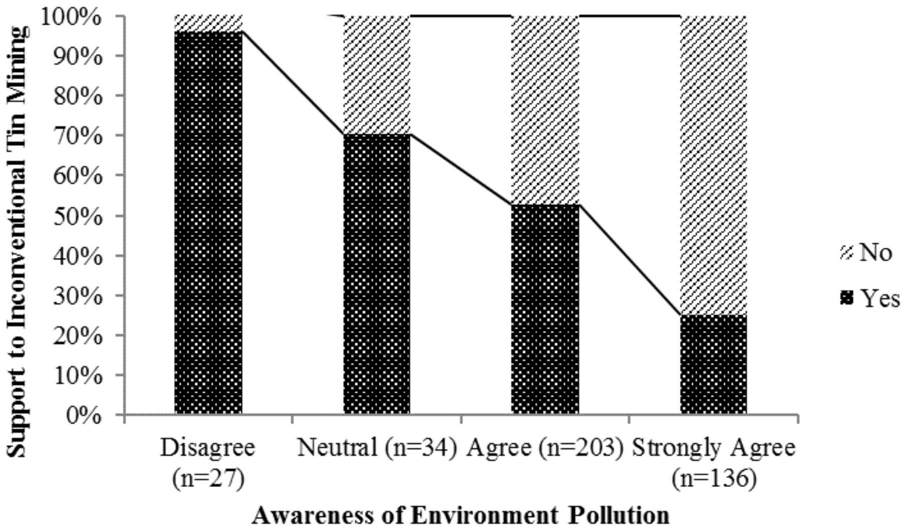

Figure 9. Awareness Inconventional Tin Mining Support

While if we make comparison between inconvetional tin mining support and willingness to participate, those who are not supporting inconventional tin mining, are not willing to participate (**Figure 10**).

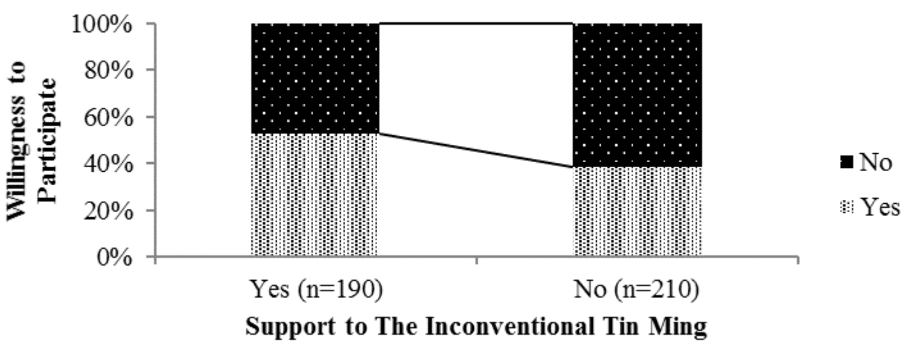

Figure10. Supporting for inconventional tin mining vs willingness to participate

Comparison between inconvetional tin mining support and expectation is shown in Figure 11. Those who are not supporting inconventional tin mining said that they are not satisfied.

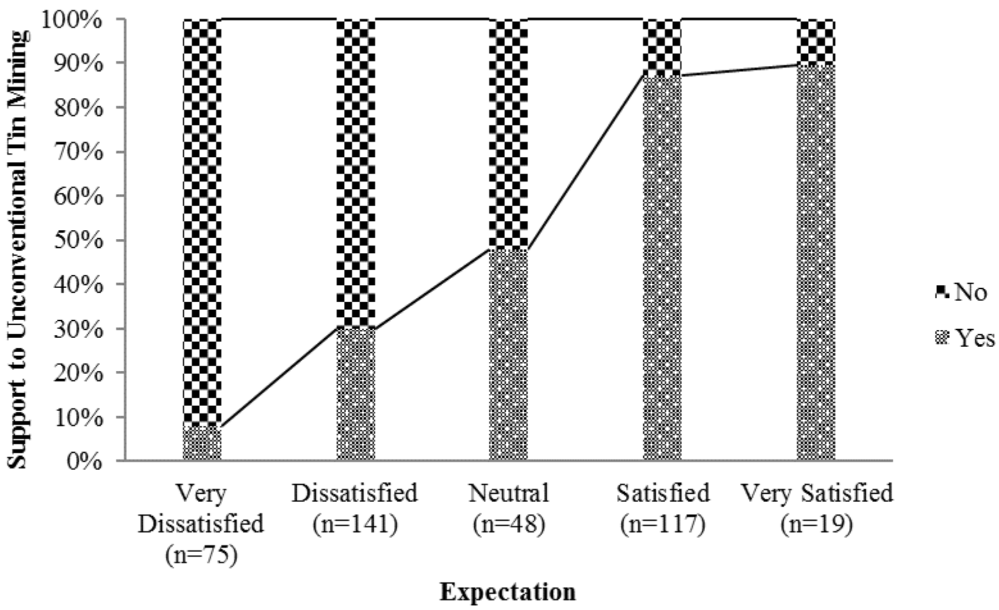

Figure11. Expectations Supporting For Inconventional Tin Mining

So, supporting for inconventional tin mining is influence by aspects of awareness, willingness to participate and expectation.

Awarenessand Perseption Based on Area

Survey shows that 14 out of 18 villages surveyed have very high awareness, 3 out of 18 villages are high categorized and 1 village is middle categorized. The composion of people awareness in each village shown in **Figure 12**.

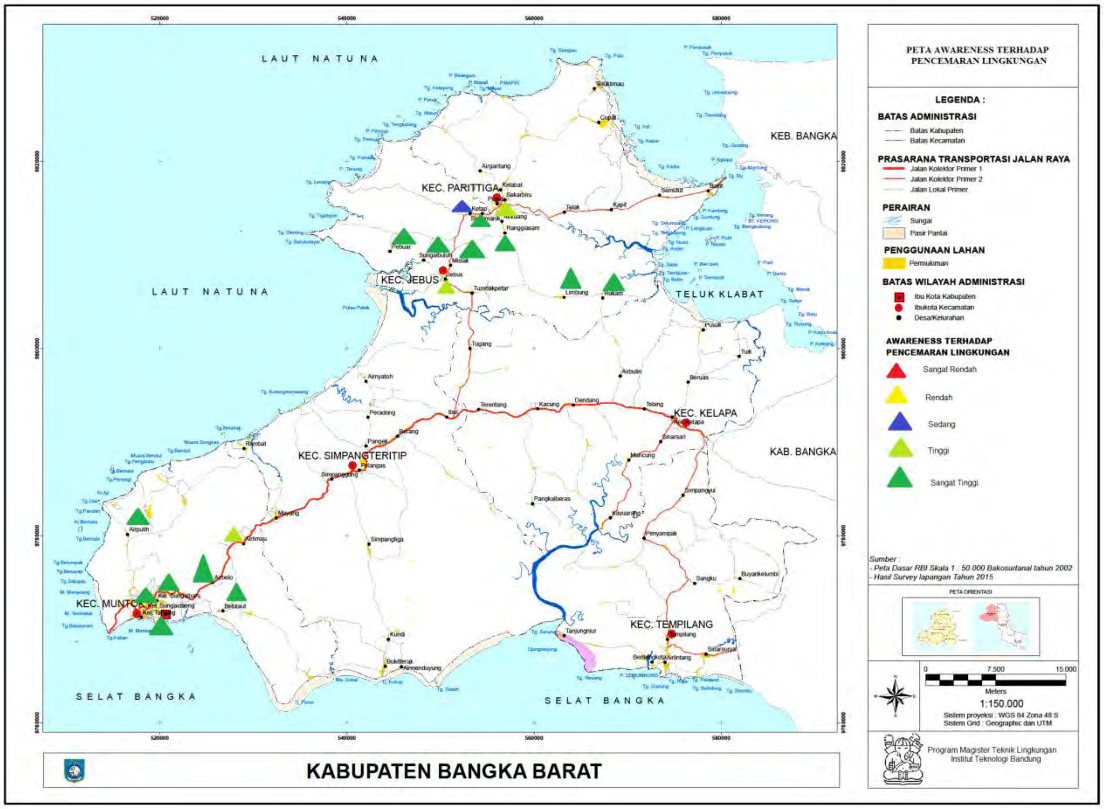

Figure12. Awareness Mapping Based On Area

While composition of social, economic and environment perception shown in **Figure 13.**

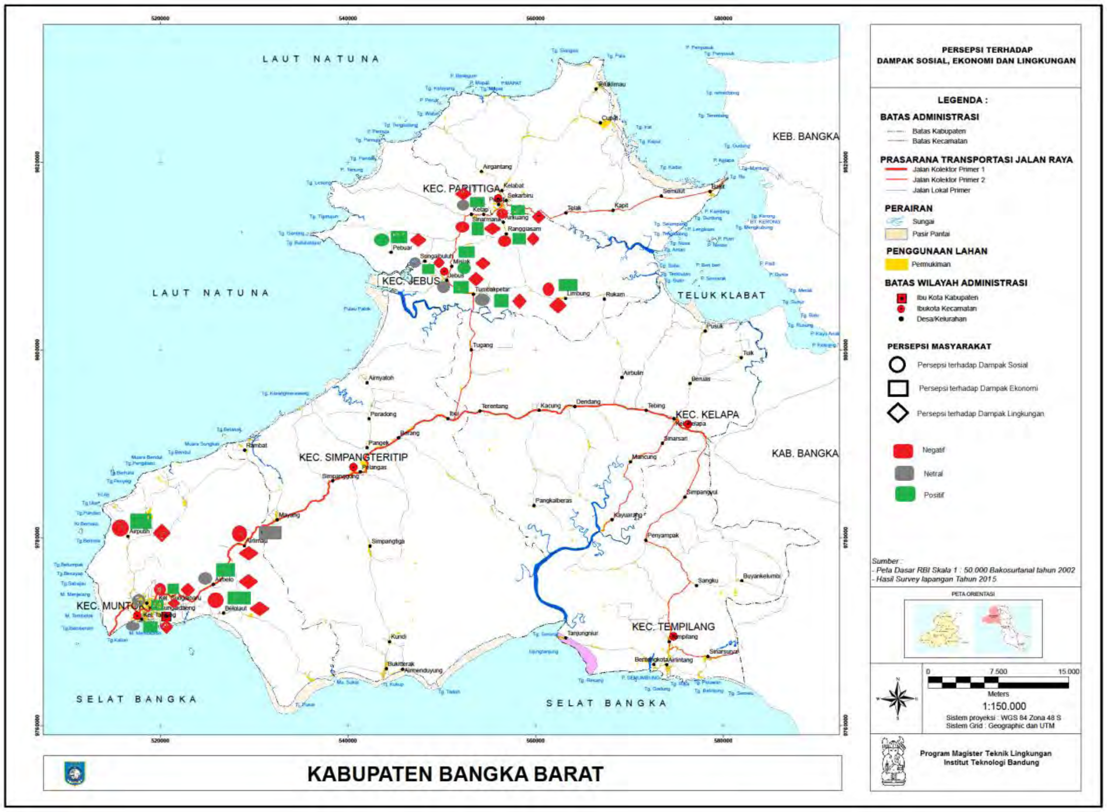

Figure 13. Perception Mapping Based On Area

If we make comparison between perception and existing environment condition, those who live in middle condition are neutral to the social impact. And those who live in bad environment condition have negative perception of social impact due to inconventional tin mining. For the social impacts, both communities live in very bad, bad and middle environment conditions have positive perception of economic impacts. And both communities live in very bad, bad and middle environment conditions have negative perception of environmental impacts due to inconventional tin mining.

Cluster Analysis

This study used K-means method to make 2 segment groups based on supporting for inconventional tin mining.

In cluster 1, there are 184 respondents who live in bad environment condition, have very high awareness of environment impacts, negative perception of environment impacts, neutral to the social impacts, positive perception of economic impacts, not willing to participate, satisfied and supporting to the inconventional tin mining.

In cluster 2, there are 216 respondents who live in bad environment condition, have high awareness of environment impacts, negative perception of environment and impacts, positive perception of economic impacts, willing to participate, dissatisfied and not supporting to the inconventional tin mining.

Based on respondents' attribute, cluster classifying shown in **Figure 14**.

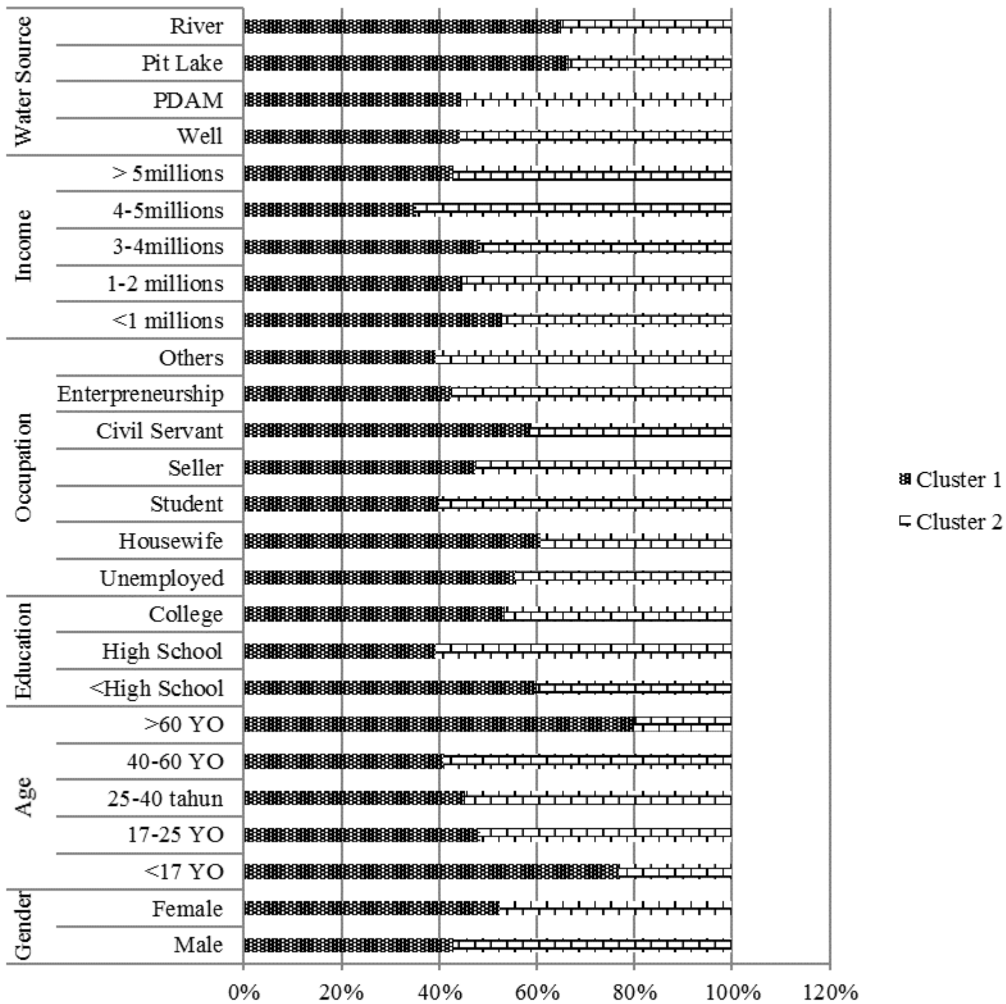

Figure 14. Cluster classifying based on respondents' attribute

Based on crosstabs analysis in **Figure 14**, respondents' characteristic in cluster 1 is dominated by women who are above 60 years old whose education below high school, as housewife with income below 1 millions and used pit lake (kolong) as water source.

Respondents' characteristic in cluster 2 is dominated by men who are 40 – 60 years old whose education high school. They are dominated by people beside civil servants, entrepreneur, housewife, and student. And they used water from PDAM and well.

Discriminant Analysis

All variables, except perception of environment impacts have role in classifying respondents. Discriminant analysis result in each cluster produces the variable as **Table 1**.

Table 1. Standardized Canonical Discriminant Function Coefficients

Variables	Function 1
Environment Condition	0.006
Perceptions of Social Impacts	0.247
Perceptions of Economic Impacts	0.031
Willingness to Participate	-0.135
Expectation	0.966

By using canonical discriminant function coefficient in **Table 1**, can be made discriminant function as follow:

$$D = 0{,}006X_1 + 0{,}247X_2 + 0{,}031X_3 - 0{,}135X_4 + 0{,}966X_5 \quad \text{(I)}$$

Discriminant classification result is shown in **Table 2**.

Table 2. Classification result

		Supporting forInconventional Tin Mining	**Predicted Group Membership**		**Total**
			Yes	**No**	
Original	Count	Yes	140	50	190
		No	35	175	210
	%	Yes	73.7	26.3	100.0
		No	16.7	83.3	100.0
a. 78.8% of original grouped cases correctly classified.					

So, based on discriminant analysis, variabels of social perception and expectation discriminate respondents' behavior in deciding supporting for inconventional tin mining with 78.8% of original grouped cases correctly classified.

CONCLUSION

The study showed that inconventional tin mining gives negative impacts on the environment and social condition, but it gives positive impacts on the economic condition. Based on cluster analysis, there are 2 clusters, they are cluster 1 (negative) and Cluster 2 (positive).Cluster 1 is dominated by women who are above 60 years old whose education below high school, as housewife with income below 1 millions and used pit lake as water source. Cluster 2 is dominated by men who are 40 – 60 years old whose education high school. They are dominated by people beside civil servants, entrepreneur, housewife, and student. And they used water from PDAM and well.

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