ISSN 1882-5796

Hanoi University of Science & Technology

South East Asian Technical University Consortium

Shibaura Institute of Technology

PROCEEDINGS

The 5th South East Asian Technical University Consortium (SEATUC) Symposium

February 24-25, 2011

Hanoi University of Science & Technology, Ha Noi, Viet Nam

HYBRID TWINNING PROGRAM 2010

PREFACE

SEATUC (South East Asian Technical University Consortium) was founded in 2006 with the aims of creating opportunities to exchange collaboration in educational and research activities among its member universities; fostering the exchange of scientific and engineering activities by the member universities through symposia, publications, promotion of research and personnel exchange for the benefit of people in South East Asian countries. This year, the Consortium will organize its 5th Symposium on 24th – 25th February 2011 at Hanoi University of Science and Technology (HUST), Vietnam.

The Symposium this year has broadened from 6 to 14 engineering fields with the total papers of 148. This record number shows the popularity of the Symposium among researchers and students of member institutions and the continuous success of the Consortium.

On behalf of the Organizing Committee, I would like to express my appreciation to Hanoi University of Science and Technology (HUST) for their great effort in hosting the event, and Shibaura Institution of Technology (SIT) for their co-organization in holding the Symposium. My appreciations are also to scientists, researchers and students who have submitted papers and actively participated in the Symposium.

Prof. Dr. Ha Duyen Tu
Vice-President of Hanoi University of Science and Technology
President of SEATUC

Time Table of 5th SEATUC SYMPOSIUM, HUST (Vietnam) Feb. 24th – 25th 2011

DAY 1: 24th February 2011 (Thursday)

TIME	VENUE and EVENT											
09:45 12:00	Venue: SEMINAR ROOM at the 10th Floor, Ta Quang Buu Library, HUST, Hanoi Event: Opening Ceremony of 5th SEATUC Symposium											
12:00 13:00	*Lunch Break at the 10 Floor, Ta Quang Buu Library, HUST*											
	ROOM 811		**ROOM 812**		**Room 813**		**ROOM 814**		**Room 902**			
	OS 12		**OS 04**		**OS 05**		**OS 03**		**OS 03**			
13:00 15:20	SIT	Goro Fujita	SIT	Taisuke Ishii	SIT	Hiroshi Hasegawa	UTM	Syuhaida Ismail	UTM	Azhan Abdul Aziz		
	SIT	Satoshi Matsumoto	SIT	Yoshihiko Ito	SIT	Kanlaya Rattanyu	UTM	Ismail Bin Said	UTM	Bagoes W.		
	SIT	Zulkarnain B.A.N.	SIT	Masanori Muroi	SIT	Krissana Nerakae	UTM	Yendo Afgani (1)	UTM	Didel M. Juliet		
	SIT	Arwindra R.	SIT	Pichitra Uangpairoj	SIT	Makoto Mizukawa	UTM	Yendo Afgani (2)	UTM	Lai, L.Y		
	SIT	Tatsuhiro Mineo	SIT	Takayuki Arimatsu	SIT	M.Azizi A. Rahman	UTM	Alireza Daneshpour	UTM	Hafizul Ridzwan Yahya		
	SIT	Nguyen Duc Tuyen	SIT	Masayuki Kobayashi	SIT	Pham Ngoc Hieu	SIT	Hoko Miwa (1)	UTM	Aliyu Salisu Barau		
	HCMUT	Nguyen P. Khai	SIT	Hiroki Obata	SIT	Phi Nguyen Truong	SIT	Hoko Miwa (2)	UTM	Ho Chin Siong		
15:20 15:40	*Coffee Break*											
15:40 18:00	HUST	Binh Minh Nguyen	SIT	Nobutaka Maezaki	SIT	Tadahiro Hasegawa	**OS 06**		UTM	Farhana Abdullah		
	HUST	Le Minh Thuy	SIT	Kenichi Iwata	SIT	Skulkittiyut Weerachai	SIT	Tatsuhiko Aizawa (1)	UTM	Abdullah Sani A		
	HUST	Luu Hong Viet	SIT	Masahiro Shibata	SIT	Youichi Hanakura	SIT	Tatsuhiko Aizawa (2)	UTM	Abdullah Sani Hj Ahmad		
	OS 14		KMUTT	Dau Hung Anh	SUT	Chaiyapak S.	SIT	Foo Jin Hoe	UTM	Ismail Said		
	HUST	Hoang Thi Linh	KMUTT	K. Saengchan	SUT	Chompunuch Lapo	SIT	Muhammad Zaimi	UTM	Juliana Johari		
	HUST	Pham Duc Duong	HUST	Truong Q. Phong	SUT	Jittima Varagul	SIT	Yuki Kagawa	UTM	Kei Saito		
	HUST	Nhu Phuong Mai	HUST	Nguyen T.X. Sam	HUST	Hoang Vinh Sinh	SIT	Yohei Hirohata	UTM	Ludin, A.N.M		
			HUST	Vu Thi Minh Hang	TNUT	Nguyen T Q Dung	SIT	Nor Akmal Fadil				
18:30	**GALA DINNER at the 10 Floor, Ta Quang Buu Library, HUST**											

OS01: Energy and Environment
OS02:Information and Communication Technology
OS03:Architecture, Urban Planning and Design
OS04:Bioscience and Engineering
OS05:Robotics and Mechanical Engineering
OS06: Materials Science
OS08:Chemical Engineering
OS10:Transportation Engineering
OS12:Electrical Engineering
OS14:Textile Engineering

Time Table of 5th SEATUC SYMPOSIUM, HUST (Vietnam) Feb. 24th – 25th 2011

DAY 2: 25th February 2011 (Friday)

TIME	ROOM 811		ROOM 812		Room 813		ROOM 814		Room 902	
	OS 01		OS 02		OS 10		OS 06		OS 03	
09:00 10:20	SIT	Jun Matsushita	SIT	Eiji Kamioka	HUST	Dinh Manh Cuong	SIT	Hironori Seki	UTM	Azizul, M.F
	SIT	Hiroshi Morita	SIT	Hirotsugu Ishida	HUST	Khong Vu Quang	SIT	Kazuo Inoue	UTM	Mohamed A. Said
	UTM	Amer Nordin Darus	SIT	Itaru Sekita	HUST	Le Minh Thuy	SIT	Keiichi Hagiwara	UTM	Mohammad Ghomeshi
	UTM	Zanariah Jasmani	SIT	Masaomi Kimura	HUST	Ngo Van Hien (1)	KMUTT	Piyapong A.	UTM	Mahmud B.M J.
10:20 10:40	*Coffee Break*									
10:40 12:00	UTM	Farid Nasir Ani	SIT	Michiko Ohkura	HUST	Ngo Van Hien (2)	HUST	Le Tuan	UTM	Zinas zachariah Bako
	UTM	Mohd. Hamdan Bin Hj. Ahmad	SIT	Noboru Horita	HUST	Phu Khanh Nguyen	HUST	D.T.H. Hue	UTM	Sayyed Javad Asad Poor Zavei
	KMUTT	Eknarin A.	SIT	Nurzal E.B. Ghazali	HUST	Pham Huu Tuyen	HUST	Nguyen D. Nam	UTM	Mahdi Torabi
	KMUTT	Suchada C.	SIT	Shuto Murai	HUST	Minh Ngoc Tran	HUST	Le Thi Chieu	UTM	Mohd H. Rasidi
12:00 13:00	*Luch Break at the 10 Floor, Ta Quang Buu Library, HUST*									
13:00 15:20	KMUTT	Tarworn R.	SIT	Sittapong Settapat	HUST	Truong Viet Anh	HUST	P. Quang	UTM	Wan M Z W Abdullah
	ITB	Edwan Kardena	SIT	Yota Kogure	HUST	Quoc Huy Vu	HUST	Nguyen Van Luong	UTM	Nor Fadzila Aziz
	OS 08		HUST	Nguyen Tien Thanh	HUST	Le Thi Thai	HUST	Thai T.T	UTM	Nursuriani Shaffee
	SIT	Benjaporn T.	HUST	Phong H.Pham	HUST	Pham T T Huong			UTM	Nurzuliza Jamirsah
	UTM	Ida I. Muhamad	HUST	Dang Khoa Nguyen	HCMUT	Nguyen T.P. Linh			UTM	Rusli, N.
	UTM	Eraricar Salleh	HUST	Ha Quoc Trung	HCMUT	Nguyen Phi Son			UTM	Sara Izrar Binti Aziz
			KMUTT	Pakorn K.	HCMUT	Tran Van Mien			UTM	Sumaiyah B.O.
15:20 15:40	*Coffee Break*									
15:40 16:40			UTM	Ahmed H. Osman	UETI	Pham H.D. Duc			KMUTT	Chamnarn Tirapas .
			UTM	Mohd. Hamdan Bin Hj. Ahmad) (1)	IHR	Dinh Minh Hai			KMUTT	Nigel Poweri
			UTM	Mohd. Hamdan Bin Hj. Ahmad) (2)					SIT	Junko Tamura
16:45	**Symposium Closing**									

Time Table of Intensive Workshop, HUST (Vietnam) Feb. 24th, 2011

Date: Feb. 24th, 2011
Venue: Room 702, Ta Quang Buu Library, Hanoi University of Science and Technology (HUST), Hanoi, Vietnam

Time	Events
14:00 17:00	Presentations for 9 person The talk is 20 minutes for the presentation

Time Table of Intensive Workshop

- Date: February 24th (Thursday) 14:00－17:00
- Venue: Room 702, Ta Quang Buu Library
  Hanoi University of Science and Technology (HUST)

14:00-14:20 **"Hypophosphite Bath Base Electroless Nickel Ternary and Quaternary Alloy Deposition"**
Muhammad Zaimi, and Kazuhiko Noda, Shibaura Institute of Technology

14:20-14:40 **"A Web-based 3D Visualization to Promote Distance Learning"**
Sittapong Settapat[1], Virasin Archirapatkave[2], Tiranee Achalakul[2], and Michiko Ohkura[1], [1]Shibaura Institute of Technology, [2]King Mongkut's University of Technology Thonburi Thailand

14:40-15:00 **"The Similarity Index of Medicine Names Based on Character Shape Similarity"**
Keita Nabeta[1], Takahiro Imai[1], Masaomi Kimura[1], Michiko Ohkura[1], and Fumito Tsuchiya[2], [1]Shibaura Institute of Technology, [2]International University of Health and Welfare

15:00-15:20 **"A Study on Magnesium Recycling"**
Yohei Chigira, and Seiichi Yoshikubo, Shibaura Institute of Technology

15:20-15:40 **"Technological Trends of Digital Audio Players and Business Model for Future"**
Jyunki Morimoto, Shibaura Institute of Technology

15:40-16:00 **"Recycling of RE-Ba-Cu-O Bulk Superconductors"**
Yotaro Shimpo, Shuichiro Taniguchi, Yoji Ikeda, Naoki Koshizuka, and Masato Murakami, Shibaura Institute of Technology

16:00-16:20 **"New Carbon Material for Higher Rating of Electric Double Layer Capacitor"**
Zulkarnain Bin Ahmad Noorden, Shibaura Institute of Technology.

16:20-16:40 **"Model-Based Design for Service Robot System Development: A Contribution to Society"**
Mohd. Azizi Abdul Rahman, Akira Yasuda, and Makoto Mizukawa, Shibaura Institute of Technology

16:40-17:00 **"Studies on the Age Determination of Architectural Remains"**
Hoko Miwa, Shibaura Institute of Technology

OS 01: Energy and Environment

OS 02: Information and Communication Technology

OS 03: Architecture, Urban Planning and Design

OS 04: Bioscience and Engineering

OS 05: Robotics and Mechanical Engineering

OS 06: Material Science

OS 08: Chemical Engineering

OS 10: Transportation Engineering

OS 12: Electrical Engineering

OS 14: Textile Engineering

Analysis of Water Supply and Sanitation Infrastructure Condition in Relation to the Water Pollution Level (Case Study: Bandung City)

Tresna Dermawan Kunaefi[1], Dwina Roosmini[1*], Herto Dwi Ariesyady[1*], and Nindia Karlina[2]

[1]Environmental Management Technology Research Group, Faculty of Civil and Environmental Engineering, Institut Teknologi Bandung, Bandung, Indonesia.

[2] Department of Environmental Engineering, Faculty of Civil and Environmental Engineering, Institut Teknologi Bandung, Bandung, Indonesia

*Corresponding author: Email: droosmini@bdg.centrin.net.id and herto@ftsl.itb.ac.id

ABSTRACT

Water supply and domestic wastewater infrastructures such as clean water supply, toilet, and wastewater disposal facilities are significantly required especially in the urban environment. Availability of clean water supply and appropriate sanitation facilities would influence environmental pollution level. Bandung City as one of the big city in Indonesia still meets the lack of these facilities. This study was aimed to describe the relation of water supply and sanitation facilities accessibility rate of Bandung citizen to the extent of water deterioration level in the area. Water source mostly used were tap water, hand pump well, and dug well. The tap water is a water source having the lowest pollution level compared to other water sources. Generally, the accessibility rate of water supply, toilet, and wastewater disposal facilities were relatively adequate, with the percentages for water supply, toilet, and wastewater disposal facility were 78.21%, 67.08%, and 64.08%, respectively. Meanwhile, the percentages of infrastructure that have fulfilled the technical and health criteria was also relatively adequate with the percentages of 69.43%, 82.24% , and 84.83% for clean water supply, toilet, and wastewater disposal facility, respectively. However, there are still some districts having less water supply and sanitation accessibility level as compared to other districts, i.e. Cinambo, Buahbatu, and Bojongloa Kidul districts. This could be related to the social and economic factors. The water supply and domestic wastewater sanitation infrastructures that supposed to have adequate number in Bandung City, has not perform important contribution towards pollution level reduction in Citarum River due to poor wastewater management practices such as direct wastewater disposal to the river body by the communities.

Keywords: clean water supply, toilet, wastewater disposal facility, pollution level

1. INTRODUCTION

Water supply and sanitation are the two most important and essential in domestic activities. The term of sanitation refers to the sanitation services and facilities of safe human defecation. Access to clean water and sanitation has always been to become one of the essential requirements that must be provided at the place of human habitation. Nevertheless, protecting precious water resources and the impact of pathogens from household waste that is harmful to health are often ignored. Sanitation

is primarily used for intervention the cycle of pathogens in order not to enter into the human body and keep the environmental sustainability (Jones and Silva, 2009).

In the World Summit on Sustainable Development, Johannesburg, September 2002, it has been declared the Millennium Development Goals (MDGs), which contain one of the agenda related to water supply and sanitation sectors. One of the goals was that at least half the population have gained access to clean water supply and sanitation facilities. Meanwhile, until the year 2000, the Indonesian population that has access to basic safe sanitation; toilets equipped with latrines or septic tanks, only reached 50.35% of the population, so that the remaining 49.65% did not obtain proper sanitation facilities. Citizens' access to waste water infrastructure basically deals with aspects of health, environment, education and poverty (Abeysuriya et al., 2007).

In the handling of sanitation, not only hygiene factor must be considered but also problems of environmental pollution caused by domestic wastewater itself. Level of pollution caused by domestic wastewater can cause contamination of clean water supply access, which is consumed by the public. A great number of pollution level often found in the water bodies of urban areas with high population density. The problem is how to reduce pollution levels or at least maintain the existing water pollution condition in order not to become higher polluted, and the more important is to prevent the spread of waterborne diseases (diseases transmitted through water) to protect the public from health problems (Avvannavar et al., 2008).

Bandung as one of the growing cities in Indonesia with a total population in 2008 of 2.4 million has issues of water supply and sanitation infrastructure. The data obtained from Bandung City Health Department from 2007 until the year 2009 showed that the accessibility of water supply and sanitation in the city of Bandung increased slightly responding the increase of the population density. In addition, the accessibility of water supply and adequate sanitation in Bandung City was not so evenly distributed to each district. There were some areas that have less percentage of water supply and sanitation accessibility level and dispose the wastewater directly into water bodies. It may result in the number of polluted rivers that are contributed towards the heavy pollution in Citarum River Basin with "D" status; heavily polluted status (Tjokronegoro, 2010).

Therefore, it could be mentioned that the problems of water supply and sanitation infrastructure such as in Bandung City, still require special attention and priority. By improving the quality of infrastructures, there are direct and indirect benefits that could be gained. Improving water supply and sanitation infrastructure will have a direct impact on improving public health, reducing water pollution, and indirectly stimulating macroeconomic growth in an area. From these things, combined with good pollution control, would stimulate sustainable development in an area (Warner, 1984). The analysis on the availability of water supply and sanitation infrastructures influences to the extent of water pollution reduction is indeed should be performed to evaluate and monitor the performances of wastewater management practices in this area.

2. MATERIALS AND METHODS

The purpose of this study was to evaluate the existing condition of water supply and domestic wastewater infrastructure in Bandung City and associate it to the actual water pollution. The methodology used in this study is shown in **Figure 1**.

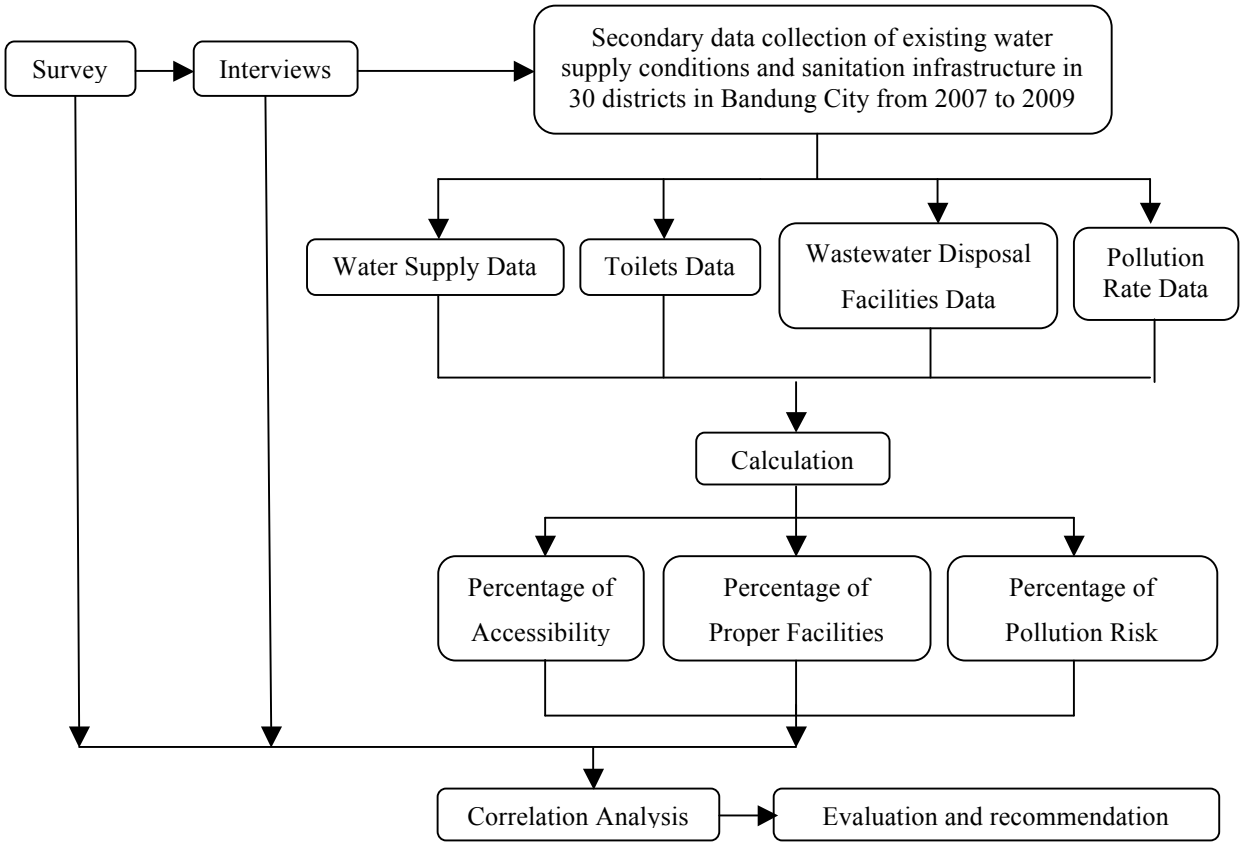


Figure 1. Methodology flow chart diagram

Field Survey

This field survey was intended to directly grasp the existing condition of water supply and sanitation infrastructure in Bandung City. In addition, the survey also aimed to observe the procedures and practices of collecting and recording the sanitation data conducted by sanitarian.

Interviews

Interviews were conducted to obtain additional information about water supply and sanitation conditions of Bandung City. Interviews were directed to the sanitarian, staff of Environmental Health Division of Health Department, and staff of Regional Water Company (PDAM) of Bandung City.

Secondary Data Collection

The collected data were water supply, toilet, and wastewater disposal facilities (SPAL) data in 30 districts in Bandung City from 2007 to 2009. This data were obtained from the Health Department and Regional Water Company (PDAM) of Bandung City. Data collected included water supply pollution level; low, medium, high, and very high pollution levels. These data were needed to determine the quality and quantity of water supply and domestic wastewater infrastructure in Bandung City.

Calculation

The data that has been collected were then subsequently calculated and analyzed. The calculation was performed to determine the level of accessibility of water supply and domestic wastewater sanitation facilities, the percentage of proper facilities, and the percentage of pollution risk levels.

Correlation Analysis

Correlation analysis was conducted to understand the relationship between water supply and sanitation infrastructure and water pollution level in some rivers in Bandung City which are tributaries of Citarum River. This correlation analysis was performed after evaluating the existing condition of water supply and sanitation infrastructures.

3. RESULTS AND DISCUSSION

Condition of Water Supply Infrastructure in Bandung City

The accessibility rate of water supply infrastructure in Bandung City was adequate enough, that was more than 75% had access to clean water supply facilities. In 2007, the access to clean water supply in Bandung City was 74.61%, and then increased to 78.08% in 2008. Small increase was then noted in 2009 to the percentage of 78.21%. From these data, it could be assumed that there have been some efforts conducted by relevant institution to improve the accessibility rate of society towards clean water supply facilities, such as by implementing monitoring and counseling to the public. Based on the calculation for each district, the accessibility of water supply facilities has been quite evenly distributed to all districts. Almost all regions had access to clean water supply facilities in more than 50%. There was only one area that still has access below 50% i.e. Bojongloa Kidul district by 41.04%. The accessibility of water supply facilities in 30 districts in Bandung can be seen in **Figure 2**.

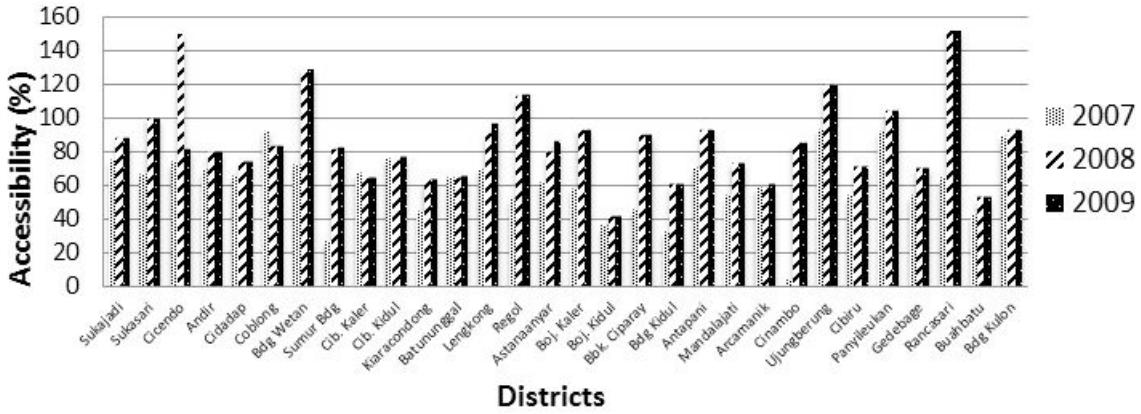


Figure 2. Percentage of accessibility rate of water supply facilities in Bandung City, 2007-2009

Water supply accessibility rate in Bandung City was 75% in average, in which 73.86% (2008) and 69.43% (2009) of them have met the requirements of water supply facility criteria. These percentages indicated that more than 50% of the society already had access to suitable clean water supply. However, the percentage of accessibility rate of proper water supply facilities in Bandung has not been equitable for all

districts. There were three districts which have less percentage of qualified water supply accessibility rate, i.e. Panyileukan, Cinambo, and Buahbatu District by 30.56%, 36.60%, and 37.25%, respectively. These small percentages of proper water supply facilities could be affected by a small amount of toilet and wastewater disposal facilities accessibility. Unhealthy sanitation of toilet and wastewater disposal facilities could pollute the water sources of society. Based on data obtained from Bandung Health Department, it was found that Cinambo District and Buahbatu District have small percentage of toilet facilities (**Figure 5**) and wastewater disposal facilities (**Figure 6**) accessibility rate. Thus, it could be mentioned that good and healthy water supply facilities is closely related to the availability of good and healthy toilet and wastewater disposal facilities too (Jowitt, 2009).

In **Figure 2**, it could be noticed that there were some of the accessibility rates with more than 100%. These numbers were resulted because some families have two or more water supply facilities. There are several water supply facilities used by the people in Bandung, such as tap water, hand pump well, dug well, rain water collecting storage, packaging, and others. Most of the communities in Bandung City (about 44%) use tap water as clean water source. There was no significant change of water supply facilities number from 2008 to 2009 (Health Department of Bandung City, 2009). Tap water gives better water quality compared with others because it is accessed from the Regional Water Company (PDAM) through piping system. Besides tap water, hand pump well and dug well are the second and third of most widely water supply facilities used in the society, as shown in **Figure 3**.

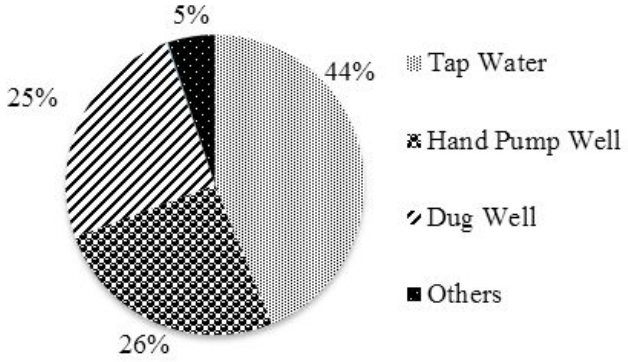


Figure 3. Water supply facilities in Bandung City, 2009

Water supply facilities are risked from water pollution. Based on data obtained, the tap water was the water supply facility that has lowest level of pollution risk. This is because the tap water is accessed through the piping system that could reduce pollution better compared to hand pump well and dug well which are non-piping system. Besides, the tap water is provided by Regional Water Company (PDAM) which has been treated by water treatment process. Percentage level of pollution risk of water supply facilities can be seen in **Figure 4**.

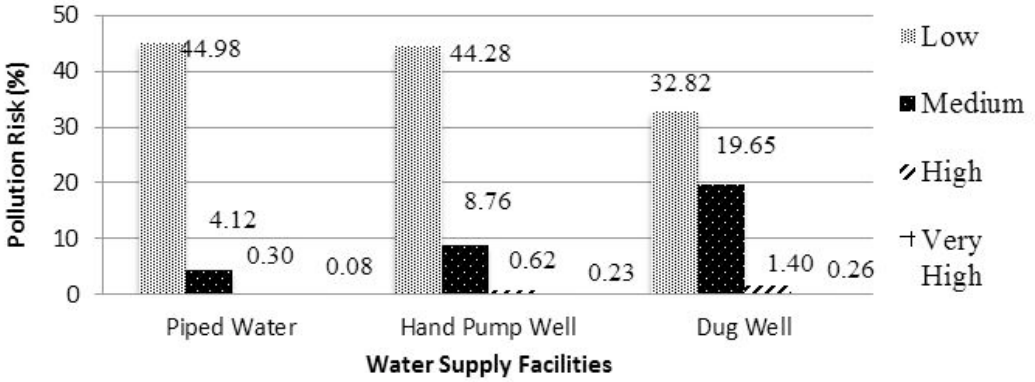


Figure 4. Percentage of pollution risk of water supply facilities

Condition of Toilet Infrastructure in Bandung City

Toilet is a human defecation facility constructed to avoid direct contact between waste itself with human, animals and insects. Besides preventing unpleasant odor, one of the most important requirements for a healthy and good toilet is that the toilet does not cause water sources and surface soil pollution around the toilet (Avvannavar, 2008).

Based on data analysis, it was found that approximately 60% of Bandung City community had toilet in their household. In 2007, 60.01% of the population had toilet facility, afterward improved to 66.11% and 67.08% in 2008 and 2009, respectively. In general, the accessibility rate of toilet facilities in Bandung City has been spread in 30 districts with the rate of almost above 50%. **Figure 5** shows the percentage of toilet facility accessibility rate in Bandung City.

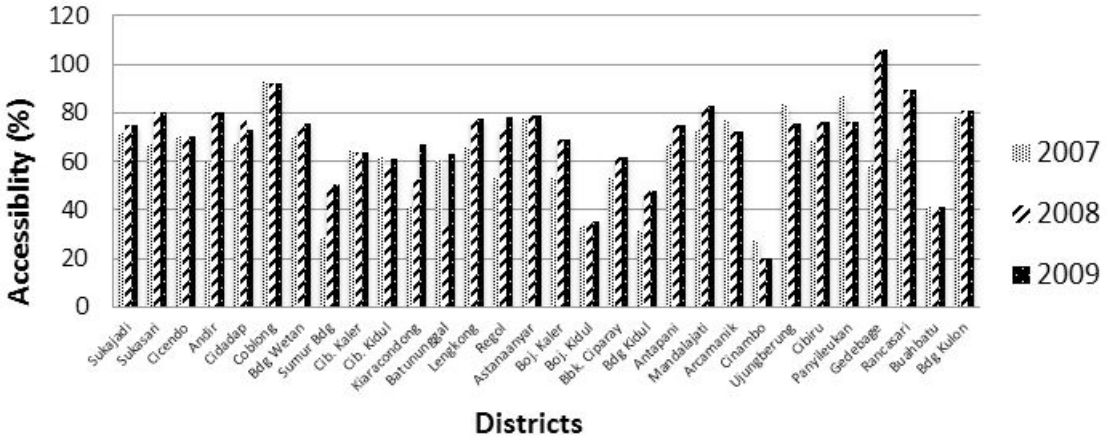


Figure 5. Percentage of accessibility rate of toilet facility in Bandung City, 2007-2009

There were three districts which have smaller percentages compared with other regions, i.e. Cinambo, Bojongloa Kidul, and Buahbatu District by 20.24%, 35.6%, and 41.29%, respectively. This small percentage of toilet accessibility rate could be caused by low level of education, economy factors, and awareness of the community on the importance of toilet facility. For those who does not have toilet, they frequently use public toilet or defecate directly on water bodies leading to water pollution. It could be noticed from the Cinambo District and Buahbatu District which have a relatively small number of toilet facility, they have the smallest percentage of qualified water supply as well. Therefore it could be mentioned that the access to

healthy and good toilet facility has considerable influence on access to clean water supply that is used by the society (Jowitt et al., 2009).

Of the approximately 60% of Bandung community with a toilet facility, 82.24% of them have toilet that have met the requirements. The proper toilet facility percentage was increased during 2007 and 2009 by the percentages of 78.29%, 82.21%, and 82.24% in 2007, 2008, and 2009, respectively. There were approximately 32.92% of people who do not have toilet facilities. This means that numerous number of the population still defecate directly into rivers or water bodies. Society that defecate directly into water bodies are often found in slums with underdeveloped economies and low education level (Warner, 1984). However it is very unfortunate that these problems do not have accurate qualitative and quantitative data, while these data are needed as indicators of environmental pollution.

Good toilets are equipped with storage and treatment facilities (Dep. of Public Works, 2005). Some of them are on-site system, e.g. latrine and septic tank, and off-site system, such as conventional sewerage, shallow sewer, and small-bore sewer. The approximate number of wastewater treatment facilities in Bandung City is shown in **Table 1**.

Table 1. Wastewater treatment facilities in Bandung City (PDAM Bandung City, 2009)

Treatment Facilities	Total (Unit)
Off-site system (house connection)	98,654
Individual Septic Tank	200,000
Communal Septic Tank	34

Therefore it could be estimated that 60% of Bandung society have wastewater treatment facilities, while others are estimated to defecate directly into water bodies. However, the types of wastewater treatment facilities data should be collected accurately, whether latrine, septic tank, sewage systems, and others. It aims to determine the level of public access to adequate waste treatment facilities and pollution levels.

Condition of Wastewater Disposal Facility Infrastructure in Bandung City

Wastewater disposal facility is a channel flowing wastewater and then absorbed it into the absorption well or flowed to off-site treatment piping system. The accessibility rate of wastewater disposal facility in Bandung was more than 60%. In 2007, the accessibility of wastewater disposal facility was about 57.80%, and then increased to 63.68% and 64.08% in 2008 and 2009, respectively. The percentage of accessibility rate of wastewater disposal facility in Bandung City is shown in **Figure 6**.

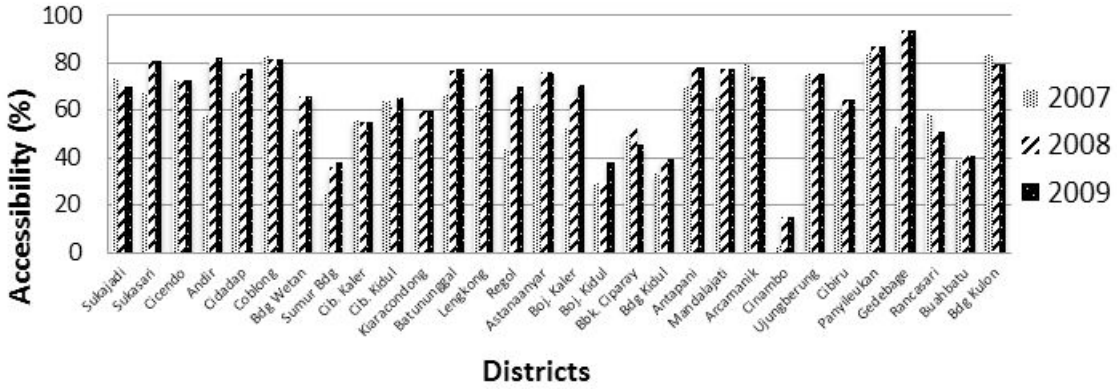
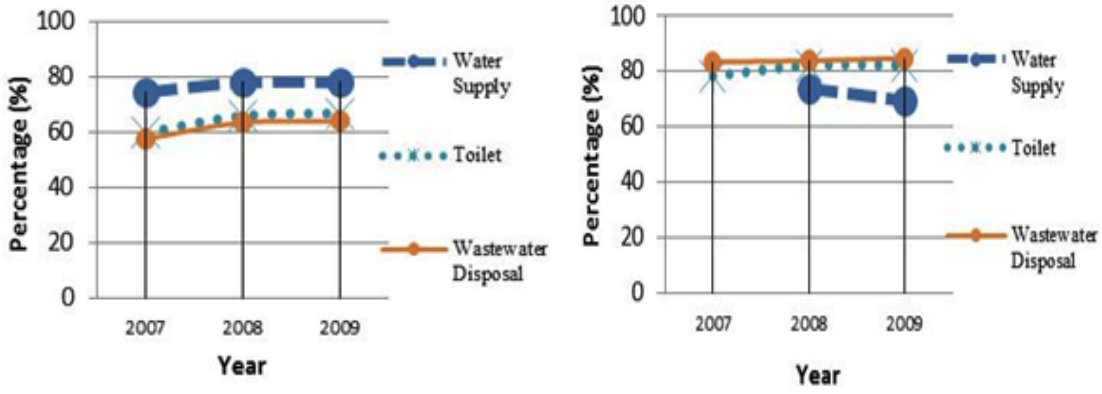


Figure 6. Percentage of accessibility rate of wastewater disposal facility in Bandung City, 2007-2009

There were five districts that have accessibility rate percentage below 50%. The districts were Cinambo, Bojongloa Kidul, Sumur Bandung, Bandung Kidul, and Buahbatu District by 15.28%, 38.18%, 38.18%, 39.24%, and 40.96%, respectively. Of this 60% of the wastewater disposal facility, 84.83% of them were accepted and met the requirements. Some of accepted criteria of wastewater disposal facility are: it does not pollute water sources with a minimum distance of 10 meters from water sources, it does not result in puddle of water, it does not have an unpleasant smell, it is closed, and it has infiltration medium into the soil (Dep. Public Works, 2005). However, based on the field survey and interviews with the sanitarian, the criteria applied for the evaluation of wastewater disposal facility to be categorized as a proper facility were just: closed, no odor, and no puddles. According to the sanitarian, if all the criteria used for the evaluation of wastewater disposal facility, then the number of proper wastewater disposal facility was just about 1-5%. Due to lack of land availability, some of the wastewater is flowed to the sewerage channel flowing to Bojongsoang Wastewater Treatment Plant (WWTP). However, there were some sewerage systems that flow the wastewater directly into water bodies and generate water pollution. However, the comprehensive data on this problem has not been available readily.

Correlation Analysis between Access to Domestic Wastewater Infrastructure Facilities and Water Pollution Level in Citarum River

Ideally, the appropriate general development must include the development of water supply and domestic wastewater infrastructure in a proper number and quality. Water supply and sanitation infrastructure in Bandung City in 2007-2009 has generally tended to increase (**Figure 7**). However, there was a slight decrease of the accessibility of proper water supply facilities of 4.43% (**Figure 8**). This condition was occurred because of accessible water source limitation due to significant water pollution in Bandung City area from domestic and industrial activities.



In terms of number, there has been an increase of water supply and domestic wastewater infrastructure in Bandung City. However, this infrastructure improvement has not been followed by appropriate wastewater treatment management. This fact was indicated by the presence of several polluted rivers in Bandung City, such as Cikapundung River, Citepus River, Cisangkuy River, Cibeureum River, and others which are tributaries of Citarum River. Heavy pollution that occurred in the Citarum River with "D" status (heavy polluted) mainly originated from domestic wastewater of Bandung City community activities (Tjokronegoro, 2010). Of the four regions of Bandung city, namely North Bandung, East Bandung, West Bandung, Central/South Bandung, only East Bandung, Central/South Bandung, and parts of North Bandung regions that have been served by sewerage system and flowed their domestic wastewater to Bojongsoang Wastewater Treatment Plant. Meanwhile, West Bandung which consists of five districts had a sewerage pipeline system, but the wastewater itself has not been treated in wastewater treatment plant but flowed directly into water bodies, namely Citepus River. The scheme of off-site wastewater management system in Bandung City is shown in **Figure 9**.

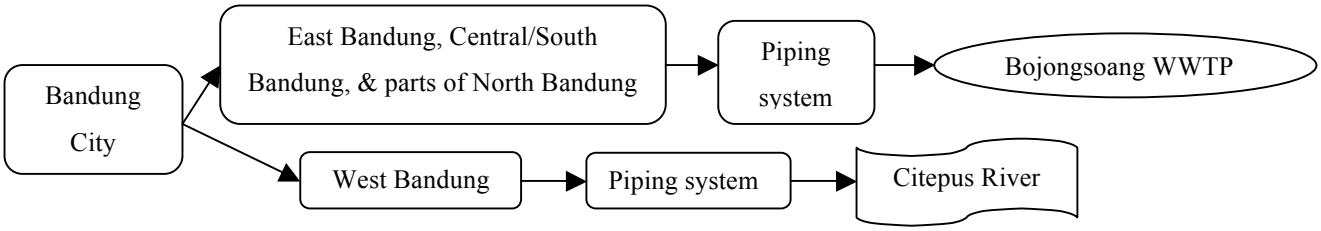


Figure 9. Scheme of off-site wastewater management system in Bandung City

This problem is worsened by the lack of community awareness that many of them still disposed wastewater directly into the rivers. Disposal or defecation of excreta was acted directly over the trench that connects to the river or through the toilet that is connected to the piping system. This condition could affect the water supply facilities that are used by the population which may cause human health hazard. As the result, the water pollution in Bandung City increased the organic concentration (represented by BOD and COD values) in the Citarum River which have exceeded threshold values (Tjokronegoro, 2010). The water quality of Citarum River is shown in **Table 2**.

Table 2. Water quality of Citarum River, 2009
(PDAM Bandung City, 2009)

Parameter	Up Stream	Down Stream
pH	6.77	6.79
Dissolved Oxygen (mg/L)	2.32	3.25

BOD (mg/L)	110	90
COD (mg/L)	135	125
Fecal Coliform (colony/100 mL)	177×10^5	7.5×10^7

Based on the water quality data of Citarum River, it can be seen that the values of BOD, COD, and fecal coliform have exceeded threshold value regulated in government regulation no. 82/2001. The threshold limited value of BOD, COD, and fecal coliform are 3 mg/L, 25 mg/L, and 5,000 colony/100mL, respectively. In this case, the domestic wastewater of Bandung City was the main contributor to the heavily pollution of Citarum River (Tjokronegoro, 2010). Domestic activities including in Bandung City contributed for about 55% of all water pollution loading in Citarum River.

Based on findings explained above, it can be concluded that the adequate and good infrastructure in Bandung City could not solve the pollution problems in water bodies because wastewater treatment management practices were inadequate. Therefore, the quality and quantity improvement of infrastructure condition must be in parallel with appropriate wastewater treatment management in order to reduce the pollution level in water bodies in Citarum River Basin.

4. CONCLUSION

The conclusions are drawn as follows:

- Access to water supply, toilet, and wastewater disposal facilities in Bandung City was relatively good, however, the quality of these water supply and sanitation facilities were still inadequate in some districts.
- The accessibility rate of sanitation facility in parallel with community awareness must be increased in order to avoid the defecation directly into water bodies to reduce the water pollution.
- The improvement of sanitation data collection and evaluation system is indeed required to figure out the accurate and actual health status.
- Recent development of water supply and domestic wastewater infrastructure in Bandung City has not provide big contribution towards pollution rate reduction in Citarum River because this development seemed not to be followed with proper wastewater treatment management practices.

5. REFERENCES

Abeysuriya, Kumudini, Mitchell, Chynthia, & White, Stuart. (2007). Can Corporate Social Responsibility Resolve the Sanitation Question in Developing Asian Countries?. Australia: University of Technology Sydney. Ecological Economics, 62: 174-183.

Avvannavar, Santosh, M. & Mani, Monto. (2008). A Conceptual Model of People's Approach to Sanitation. India: Indian Institute of Science. Science of the Total Environment, 390: 1-12.

Department of Public Works. (2005). National Action Plan Study of Water Supply and Wastewater Sector.

Health Department of Bandung City. (2009). Report of Environmental Health and Disease Control of Bandung City.

Jones, S.A. & Silva, C. (2009). A Practical Method to Evaluate the Sustainability of Rural Water and Sanitation Infrastructure Systems in Developing Countries. United States: Lafayette College. Desalination, 248: 500-509.

Jowitt, Paul, W. (2009). Water Infrastructure, the UN MDGs and Sustainable Development. United Kingdom: School of the Built Environment, Heriot Watt University. Desalination, 248: 510-516.

PDAM Kota Bandung. (2009). Final Report Corporate Plan PDAM Kota Bandung.

Tjokronegoro, Mahastuti, H. (2010). Kontribusi Pemanfaatan Lahan di Kawasan DAS Citarum Hulu terhadap Pencemaran Air. Master Theses. Environmental Engineering Department, Institut Teknologi Bandung, Bandung

Warner, D.B., (1984). Rural Water-Supply and Sanitation Planning: The Use of Socioeconomic Preconditions in Project Identification. In: G.E. Stout and G.H. Davis (Editors), Global Water: Science and Engineering - The Ven Te Chow Memorial. 68: 443-459.