FINAL PROJECT – RC14-1501

IMPROVING SURABAYA RIVER WATER QUALITY BY OBSERVING HYDROLOGICAL SYSTEM INCLUDING POLLUTANT SOURCES AND OPTIMIZING MONITORING SYSTEM

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TUGAS AKHIR-RC14-1501

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SURABAYA, JULI 2017

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PENINGKATAN KUALITAS AIR SUNGAI SURABAYA DENGAN MENINJAU SISTEM HIDROLOGI TERMASUK SUMBER POLUTAN DAN OPTIMALISASI SISTEM MONITORING

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Abstrak

Daerah Aliran Sungai (DAS) Brantas sebagai DAS terbesar kedua di Provinsi Jawa Timur secara perlahan terkontaminasi oleh air buangan dampak dari pembangunan di Pulau Jawa, Indonesia. Sungai Surabaya, sebagai salah satu cabangnya, pada hakikatnya mengalir sepanjang beberapa kabupaten dan kota menuju Laut Jawa digunakan oleh masyarakat untuk kebutuhan sehari-hari termasuk sebagai air minum. Namun, banyaknya polutan yang masuk mencemari Sungai Surabaya menyebabkan kualitas air Sungai Surabaya menjadi buruk. Selain itu, pemerintah masih menitik-beratkan pada kuantitas seperti kontrol banjir, namun kualitas dan sistem monitoring sebagai salah satu aspek terpenting untuk memberikan informasi kepada masyarakat dan institusi masih belum dikontrol sepenuhnya.

Tujuan tugas akhir ini adalah memfokuskan area-area yang berpotensial membuang air limbahan terhadap Sungai Surabaya dalam rangka untuk memberikan rekomendasi dalam optimalisasi sistem monitoring. Pada tahap awal dilakukan tinjauan pustaka untuk mendapatkan pengetahuan awal dan kemudian dilakukan wawancara dengan ahli. Data sekunder kemudian digunakan untuk melakukan studi ini dan perhitungan *air buangan dilakukan dalam rangka untuk mengestimasi area yang berpotensi membuang air limbahan. Evaluasi monitoring dan beberapa rekomendasi dibuat dengan tujuan memperbaiki kualitas air Sungai Surabaya.*

Berdasarkan perhitungan air buangan, ditemukan bahwa lebih dari 60 desa yang terletak sepanjang Sungai Surabaya berdampak kepada kualitas air sungai karena membuang air limbah domestik dengan atau tanpa pengelohan air limbah, seperti fasilitas sanitasi, menuju Sungai Surabaya. Diestimasikan air buangan yang masuk dapat mencapai 15207.20 m^3/day, dengan beban BOD dari air limbah domestik dapat mencapai 7749.34 kg/day dan konsentrasi BOD rata-rata adalah 482.97 mg/L. Data sekunder dari Balai Besar Wilayah Sungai Brantas menunjang status air Sungai Surabaya sebagai air tercemar dengan membuktikan bahwa 6 dari 12 parameter yang dikontrol, termasuk parameter kimia dan parameter fisika, tidak memenuhi standar sebagai air kelas II sebagaimana telah ditetapkan oleh pemerintah. Data dari Program Penilaian Peringkat Kinerja perusahaan (PROPER) oleh Kementrian Lingkungan Hidup juga menunjukan bahwa setidaknya 16 industri melebihi kapasitas air limbah buangan yang diizinkan. Dengan bantuan Google Earth, dapat dilihat bahwa lokasi monitoring yang ada tidak sepenuhnya mengontrol area dan industry yang mencemari Sungai Surabaya sementara waktu yang dilakukan untuk memonitor Sungai Surabaya sangat kurang. Berdasarkan analisa diatas yang telah dilakukan, beberapa rekomendasi dibuat untuk optimalisasi sistem monitoring dengan harapan dapat memperbaiki kualitas sungai air Surabaya. Solusi dari tugas akhir ini adalah menambah lokasi-lokasi berpotensi untuk dimonitor, pemakaian data logger, melakukan biomonitoring, dan penelitian lebih dalam untuk kemungkinan pengaplikasian sensor kualitas air kreatif.

Keywords: Sungai Surabaya, Sistem Monitoring, Kualitas Air, Manajemen Air, Optimalisasi

IMPROVING SURABAYA RIVER WATER QUALITY BY OBSERVING HYDROLOGICAL SYSTEM INCLUDING POLLUTANT SOURCES AND OPTIMIZING MONITORING SYSTEM

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Abstract

Brantas River Basin as the second basin in East Java Province eventually contaminated by the wastewater as one of the impacts of development in Java Island, Indonesia. Surabaya River, as one of the sub-branches, flowing along some districts and cities toward the Java Sea that is being utilized by the community for daily needed including drinking water. On the other hand, more pollutants are flowing into Surabaya River, lead its quality becomes poor. Monitoring system has an important role to give information for the users and the government as a first step in order to make an integration and improvement over both the quality and the quantity. While the institution focus on quantity such as flood control, its quality has not been fully controlled yet, and monitoring stay behind.

The purpose of this study is focusing on which areas are potentially flows excessing wastewater in order to conduct recommendation on optimizing the monitoring system in Surabaya River. A literature review was performed in order to obtain preliminary knowledge, and interview with experts were then conducted. Secondary data is used during this study, and analysis of wastewater is conducted in order to estimate which area(s) potentially dispose the wastewater. Evaluation of *monitoring and some solutions are undergone in order to improve the quality of Surabaya River.*

Based on wastewater discharge calculation, it is found that more than 60 villages located along Surabaya River affected the quality by disposing the domestic water to Surabaya River, with and without wastewater treatment first such as sanitation facilities. It can be estimated that domestic waste flows to Surabaya River approximately 15207.20 m^3/day, with estimation BOD loads from domestic wastewater up to 7749.34 kg/day and the average BOD concentration from domestic wastewater is 482.97 mg/L. Secondary data from Basin Authority of Brantas River in 2015 support the state of poor quality in Surabaya River by showing 6 of 12 measured parameters, including physical and chemical parameters, do not achieve the standard to be stated as the second class, as it stipulated by the government. Data from National Evaluation on Environmental Management (PROPER) by Ministry of Environment also shows that at least 16 industries excessing the allowed capacity of industrial wastewater. Based on observation at monitoring location(s) by using Google Earth, the existing location(s) are not fully controlling the villages and industries while the frequency of monitoring the quality is very limited. Based on SWOT analysis, some solutions are made in order to optimize the monitoring system that can lead to improvisation of Surabaya River water quality. These solutions include adding new potential location(s), attaching a data logger, the use of biomonitoring, and creative water quality sensor.

Keywords: Surabaya River, Monitoring System, Water Quality, Water Management, Optimization

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The author completely understands that this report still needs to be improved. The author hopes this thesis report will be useful and easily understandable for whom it may concern.

Surabaya, July 2017

The Author

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CHAPTER I
INTRODUCTION

1.1. Background

Indonesia, as the largest archipelago country in the world which strategically positioned between the Pacific and Indian oceans, consists of five biggest islands including Sumatra, Java, Borneo, Sulawesi, and Papua, and over than 17.500 small islands including Bali and Strait of Sunda. According to Indonesia census year 2010, the total population of the country is 237.641.326 with the average density of population is 124 per km^2. However, the population varies considerably from island to island, that lead to imbalance distribution of the population in each province as it shown figure 1.1. This uneven distribution of population impacts on several problems in each province, concerning on poor infrastructure as the major problem, especially water quality aspect. This also impacts on the quality of education in which less equal in some areas. As its consequence, this leads to lack of awareness from the community about environmental aspect as the most important thing to be maintained.

Figure 1. 1 Indonesia Distribution of Population

Java Island, as it stated as the most populous island in Indonesia, is also being influenced by the impact of this inequity of distribution. As its result, the quality of the water in Java Island has been deteriorated by urban development. One of the basin that is being the major concern from the government is Brantas River Basin.

According to Ministry of Public Works, it is explained that Brantas River Basin is the second biggest basin in Java Island, located in East Java Province, Indonesia. Its Brantas River has total length which is approximately 320 km and the basin area is around 14.103 km^2, covering 25% of East Java province area. Water resources in Brantas River Basin are an important aspect for people needs, from and for human civilization, and without any water resources development, the fulfillment of human needs has not reached a satisfying condition.

Several sub-branches of Brantas River itself are flowing across few cities and some districts. One of the sub-branches that has a significant role in population needs is Surabaya River. While people use the water to be processed for many needs such as drinking water, it is argued that the development should be concerned in Surabaya River due to its poor quality. The governor of East Java province states that the quality of the water in Surabaya River did not the standard criteria as it arranged by Government Regulation No. 82 Year 2001. While the development of industries and a fast population growth have contaminated the quality during the time, the priorioty from the responsible institution itself still remains flood control. In addition, the control of the quality of water and the monitoring system stay behind.

Figure 1. 2 Surabaya River

According to Living Environemntal of Ketapang District (2005), it is stated that monitoring system intends to inform the factual data about current condition on water quality in Brantas River Basin, tendencies and dependencies on the past and environmental changes prediction in the future, and moreover its information can be used as a reference for designing, evaluating, and controlling environmental surveillance, policymaking on management of the environment and legislation regulation. It can be concluded that monitoring system is the first and the most necessary role that needed to be improved before it leads to the improvement and the restoration of Surabaya River itself.

This research project is a follow-through of the research in which the author wants to focus on evaluating and optimizing the monitoring system in Surabaya River. In order to develop this research subject, the author will have some literature review and study case will be planned. The aim is to give a conclusion and recommendation to optimize monitoring system in Surabaya River of East Java, Indonesia.

1.2. Research Question

The main research question is concluded based on the quality of water and monitoring system in Brantas River, especially Surabaya, that have been explained above. Research sub-questions are arranged to understand and answer the main question. Both the main and sub-questions will be explained below.

Main Question

"How to improve Surabaya River water quality by observing hydrological system including pollutant sources and optimizing monitoring system in Indonesia?"

Sub-Questions:

- ***What is water monitoring system?***
- Literature review and explanation about water monitoring system (conceptual background)
- ***How does the water monitoring system work in Surabaya River of East Java, Indonesia?***
- Find the data about the current performance of water monitoring system (how it works, how many stations, etc) in Surabaya River of East Java
- ***What is the main problem of water quality monitoring system in Surabaya River of East Java, Indonesia?***
- Identify the main problem of water quality monitoring system in Surabaya River of East Java, Indonesia. This can be based on literature review and interview with some responsible stakeholders of Surabaya River
- ***How is the condition of water quality in Surabaya River of East Java, Indonesia?***
- Analyze the existing condition of Surabaya River
- ***Has the existing water quality monitoring system in Surabaya River been well optimized to control the quality of its water?***
- Study case by hydrological analysis and water quality modeling compare with existing points or station that has been established. Is there any missing point to control the pollutant? Are the existing stations sufficient enough with governance law? Does it need any additional stations?

- ***What is the best solution to optimize the water quality monitoring system in Surabaya River of East Java, Indonesia by approaching the most sustainable system that has been used in some other countries?***

- Approaching some countries as a reference to optimize the water quality monitoring system in Surabaya River of East Java, Indonesia. In this case, the author chooses Netherlands as the referenced country.

1.3. Research Objective

Giving information about current water quality monitoring system in Brantas River, analyzing and evaluating the main problem of water quality monitoring system in Surabaya River, and recommending solution that can be adapted by the existing condition referenced to Netherlands.

1.4. Scope of Work

In this research, the author made some limitations and scopes to keep the concern on the main topic. These would make sure the research can be well conducted. Below are the limitations and scope of this research:

a. The period of this research is 3 months, start from 13 February 2017 until 29 May 2017
b. This research is based on the real project of Brantas River Basin of East Java, Indonesia
c. This thesis project focuses on Surabaya River Basin of East Java, Indonesia
d. The location of data analysis is in Surabaya River of East Java, Indonesia
e. The author will only analyze the monitoring system in Surabaya River
f. The author will not consider the methods of implementation
g. The author will not consider any sediment transportation that occurs in Surabaya River Basin

h. The author will not consider the impact of economic and social life
i. Any uncompleted data will be assumed and or ignored during this research

CHAPTER 2
LITERATURE REVIEW

2.1. Brantas River

Brantas River is the second longest river after Bengawan Solo River in Java Island, Indonesia. The water source is located in Sumber Brantas Village, Batu, flowing to Malang, Blitar, Tulungagung, Kediri, Nganjuk, Jombang, and Mojokerto. In Mojokerto, Brantas River split into two branches, Surabaya River (flowing into Surabaya) and Porong River (flowing into Porong, Sidoarjo District). (PUPR, 2005)

Brantas River Basin is a national strategic basin, authorized by the Central Government (*Pemerintah Pusat)*, under the regulation of Ministry of Public Works (*PerMen PU)* number 11A Year 2006 on River Basin Establishment and Criteria. The area of Brantas River Basin is 14.013 km^2, crossing through 9 districts and 6 cities, or similar with 26.5% of total area of East Java Province, Indonesia. The river length is 320 km, flowing accross an active volcano, Mount Kelud. In 2005, the population of Brantas River Basin is 15.844, approximately 43% of total population in East Java Province, with population density 1272 per km^2. (PUPR, 2005)

The average rainfall intensity in Brantas River reached 2000 mm per year, with 85% of the total rainfall intensity falls in rainy season. The average surface water potential is 12 billion m^3 per year, but the available dams can only utilize around 2.6 – 3 billion m^3 per year. Brantas River has a really important role on supporting East Java Province as the national supplier of foods and needs, (PUPR, 2005)

Figure 2. 1 Administrative map of Brantas River Basin
(Source: Ministry of Public Works)

2.2. Surabaya River

Surabaya River is the branch of Brantas River, flowing from Mlirip Floodgate into East-Sea, crossing Brantas delta and disembogue on Jagir Floodgate, Wonokromo area, Surabaya City. The total length of Surabaya River from Mlirip Dam into Jagir Dam is 41 km. The main function of Surabaya River is the main raw material for drinking water, irrigation, raw material for industrial water, and main water resources in Surabaya. For instance, Surabaya PDAM and Sidoarjo PDAM as the local drinking water company are the institution that takes benefit from the natural water from Surabaya River (PUPR, 2005).

Basin Authority in Brantas River (BBWS) stated that in Jagir Dam the River split into 2 sub-branches: Mas River and Wonokromo River in which both of them downstream in Java Sea. There are several small rivers in which dwastewater flows and contaminated Surabaya River: Mlirip River, Marmoyo River, Lamong River, Kedondong River, Central River, Kedurus River.

The quality of Surabaya River is mostly affected by industries. In these past few years, both of the government and non-government organizations are concerning Surabaya River to be the main sources for their natural drinking water, but at the same time the quality is getting worse, indicated with a lot of dead fish, even extinction of some of fish types in Surabaya River that never been seen again in the river. These impacts encourage East Java Province Government, Non-Government Organization, and other responsible stakeholders to conduct variable events in order to improve and restore the condition of Surabaya River as it is supposed to be. (PUPR, 2005)

2.3. Hydrological System

Hydrological system is a term of entire cycle of water movement while total volume of water in the world remains constant. In addition, something that will change in the water are its quality and its availability. Research about hydrological system (Franks, 1987) stated that water is constantly moving, driven by solar energy. Evaporation is being known as the process of water heat into the sky by the sun. This process leads to cloud-form and precipitation (rainfall). Evaporation also occurs from lakes and rivers. When evaporation contributes significant quantities of the water by the plant, this process is called evapotranspiration. While 80% of precipitation falls back to the ocean, the remainder falls onto land. This water repenlishes soil and groundwater, fills the streams and lakes, and provides all the needed water. Movement of water is continuous and so water is a renewable resource.

In the terms of the total volume, 97.5% of the total water in the world is defined as saline water in which 99.99% of saline water found in the oceans. This means only 2.5% of the total volume of water is defined as non-saline, while not its availability can be found everywhere. 75% of non-saline water is locked up as ice caps and glaciers and 24% of this non-saline water is defined as groundwater. This means that less than 1% of total of freshwater is found in lake, river, and soul; only 0.01% of the non-saline water can be found in lakes and river while the rest presents as soil moisture.

2.4. Wastewater Discharge

In his book, Corcoran et al. (2010) stated that wastewater is defined as a combination of one or more of:

- Domestic effluent consisting black water (excreta, urine, and faecal sludge), and grey water (kitchen and bathing wastewater);
- Water from commercial establishment and institutions (including hospital);
- Industrial effluent, storm water, and other urban run-off;
- Agricultural, holticultural and aquaculture effluent, either dissolved or as suspended matter.

Wastewater discharge is based on freshwater consumption per person per day. The amount of freshwater turns to wastewater is estimated in range between 60% - 85%. Wastewater discharge can be accumulated by these following formulas:

Q avg = Fresh water needed per person x total population **(2.1)**

Q waste = (60% - 85%) x Q avg **(2.2)**

According to Research and Development Centre, Ministry of Public Works, potential pollution load (PBP) can be estimated with this following formula below:

PBP = Population x Emission Factor x Equivalent Ratio x $\propto$ **(2.3)**

Value for population emission factor:

- BOD = 40 gr/person/day
- COD = 55 gr/person/day
- TSS = 38 gr/day

Value for equivalent ratio:

- Urban city area = 1
- Sub-Urban area = 0.8125
- Rural area = 0.625

Alpha ($\propto$) is known as coefficient of delivery load:

$\propto$ = 1, used for area in range 0 – 100 meters from the river

$\propto$ = 0.85, used for area in range 100 – 500 meters from the river

$\propto = 0.3$, used for area in range more than 500 meters from the river

2.5. Surface Water Contamination

When a type or types of pollutant enters surface water with certain amounts that caused harmful and dangerous for aquatic life even human activities, this means that surface water has been contaminated by one or several kinds of pollutant. The major type of pollutants that caused contamination on surface water are divided into 3 types; toxic compounds, oxygen balance affecting compounds, suspended solids and mechanical pollution, and eutrophication (Akkerman, 2016). pH and temperature are some of parameters that will affect the characteristic of water.

2.5.1. Toxic Compounds

Toxic compounds are divided into 3 types: chemicals, microbes, and radioactivity.

Chemicals cause damage for humans and biological (aquatic) activity. Some common chemical toxics that might be found on surface water are metals such as lead, zinc, copper, arsene, mercury, and mineral oil. Mineral oil mainly consists of alkane carbon chains, therefore the longer the chain (up to 40 C-C), the more difficult it is degradated in nature. The brief example of mineral oil in daily activity is car petrol, which mostly consists of mineral oil and benzene, and other compounds. Some main sources of these chemicals come from industrial wastewater, sewage overflow, petrol, oil, and run-off from industrial sites or roads. (Akkerman, 2016)

Microbes are very tiny single-cell organism that can fit into eye of a needle with million amounts, including bacteria, archaea, fungi, and protest [1]. Because their existences are everywhere and they have a really unique characteristic, some of them are contaminated the quality of water as “bad microbes”.

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[1] Source available at <http://www.microbeworld.org/what-is-a-microbe>

Some of main examples that can be found on water sampling test are including *E-coli* (indicating fecal contamination), *Streptococcus faecalis* (indicating recent fecal contamination such as dogs, geese, and human poo), *Cyanobacteria,* and *Clostridium botunilum*. These microbes are usually found in stagnant water e.g. ponds and shallow lakes. These microbes are main suspects affecting human's health resulting on various kind of illness. (Akkerman, 2016)

Radioactivity refers to the particle which are emitted from nuclei as a result of nuclear instability that has neither visible nor smell, in which the nuclear isotopes are being unstable and emit some kind of radiation when the nucleus experienced some intense conflict between the two strongest forces in nature, causing varieties of radioactive decay, in which the mainly types are *alpha, beta,* and *gamma* radiation[2]. Referenced from Ghosh, D. et al (2008), it is stated that some of studies discovered a possible link between *alpha* radioactivity in water and gastric. National Academy of Science report, US EPA (1996) estimated that 89% of lung cancer caused by breathing free radon that comes from water to the indoor air and 11% of stomach cancer caused by drinking water that contains radon.

Oxygen balance affecting compound means that the compounds influence the level of dissolved oxygen in the water. Some compounds are consuming oxygen and therefore being degradated by oxidation. Some examples of oxygen balance affecting compounds are cooling water discharge, sewage discharge, dead fish or birds and leaves, and duckweeds. Oxygen level result of how much water can enter through the water/air interface, and how much food is consumed. The amount of food is related to the amount of consumed oxygen which is notaby called as Biochemical Oxygen Demand (Akkerman, 2016).

[2] Source available at <http://hyperphysics.phy-astr.gsu.edu/hbase/Nuclear/radact.html>

Biochemical Oxygen Demand, as known as BOD, is determined as general parameter to define wastewater pollution. Defining BOD from upstream into estuary is necessary in order to track pollution flow in the water. BOD is size of the amount of organic material decomposing in the water. BOD process will decrease the amount of dissolved oxygen. If the oxygen is being utilized, water condition will be septic which leads to problems of aesthetic. (Corbitt, 2004)

Chemical Oxygen Demand, as known as COD, is how much amount of oxygen in ppm or milligram per liter (mg/l) which is needed at specific condition to decompose organic particle chemically (Sugiharto, 1987). COD shows amount of needed oxygen in oxidize organic things chemically, either chemical things that can be easily or hardly decomposed (Agustiningsih, 2012).

2.5.2 Suspended Solids

Suspended solids are not dissolved compound that, under the circumstances e.g. turbulence, do not float and sedimentation does not occur. This means that these compounds are difficult to catch. The compounds are usually *lutum* or *silt* parts (nano-size sludge particles) that are electrically charged. This affect on how other contaminations such as toxics can cling and stick into these compounds. (Akkerman, 2016)

2.5.3. Eutrophication

Science research on pollution (BBC, 2014) has shown that the use of fertilizers turns to be the major problem on water when the rainwater carried it off into rivers and lakes. This results on increasing nitrate or phosphate in the water that persuade algae growth, which forms a bloom over the water surface. This caused on prevention of sunlight reaching water plants in which then they die. Hence, lake or river may inactive because the bacteria breaks down the dead plants and expend the oxygen in the water. This cases eutrophication.

Eutrophication is divided into three circumstances; oligotrophic, hypertrophic, and eutrophic. Oligotrophic signified by few nutrients, high oxygen level (>80% saturation), and complete mineralization (BOD < 3 mg/l). Meanwhile, hypertrophic seems to be the opposite of oligotrophic; excessed of nutrition, low oxygen level (0-10% saturation), no mineralization (BOD > 15 mg/l), and contents of pathogens (bacteria causing illness). Eutrophic is known in Netherlands surface water, indicated by good nutrition, day-night oxygen level (0 – 50% saturation), and limited mineralization (BOD 5 – 15 mg/l). (Akkerman, 2016)

2.5.4. PH and Temperature

When water released into the environment with some differences of the temperature, either it's higher or lower, a problem of temperature differences will appear. Water temperature related with physics, chemistry, and biological condition. Aquatic ecosystem can be disturbed as a result of temperature differences. (Corbitt, 2004 cited in Natalia, 2014 p.11)

Normal water neither has characteristic of acid nor bases, with value of acidity (pH) = 7. Water with value of acidity (pH) less than 6.5 can damage distribution pipes.

Value of acidity (pH) expresses the acid intensity or alkalinity in liquid, represent concentration of its ion hydrogen. pH can be determined easily by simplifying colorimetric clues which gives an accuracy of 0.2 unit. pH measurement is a practical necessary process, there are various of chemical and biochemical reactions occur in certain specify levels. If the measurement result representing excess level of pH compared to law standard, it can be minimized using Osmosis Reverse to produce pure water and lowering the level of pH from 7 until 6.5 or 5.0 (Mahida, 1994 cited in Natalia, 2014 p.12).

2.5. Water Quality Assessment

In his work on water technology, Gray (2010) stated that assessment of the water quality is critical for pollution control and the protection of surface and groundwater. Water quality often remains dynamic, so the quality data are needed specifically:

(a) because quality varies in space;
(b) because varies in time;
(c) because waste loads differ at different points in the system;
(d) for effluent description
(e) for setting consents, mass balance calculations, and/or river modeling

The main factors influencing the variation in quality are dilution, water temperature causing variation in biological activity and oxygen solubility, and seasonal changes in water inputs. Selection of parameters for water quality assessment is dependent on the type of receiving waters, the character and nature of the discharges into the receiving water, water use and any legal designation relating to the system. The key parameters for physicochemical of a selection of different water systems and effluents are given below:

(a) river: Biochemical Oxygen Demand (BOD), oxygen temperature, NH_3, NO_3, PO_4, Cl, etc.;
(b) lake: oxygen (at various depth), temperature (at various depth), NO_3, PO_4, SiO_s, Fe, Mn, Na, K, etc.;
(c) groundwater: Fe, Mn, NH_3, SO_4, As, F, conductivity;
(d) estuary: oxygen, temperature, BOD, suspended solids;
(e) drinking water: coliforms, Fe, Mn, toxic metals, pesticides, etc.;
(f) effluents;
    (i) biodegradable – sewage, agricultural, food processing: BOD, chemical oxygen demand (COD), suspended solids, NH_3, PO_4, etc.;

(ii) industrial – toxic: COD, BOD, suspended solids, NH_3, metals, and/or other toxic compounds;

(g) general characteristics – typing water source, hardness, alkalinity, pH, color, conductivity, Fe, Cl, Na, K, silica, SO_4, temperature, etc.

The different types of sampling programs applied in water quality assessment are defined in Table 2.1.

Table 2. 1 Different types of sampling programs

Survey	A survey is a series of intensive, standardized observations designed to measure specific parameters for a specific purpose and limited to a short sampling period
Surveillance	Surveillance is used to describe a continued program of surveys carried out systematically over a longer time to provide a series of observations relatives to control or management (e.g. national assessment of river or lake water quality)
Monitoring	Monitoring is continuous standardized surveillance undertaken to ensure that previously formulated standards are being met (e.g. assessment by industry or a regulator to ensure compliance to consent conditions)

(*Source: Gray, 2010)*

Research (Harmancioglu, et al., 1999) stated that water quality monitoring comprises all sampling activities to collect and process data on water quality for the purpose of obtaining information above the physical, biological, and chemical properties of water. Besides collecting data, monitoring activities cover the subsequent procedures, such as laboratory analysis, data processing, storage, and data analysis to produce expected information.

In some studies, two basic functions are defined for water quality monitoring: prevention and abatement. The first one has objective of maintaining the existing unpolluted or acceptable status of water quality; while the second one puts the emphasis on a control mechanism by reducing moderating pollution conditions. (Dandy and Moore, 1979; Karpuzu, et al., 1987 cited in Harmancioglu et al., 1999)

Monitoring system has an important role to define the quality status. Monitoring of the water quality can be performed in many ways depending on the reasons and the objectives of a particular monitoring programme, such as identification of state (concentration) and trends, identification of mass flow (loads), testing of compliance with standard and classifications, and early warning and detection.

2.6. Water Quality Monitoring System in Brantas River and Surabaya River

There are 3 stakeholders that responsible in monitoring water quality; the first one is Jasa Tirta I which has a role to control the quality and report the progress into the government routinely; the second one is Basin Authority in Brantas River as a sub-directorate of Ministry of Public Works who has a role to manage and execute; and environmental consortium who has a role as security patrol of quality in Brantas River.

According to Government Regulation No. 82 Year 2001 of Water Quality and Water Pollutant Management, the water class is divided into 4 classes:

a. First Class: the utilization of the water is to being used as raw water for drinking water;
b. Second Class: the utilization of the water is to being used for recreation, fish cultivation, field and farms, and irrigation;
c. Third class: the utilization of the water is to being used for fish cultivation, farms, irrigation;
d. Forth class: the utilization of the water is to being used only for irrigation.

All the standard parameters for each class can be found in table below

Table 2. 2 The standard parameters for each class

Parameter	Unit	Class				Information
		I	II	III	IV	
Temperature		Deviation 3	Deviation 3	Deviation 3	Deviation 5	Temperature deviation of its natural temperature
Turbidity	NTU	5	25	25	25	
Conductivity		20 - 1500	21 - 1500	22 - 1500	23 - 1500	
Total Suspended Solids	mg/L	50	50	400	400	For conventional drinking water management, supended residue < 5000 mg/L
Total Dissolved Solid	mg/L	1000	1000	1000	2000	
pH		6 until 9	6 until 9	6 until 9	6 until 9	
Dissolved Oxygen	mg/L	> 6	> 4	> 3	0	Have to reach the minimum number
BOD	mg/L	2	3	6	12	
COD	mg/L	10	25	50	100	
Ammonia (NH3-N)	mg/L	0.5	-	-	-	For sensitive fish cultivation = 0.02
Nitrate (NO3-N)	mg/L	10	10	20	20	
Nitrite (NO2-N)	mg/L	0.06	0.06	0.06	-	For convensional drinking water = 1 mg/L
Phosphat (PO4-P)	mg/L	0.2	0.2	1	5	

(*Source: Government Regulation No. 82 Year 2001)*

According to Ministry of Environmental Regulation No.115 Year 2003 of Guidelines for Determining the State of the Water, determination of the quality is based on *Storet* Method. *Storet* Method is one of the most general methods to determine the status of water. With this method, the parameters that excess the limit can be known clearly. In general, this method is solely comparing the quality data with the standard. "US-EPA (*Environmental Protection Agency)"* is referenced as the method to clarify the water quality in forth class, as it shown in table below.

Table 2. 3 Standard determination of the quality of the water

No	Category		Score	Status
1	Class A	Very fine	0	**Reach the standard**
2	Class B	Fine	-1 until -10	**Mild Contaminated**
3	Class C	Intermediate	-11 until -30	**Medium Contaminated**
4	Class 4	Poor	>30	**Heavily Contaminated**

(*Source: BBWS Brantas)*

The procedure to determine the quality status of the water with *Storet* Method are explained below:

1. Making the time series data by collecting the data for the quality of the water and the discharge of the water in a periodic way;
2. Comparing the measurement result of the data of each parameters with the standard;
3. If the measurement result achieve the standard (measurement result < standard), mark it as 0;
4. If the measurement result does not achieve the standard (measurement result > standard), mark it as it explains in table 2.4;
5. Calculate the total negative marks from all parameters and determine the status of the standard from total score;

Table 2. 4 Score Determination

Total Examples	Value	Parameters		
		Physics	Chemical	Biology
< 10	Maximum	-1	-2	-3
	Minimum	-1	-2	-3
	Average	-3	-6	-9
> 10	Maximum	-2	-4	-6
	Minimum	-2	-4	-6
	Average	-6	-12	-19

Total examples are the total parameters that being used to determine the status of water quality
(*Source: BBWS Brantas)*

CHAPTER 3
METHODOLOGY

In this chapter, a flowchart for the graduation project has been designed in order to lead every steps from beginning until the end of the process. Every steps will be explained briefly.

3.1. Flowchart

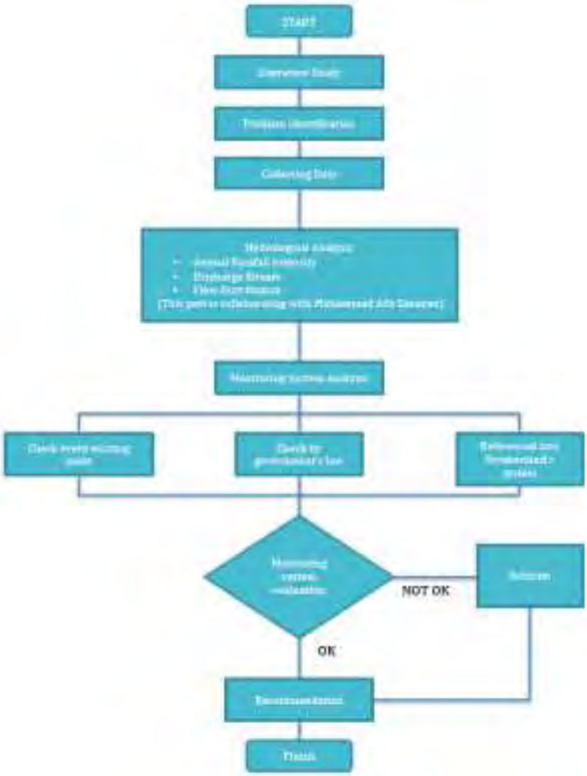


Figure 3. 1 Methodology Flowchart

3.2. Literature Study

The purpose of literature study is to derive any other explanation and information of the site area. This literature study can be done by a thorough review of books, journals, articles, and any other sources that can support the author to learn deeper knowledge when conduct the research project. This also helps the author to analyze, calculate, finds solution and recommendation for this graduation project.

3.3. Problem Identification

By doing literature study as it mentioned, problem of the area can be indicated to solve a matter. A good and complete of identification results a better output. In this research project, a problem identification is summarized by interviewing some experts and related institution and surveying the site area.

3.4. Collecting Data

3.4.1. Interview with experts

In this research project, the author has conducted some interviews with some of responsible stakeholders in Surabaya River. This interview has undergone on April 2017. The author came to Indonesia with the purpose of collecting data and deepening knowledge about Surabaya River. All result of interview will be explained in chapter 4.

3.4.2. Quality data

The quality of the data is obtained from the Basin Authority in Brantas River (BBWS) and the real-time monitoring data from Floris Boogaard as the professor at Kennicentrum Noorderruimte Hanze University of Applied Sciences. These data are the several parameters of the quality such as Biochemical Oxygen Demand, Chemical Oxygen Demand, Turbidity, etc. This data will be used to assess the status of the water with *Storet* Method and model the water quality in Surabaya River.

3.4.3. Map of water monitoring location

The map of the sampling water points is obtained from the Basin Authority in Brantas River, known as BBWS. This represents the existing points used to take the sample of the water when it comes to assess the parameters at intended laboratories. Map of sampling water points can be found on Appendix.

3.4.4. Water quality monitoring schedule

Time schedule of when BBWS does the monitoring is obtained from BBWS itself. This represents time schedule of when BBWS executes the monitoring in every location.

3.4.5. Amount of Population

Amount of population is obtained through website General Directorate of Village Administration, Ministry of Home Affairs. This data will be used to calculate wastewater discharge.

3.5. Hydrological Analysis (wastewater discharge)

In this case, due to the limitation of the data, the hydrological analysis will be the domestic wastewater analysis. The steps to calculate wastewater are stated below:

1. Determine the estimation area along the Surabaya River
2. Determine the city/district, sub-district, and village
3. Find the population which disposal the domestic wastewater into the Surabaya River
    a. For uncompeleted data, using data population in 1994 and population growth rate in Indonesia based on Central Bureau of Statistic determine population estimation in 2016
4. Find percentage of population which does not use sanitation facility in every district/city
5. Calculate how many population(s) that does not use sanitation facility
6. Calculate how much BOD loads per kilogram per day

7. Calculate how much the wastewater discharge per m3 per day
8. Calculate the concentration of BOD

3.6. Monitoring System Analysis

To do the monitoring system analysis, the author will connect every point that has been obtained from Basin Authority in Brantas Basin on google earth. The measurement and the slope will be estimated from google earth too. These following steps will be done:

a. After connecting every point, see and check if there is some missing points to be monitored referenced into the theory explained in literature review;
b. By referencing the data from the water quality part, check if there is any error data such as illogical value that opposites the theory. This indicates that problem occurs in the system;
c. Checking the monitoring system by referencing the National Standard Indonesia whether or not it achieves the standard;
d. Using the wastewater data that has been calculated, compare with the monitoring system and checking whether there are some missing points to control the quality;
e. By referencing into the Netherlands system and research, adjusting if there is some equipment or tools or any solution that can be used in Indonesia to optimize the monitoring system in the future;
f. Making a SWOT (Strength Weakness Opportunity Threat) to find the most sustainable solution.

CHAPTER 4
DATA AND ANALYSIS

4.1. General Review

In this chapter, a summary of required analysis will be explained in order to evaluate the monitoring system in Surabaya River.

I. Wastewater discharge, consists of:
   a. Projected of Surabaya Population in 2016;
   b. Calculate wastewater discharge;
   c. Calculate Biochemical Oxygen Demand loads;

II. Investigation the water quality, consists of:
   a. Using the *Storet* Method to assess the status of the water quality in Surabaya River;
   b. Classifying the status of the water quality in Surabaya River for every each point where the sampling water is taken;

III. Assessment the monitoring system in Surabaya River, consists of:
   a. Assessment of the location by using google maps to connect every points where the sampling water is taken including how many industries affect the quality of the water and how much wastewater will flows into Surabaya River. This will be correlated with the wastewater discharge analysis;
   b. Assessment of the time frequencies by making a list of when the Basin Authority in Brantas River does monitoring in every location and checked by Indonesia National Standard;

IV. Solution and recommendation for optimizing the monitoring system (SWOT analysis)

4.2. Wastewater discharge

Analysis of the wastewater discharge is an assumption to approach the estimation of how much BOD load that comes from the domestic wastewater will flow into Surabaya River due to lack of the data. The approach of domestic wastewater and its BOD loads can be accumulated by estimating area in 500 meters zone along the river within the total population. The total population(s) itself are obtained through website General Directorate of Village Administration, Ministry of Home Affairs. In his research, Musmidyono (1994) stated that the biggest domestic wastewater influence the quality of the are is the wastewater comes from sanitation. Therefore, in this case, we assume and calculate the wastewater comes from the population with and without sanitation facilities.

To determine the assumption of the domestic wastewater discharge, first we collect the area that flows the wastewater towards the Surabaya River. According to the Ministry of Public Works of Irrigation of East Java Province (1995), there are 3 districts including Mojokerto, Gresik and Sidoarjo, and 1 city which is Surabaya are flowing the wastewater into Surabaya River. There are at least 37 villages within various population live there (Appendix 4). The villages can be found in figure 4.1 below. To determine the population, we obtained the data from General Directorate of Village Administration, Ministry of Home Affairs[3]. The data that we use are the data from 2016 as the latest published data (Appendix 4).

---

[3] Source reffered to <
http://prodeskel.binapemdes.kemendagri.go.id/mpublik/>

Jetis (40%)
Canggu
Mlirip
Kramat Temanggung
Singkalan
Jetis (60%)
Perning (30%)
Mojolebak
Bendung
Ngabar
Kupang
Banjarsari
Perning (70%)
Sumberrame
Kedaung Anyar
Kedung Sukodani
Bakung Pringgodani
Bogempinggir

Pasinan Lemah Putih (50%)
Sumengko
Lebani Waras
Wringin Anom
Penambangan
Jeruk Legi
Sidomulyo
[illegible]
Suko
Jambung
Pedagangan
Wates Tanjung
Pasinan Lemah Putih (50%)
Karangandong
Banjaran
Tempel
Sarangkrajan
Petapan Madu Retno
Tanjungan
Krembangan
Mojosarirejo
Sumput
Kesamben Wetan

Petiken
Tenaru
Mulung
Driyorejo
Cangkir
Bambe
Krikilan
Karangpilang
Warugunung
Tawangsari
Ngelok
Wonocolo
Bebekan
Sepanjang
Kedurus
Kebraon
Pagesangan
Kebonsari
Jambangan
Karah
Jajartunggal

Gunungsari
Wiyung
Babadan
Balasdumprik
Lidahwetan
Lidahkulon
Jeruk
Ketintang
Sawung Galing
Wonokromo
Jagir
Darmo

Figure 4. 1 Villages Located 500 Meters near Surabaya River
(*Source: Ministry of Public Works)*

However, some missing data occur when we find the population through the Indonesia Central Bureau of Statistic. To support these missing data, we estimate the population by correlating the data that we found in 1994 with growth of population in East Java based on Central Bureau of Statistic.

Table 4. 1 Population growth in East Java, Indonesia

Provinces	Population Growth Rate Per Year				
	1971 - 1980	1980 - 1990	1990 - 2000	2000 - 2010	2010 - 2015
East Java	1.49	1.08	0.70	0.76	0.67

(*Source: Indonesia Central Bureau of Statistic)*[4]

To determine the estimation of the population, we use this following basic formula:

$$r = \left(\frac{P_t}{P_0}\right)^{1/t} - 1$$

4 Source available at <https://sirusa.bps.go.id/index.php?r=indikator/view&id=86>

Where: r = population growth rate
Pt = population at years t
Po = population at early years
T = time difference (years) between years 0 and years t

This figure below is the example of determining the estimation of the population in 2016 using data in 1994.

Years		1994	1995	1996	1997	1998	1999	2000
Population Growth Rate			0.007	0.007	0.007	0.007	0.007	0.007
Total Population		3262	3285	3308	3331	3354	3378	3401
		4026	4054	4083	4111	4140	4169	4198

2001	2002	2003	2004	2005	2006	2007	2008
0.0076	0.0076	0.0076	0.0076	0.0076	0.0076	0.0076	0.0076
3427	3453	3480	3506	3533	3560	3587	3614
4230	4262	4295	4327	4360	4393	4427	4460

2009	2010	2011	2012	2013	2014	2015	2016
0.0076	0.0076	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
3641	3669	3694	3718	3743	3768	3794	3819
4494	4528	4559	4589	4620	4651	4682	4713

Figure 4. 2 Increasing of Population using growth rate formula

In this case, as it mentioned on previous paragraph above, we assume that the population that flows the domestic wastewater towads the Surabaya River is the population lives in zone 500 meters from the Surabaya River. This assumption is based on previous research (Musmodiyono, 1994) in his master thesis that stated the population that lives in at least 500 meters from the river will flow the domestic wastewater into the nearest river in a particular way. We use the data in 1994 to assume the percentage of the population who lives in zone 500 meters from the Surabaya River. The data can be found in Appendix 4.

According to World Health Organzation (WHO), it is stated that the average fresh water needed per person equals 60 litre per person per day. As it mentioned in chapter 2 (equation 2.2), we assume that the people will waste 80% of freshwater needed. Therefore:

The amount of wastewater = 80% x 60 l/person/day
= 48 l/person/day

The data of the percentage of the population with and without sanitation facilities are obtained from East Java Provincal Health. These data are based on the data in 2015 as the latest data they published based on real surveys. The data can be found in Appendix 6, 7, 8 and 9.

No	Nama Kabupaten	Nama Kecamatan	Identitas Data (Data aktual ter-entry / Data di BPS)		Baseline					Kemajuan				
			Jumlah Desa/Kel	Jumlah KK	JSP	JSSP	Sharing	BABS	% Akses Jamban	JSP	JSSP	Sharing	BABS	% Akses Jamban
					KK	KK	KK	KK		KK	KK	KK	KK	
1	SIDOARJO	TANGGULANGIN	19/19	23.550/22.863	18.363	0	515	13.148	56.80	22.776	0	572	202	[illegible]
2	SIDOARJO	BUDURAN	15/15	24.033/22.596	19.700	0	384	646	95.74	23.636	0	125	[illegible]	[illegible]
3	SIDOARJO	SIDOARJO	24/24	56.028/50.617	24.496	3.811	746	27.751	57.67	52.730	0	2.059	1.239	97.45

Percentage of Population with sanitation facilities

Figure 4. 3 Example of percentage population with and without sanitation facilities

Equation 2.2 and 2.3 as it mentioned on chapter 2 sub–chapter 2.4 is used to determine the domestic wastewater discharge and the potential pollution load. In this case, BOD load is chosen to be estimated. Therefore, we use BOD = 40 gr/person/day. The equivalent ratio depends on the area that affects the river. As it stated on previous paragraph above that Surabaya River is affected by 3 districts and 1 city, therefore for the district use equivalent ratio = 0.8125 and for the city we use equivalent ratio = 1. Alpha is based on the range where the population live. Because we assume that the population that will flow the domestic wastewater is 500 meters near the Surabaya River, therefore we use alpha = 0.85.

BOD concentration can be calculated by using this formula:
BOD concentration = $\frac{BOD\ Load}{Qwaste}$

<u>Example of the calculation:</u>
Area 1 = Mlirip River into Marmoyo River
District /Area= Mojoketro District
Sub District = Jetis
Village = Canggu village
Total Population in 2016 = 11575

Assumed that percentage population in zone 500 meters from the river is as the same as in 1994
Data in 1994:
Population = 3889, Population in zone 500 meters = 1948
Percentage (%) = $(\frac{1948}{3889})$ x 100 = 49.96%
Therefore, in 2016 total populations in zone 500 meters are 49.96% x 11575 = 5783
Based on Indonesia Health Department, population without sanitation facilities in Jetis Sub-District is 23.86% of total population.
Total population without sanitation = 23.86% x 5783 = 1380
Total population with sanitation = 5783 – 1380 = 4403
Amount of wastewater = 48 l/person/day = 0.048 m^3/person/day

<u>For population without sanitation facilities:</u>
$Qwaste_1$ = 0.048 x 1380 = 66.23 m^3/day
BOD = 40 gr/person/day
For sub-disrict, we use equivalent ratio = 0.8125
$\propto$ = 0.85
$BOD\ Loads_1$ = 1380 x 40 x 0.8125 x 0.85
= 38128 gr/day
= 38.12 kg/day

<u>For population with sanitation facilities:</u>
$Qwaste_2$ = 0.048 x 4403 = 211.35 m^3/day
BOD = 40 gr/person/day
For sub-disrict, we use equivalent ratio = 0.8125
$\propto$ = 0.85
BOD Loads_2 = 4403 x 40 x 0.8125 x 0.85
= 94270 gr/day
= 94.27 kg/day

Qwaste = $Qwaste_1$ + $Qwaste_2$ = 66.23 + 211.35 = 277.59 m^3/day
BOD Loads = BOD Loads_1 + BOD Loads_2 = 38.12 + 94.27 = 132.39 kg/day

$$\text{BOD concentration} = \frac{BOD\ Load}{Qwaste} = \frac{132.39}{\frac{277.59}{1000}} \times 10^6 = 476.93 \text{ mg/L}$$

All the results from the estimation of wastewater discharge analysis can be found in Appendix 4. To sum up:

Total estimation domestic wastewater discharge = 15207.20 m^3/day
Total estimation BOD loads from domestic wastewater = 7749.34 kg/day
Estimation average BOD concentration from domestic wastewater = 482.97 mg/L

Below is the figure of schematic of domestic wastewater along the Surabaya River. This scheme will help the author to determine whether or not the villages that dispose domestic wastewater have been controlled by the existing monitoring locations. This will be discussed in sub-chapter 4.4.

Figure 4. 4 Scheme of domestic wastewater along Surabaya River
(*Source: Google Earth)*

Furthermore, appendix 4 also shown that when the water flows toward the downstream of the Surabaya River itself, the value of BOD concentration is inconstantly increasing. While the water has a character to purify itself, the BOD concentration should have decreased in a certain time. This indicates the closer the river into the downstream, the more industries and villages contaminate the water.

4.3. Investigation of the Quality of the Water in Surabaya River

The data for the inverstigation of quality of the water are obtained from Brantas Authority in Basin River (*Balai Besar Wilayah Sungai)* as known as BBWS. These data are derived as results from analysis on field or laboratories. Based on Government Regulation No. 82 Year 2001 as it mentioned on chapter 2 sub-chapter 2.8, BBWS stated that water class and water quality standard to determine the quality of water has to reach at least the second class in order to achieve the standard.

To analyze the quality of the water in Surabaya River, BBWS measures both physical parameters and chemical parameters. Measured physical parameters included temperature, turbidity, suspended solids, dissolve solids, and conductivity, while measured chemical parameters included PH, dissolved oxygen, biochemical oxygen demand (BOD), chemical oxygen demand (COD), phosphate, nitrate, and nitrite. 13 points of location to both take the sample of water to be assessed in laboratories and on-site analysis using the needed equipments are used by BBWS in order to monitor the quality in certain time. The locations of the monitoring are shown in table below.

Table 4. 2 Monitoring locations

No	Name	Locations
1	Perum Jetis Permai Bridge	Jetis Permai Residence, Mojokerto
2	Jetis IV Bridge	Jetis Village, Mojokerto
3	Perning Bridge	Jetis Village, Mojokerto
4	Legundi Bridge	Legundi, Krian Sub-District
5	Bambe Bridge	Bambe Sub-District, Gresik
6	Karangpilang Bridge	Sidoarjo - Surabaya Border
7	Joyoboyo Bridge	Joyoboyo, Wonokromo Sub-District, Surabaya
8	Jagir Wonokromo Bridge	UPT. PSAWS Buntung Paketingan, Surabaya
9	Nginden Intan Bridge	Nginden Intan, Surabaya
10	Tambangan Wonorejo	Wonorejo, Surabaya
11	Bungkuk Bridge	Ngagel, Surabaya
12	Yos Sudarso Bridge	Yos Sudarso, Surabaya
13	Petekan Bridge	Perak, Surabaya

(*Source: BBWS Surabaya)*

These sub-chapters below will show every graph for each parameter that has been conducted in monitoring locations.

4.3.1. Physical Parameter Result

A. Temperature

Temperature is the easiest parameter to measure. This parameter directly measured on the field. Graph 4.1 depicts the average result of surface water temperature occurs in Surabaya River.

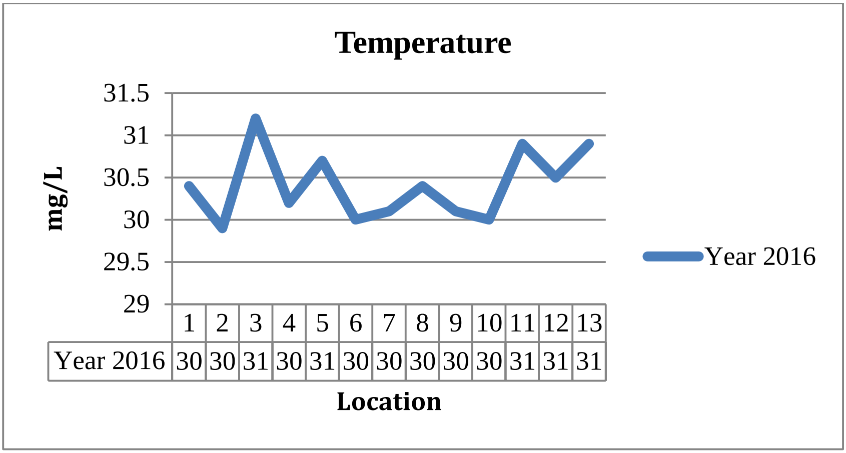


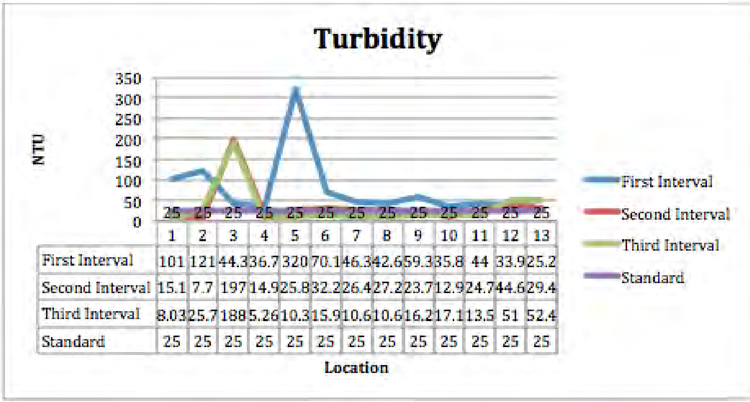
Figure 4. 5 Temperature result (in oC)

B. Turbidity

Turbidity caused by suspended solids. This parameter indicates degree of the darkness in water, caused by solids material float. This parameter is advisedly measured directly in the field, because turbidity can be irreversible when it is placed for long time, leading to inaccuracy of the data. The measured data of turbidity in Surabaya River can be found in Graph 4.2.

It can be perceived that the turbidity results are fluctuating. In general, the average result is 48.37 NTU[5] in which means that it does not reached the water quality standard which as it categorized the second class. The higher level of turbidity occurs at point 3 (Perning Bridge) and point 5 (Bambe Bridge).

[5] NTU known as Nephelometric Turbidity Units

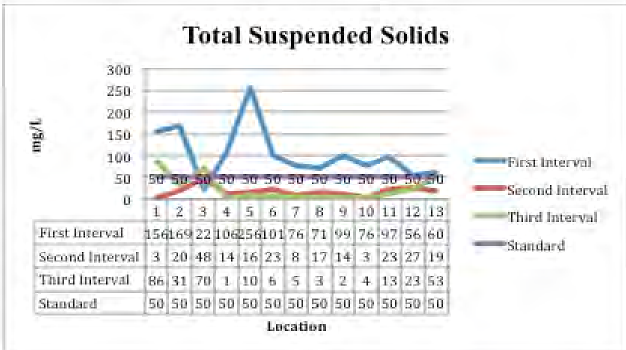


	1	2	3	4	5	6	7	8	9	10	11	12	13
First Interval	101	121	44.3	36.7	320	70.1	46.3	42.6	59.3	35.8	44	33.9	25.2
Second Interval	15.1	7.7	197	14.9	25.8	32.2	26.4	27.2	23.7	12.9	24.7	44.6	29.4
Third Interval	8.03	25.7	188	5.26	10.3	15.9	10.6	10.6	16.2	17.1	13.5	51	52.4
Standard	25	25	25	25	25	25	25	25	25	25	25	25	25

Figure 4. 6 Turbidity level

C. Total Suspended Solids

As it stated on chapter 2, total suspended solids is one of the factor affecting the quality of the water. At this parameter, the analysis conducted in the laboratory. The result of this parameter result will be found in Graph 4.3 below.



	1	2	3	4	5	6	7	8	9	10	11	12	13
First Interval	156	169	22	106	256	101	76	71	99	76	97	56	60
Second Interval	3	20	48	14	16	23	8	17	14	3	23	27	19
Third Interval	86	31	70	1	10	6	5	3	2	4	13	23	53
Standard	50	50	50	50	50	50	50	50	50	50	50	50	50

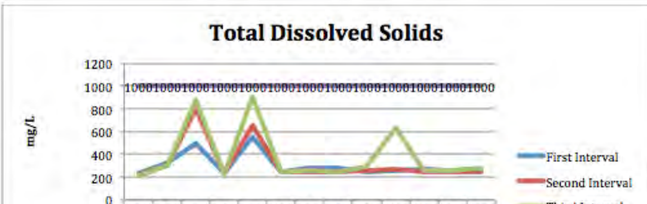
Figure 4. 7 Total Suspended Solids

In general, the average result of total suspended solids in Surabaya River is 48.34 mg/L[6]. It means the average result still reaches the water quality standard as the second class. However, at the first interval, the graph shows the huge result that means the suspended solids occur badly in January-March period. It may be caused by the rainy season, because rain will cause higher suspended solids as result of sediment and mud are suspended in the water.

D. Total Dissolved Solid (TDS)

Total dissolved solid is a condition where solid substance dissolved in the water body. Graph 4.4 shows the result of total dissolved solid occurs in Surabaya River.

In general, the average result of total dissolved solid occurs in Surabaya River is 337.36 mg/L. It means that the average result still reaches the water quality standard as the second class. The higher result of total dissolved solids occurs at Perning Bridge, Mojokerto District and Bambe Bridge, Gresik District.



	1	2	3	4	5	6	7	8	9	10	11	12	13
First Interval	230	329	496	238	556	241	276	277	251	261	273	263	270
Second Interval	225	306	801	230	648	241	249	251	254	272	245	252	251
Third Interval	212	304	876	225	897	242	253	252	293	629	253	259	276
Standard	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Figure 4. 8 Total Dissolved Solids

6 mg/L known as milligram per litre

E. Conductivity

Conductivity indicates the capability of the water to conduct the electric current. This obtains to observe electrolyte levels dissolved in the water. Conductivity is represented by unit μS/cm. Conductivity is also influenced by the temperature. Every time the temperature gets higher, the conductivity will get higher two times. Graph 4.5 will show the result conductivity occured in Surabaya River.

Generally, the average result of conductivity occurs in Surabaya River is 693.54 μS/cm[7]. It means that in general Surabaya River still reached the water quality standard that stated on chapter 2 as the second class. However, the graph shows the higher result at Perning Bridge and Bambe Bridge on January-March period (first interval). These points have to be considered in order to improve the quality.

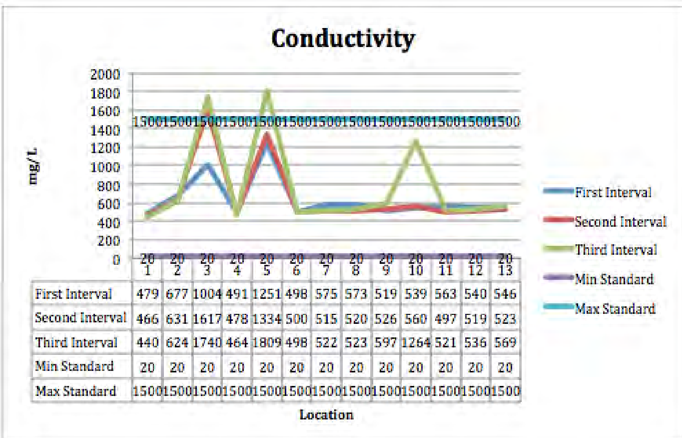


Figure 4. 9 Conductivity Result

7 μS/cm known as micro-Siemens per centimeter

4.3.2. Chemical Parameter Result

In a monitoring system, chemical parameters can be known after laboratory analysis. These graphs below will show the result of each parameter.

A. PH

As it mentioned on chapter 2, pH indicates the quality of the water. PH is a numeric scale used to specity the acidity or basicity of an aqueous solution. Normal water has pH ranges from 6.5 to 7.5; if the value less than this range then the characteristic of water is acidic and if the value is higher than the range, the characteristic of water is alkaline. Graph 4.6 shows the pH level occurs in Surabaya River.

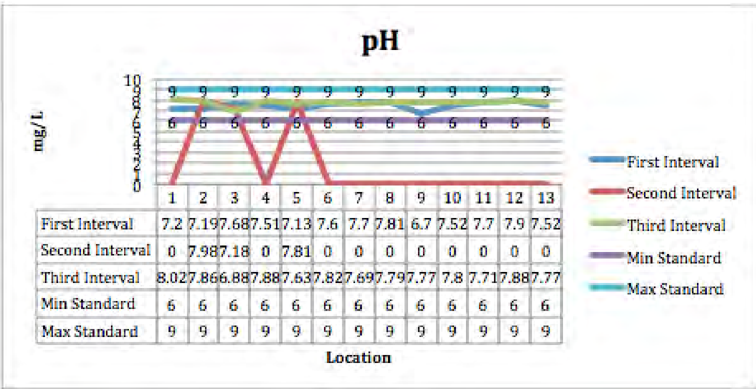


Figure 4. 10 PH result

In general, the average pH value that occurs in Surabaya River is 5.66. It means that the pH result does not achieve the water quality standard as second class, indicated by the result value does not achieve the minimum value of 6. However, the pH result for the second interval shows mostly shows zero value, indicates that there is an error in which pH level cannot be zero as it explained in the theory.

B. Dissolved Oxygen

Dissolved oxygen is an important factor to indicate whether the water fresh or not before and after it is influenced by some compounds as it stated in chapter 2. Graph 4.7 shows the level of dissolved oxygen after it contaminated.

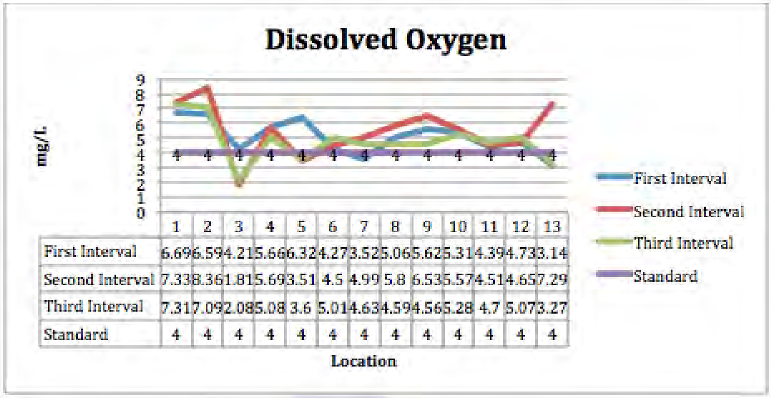


Figure 4. 11 Dissolved Oxygen Result

In general, the result of dissolved oxygen occurs in Surabaya is 4.79 mg/L. It means that dissolved oxygen level still achieves the water quality standard as second class. However, at Perning Bridge indicates the poor quality that might cause as low dissolved oxygen level in water.

C. Biochemical Oxygen Demand (BOD)

As it stated in chapter 2, BOD is the most general parameter to indicate the quality of the water. Graph 4.8 will shows the result of BOD occurs in Surabaya River.

In general, the average value of BOD occurs in Surabaya is 7.07 mg/L. It means that the value does not achieve the water quality standard as second class. Almost in every all points the BOD level achieve a huge value that indicates Surabaya River is contaminated. Point 3, 5, and 12 shows that Perning Bridge, Bambe Bridge, and Yos Sudarso Bridge have a really huge amount of BOD level that contaminated Surabaya River.

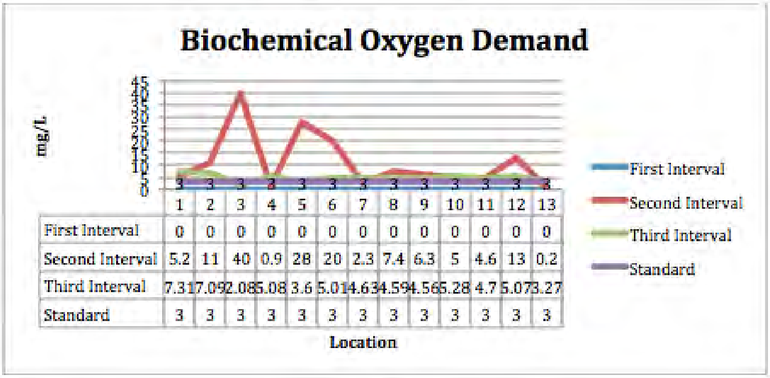


Figure 4. 12 BOD result

D. Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) is also the most general parameter to indicate the quality of the water after BOD. Graph 4.9 will show the result of COD level in Surabaya River.

As it shown in Graph 4.9, in general the average value of COD is 21.283 mg/L, meaning that the COD level still reaches the water quality standard as second class. However, the highest value on location 3 shows that COD level at Perning Bridge is really huge. It is lso shown that location 5, 7, 8 have high values, meaning that the COD level at Bambe Bridge, Joyoboyo Bridge, and Jagir Wonokromo Bridge excessed the water quality standard.

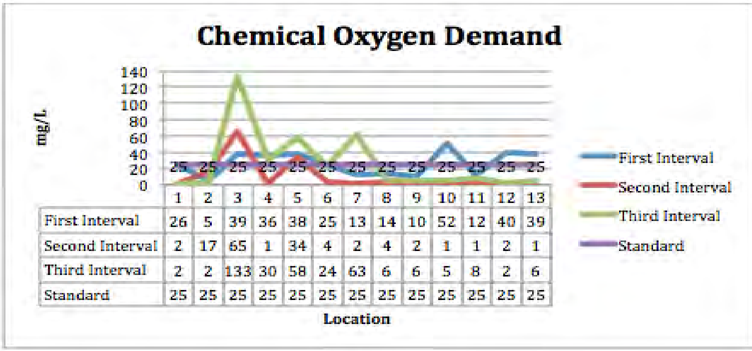


Figure 4. 13 COD Result

E. Ammonia

Ammonia is a non-colored particle with strong smell and easily dissolved in water. Ammonia indicates bacterial decay of organic. Graph 4.10 will show the ammonia level in Surabaya River.

In general, the average level of ammonia in Surabaya River is 1.675 mg/L, which means that average level does not achieve the water quality standard as second class. As it is shown on the Graph, point 3 (Perning Bridge) and point 5 (Bambe Bridge) have really huge levels of ammonia.

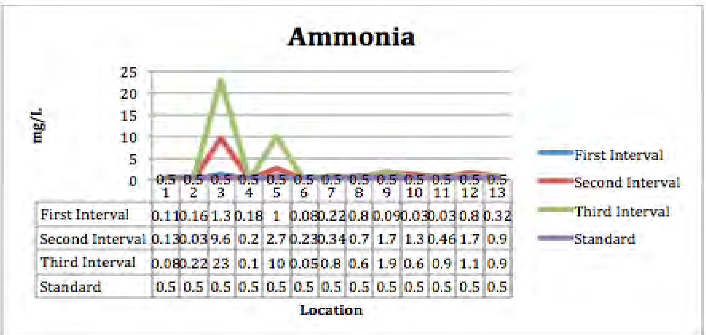
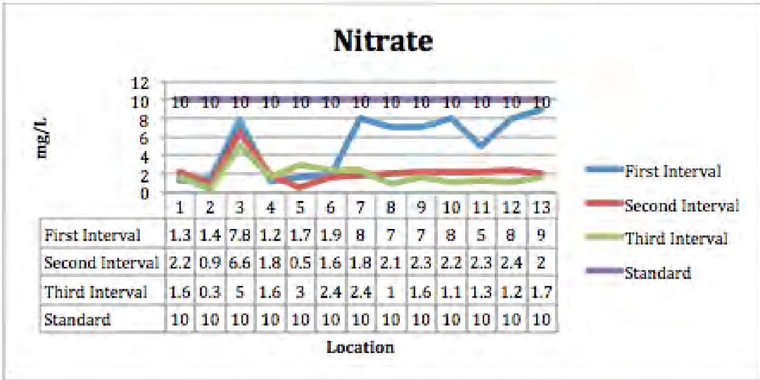


Figure 4. 14 Ammonia result

F. Nitrate

The amount of nitrate in the water usually comes from agricultural waste, especially the use of excessed fertilization that disposal into river surface water. As it stated on chapter 2, nitrate demonstrated general parameter to assess the water quality in river. Graph 4.11 will show the average level of nitrate in Surabaya River.



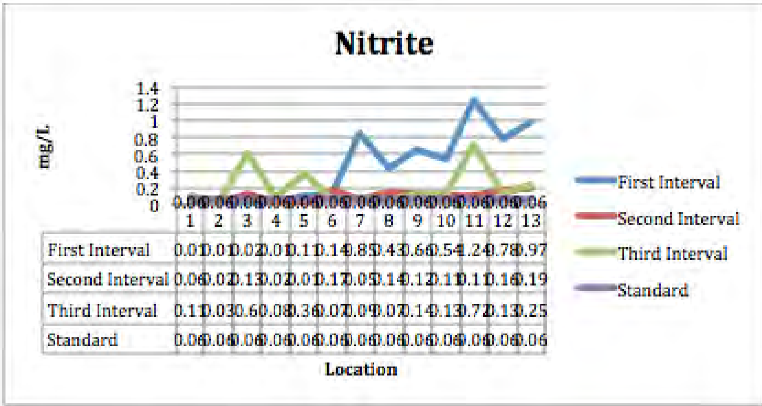
	1	2	3	4	5	6	7	8	9	10	11	12	13
First Interval	1.3	1.4	7.8	1.2	1.7	1.9	8	7	7	8	5	8	9
Second Interval	2.2	0.9	6.6	1.8	0.5	1.6	1.8	2.1	2.3	2.2	2.3	2.4	2
Third Interval	1.6	0.3	5	1.6	3	2.4	2.4	1	1.6	1.1	1.3	1.2	1.7
Standard	10	10	10	10	10	10	10	10	10	10	10	10	10

Figure 4. 15 Nitrate result

In general, the average level of nitrate in Surabaya River has a value of 3.09 mg/L, means that the average level still achieves the water quality standard as second class. However, point 3, 7, 10, 12, and 13 show a huge value of Nitrate and can be concluded that Perning Bridge, Joyoboyo Bridge, Tambangan Bridge, Yos Sudarso Bridge, and Petekan Bridge have a high level of Nitrate in the surface water.

G. Nitrite

As it is stated in chapter 2, nitrite is also one of the most general parameters that is measured in the river. Nitrite is one of the most dangerous of water contamination for every living organism. Nitrite can oxidized iron ion and copper ion in hemoglobin, causing hemophilia disorders. High level of nitrite may disturb ecosystem balance in water, lead to abnormal alga growth. Nitrite also indicates huge amount of industrial wastewater which is not fully purified before it flows to the river. Graph 4.12 will show the average level of nitrite in Surabaya River.



	1	2	3	4	5	6	7	8	9	10	11	12	13
First Interval	0.01	0.01	0.02	0.01	0.11	0.14	0.85	0.43	0.66	0.54	1.24	0.78	0.97
Second Interval	0.06	0.02	0.13	0.02	0.01	0.17	0.05	0.14	0.12	0.11	0.11	0.16	0.19
Third Interval	0.11	0.03	0.60	0.08	0.36	0.07	0.09	0.07	0.14	0.13	0.72	0.13	0.25
Standard	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06

Figure 4. 16 Nitrite result

In general, the average result of nitrite in Surabaya River is 0.252 mg/L. It means that the average value does not achieve the water quality standard as second class. Mostly it shows huge value of nitrite, meaning that Surabaya River is heavily contaminated. Location 3, 5, 7, 9, and 11 show a huge result of nitrate, meaning that Perning Bridge, Bambe Bridge, Joyoboyo Bridge, Nginden Intan Bridge, and Bungkuk Bridge have a really huge amount of nitrite in the surface water.

H. Phosphate

As it is stated in chapter 2, phosphate is also one of the most general parameters measured in the river. Amounts of phosphate are usually the result of both excessed industrial wastewater and agricultural waste. Graph 4.13 will show the average level of phosphate in Surabaya River.

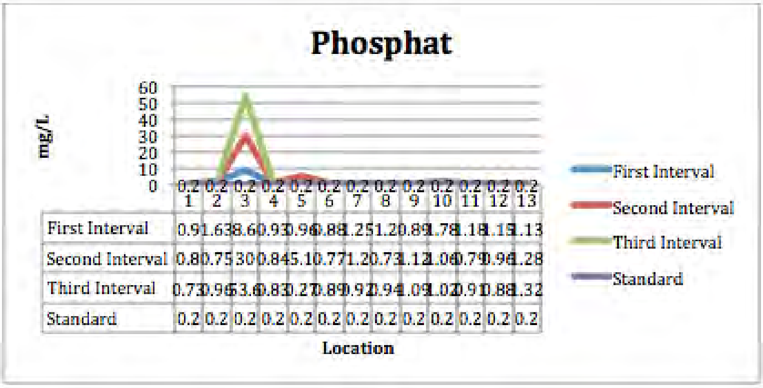


Figure 4. 17 Phosphate Result

In general, the average result of phosphate level in Surabaya River is 3.391 mg/L. It means that the average result does not reach the water quality standard as second class. Point 3 shows that Perning Bridge has a really huge amount of phosphate in the surface water.

To sum up, table 4.3 below reflects overall results of Surabaya River water quality. From 12 parameters above, 6 parameters achieve the standard meanwhile the others not. This indicates that the water is still contaminated both from the industrial and the domestic wastewater. All the data for water quality result can be found on Appendix.

Using the Storet-Method, the status of water quality in Surabaya River can be determined. Table 4.4 shows the score and the state of the water in each monitoring location in Surabaya River by using Stored Method.

Table 4. 3 Water quality result

Parameter	Average	Unit	Second Class Standard		Result
			Minimum	Maximum	
Turbidity	48.36897436	NTU		25	NOT OK
TSS	48.38461538	mg/L		50	OK
TDS	337.3589744	mg/L		1000	OK
Conductivity	693.5384615		21	1500	OK
pH	5.657179487	-	6	9	NOT OK
DO	5.085128205	mg/L	4		OK
BOD	5.085128205	mg/L		3	NOT OK
COD	21.28205128	mg/L		25	OK
Ammonia	1.675897436	mg/L		0.5	NOT OK
Nitrate	3.082051282	mg/L		10	OK
Nitrite	0.251820513	mg/L		0.06	NOT OK
Phosphat	3.390769231	mg/L		0.2	NOT OK

Table 4. 4 The state of the quality of the water in Surabaya River

No	Location	Score	Status
1	Perum Jetis Permai Bridge	-35	Heavily Contamined
2	Jetis IV Bridge	-35	Heavily Contamined
3	Perning Bridge	-49	Heavily Contamined
4	Legundi Bridge	-17	Medium Contamined
5	Bambe Bridge	-51	Heavily Contamined
6	Karangpilang Bridge	-31	Heavily Contamined
7	Joyoboyo Bridge	-40	Heavily Contamined
8	Jagir Wonokromo Bridge	-34	Heavily Contamined
9	Nginden Intan Bridge	-39	Heavily Contamined
10	Tambangan Wonorejo	-38	Heavily Contamined
11	Bungkuk Ngagel Bridge	-33	Heavily Contamined
12	Yos Sudarso Bridge	-43	Heavily Contamined
13	Petekan Bridge	-42	Heavily Contamined

It can be seen that the highest score occurs at Bambe Bridge (Mojokerto District) followed by Perning Bridge (Gresik District).

In 2015, the data from National Evaluation on Enviromental Management Performance (PROPER) by Ministry of Environment shows that there are several industries that exceed allowed capacity of industrial wastewater load. Some of them are located in Mojokerto DIstrict, as it shown on Table 4.3

where the status of Perning Bridge in Mojokerto District is heavily contaminated. This data can also be used to approach whether the new location is needed or not. This will be discussed on sub-chapter 4.4.1. Table 4.5 shows the industries excessing maximum BOD loads capacity as it is already stipulated by the government. All the data can be found on Appendix.

Table 4. 5 Industries dispose excessed wastewater

No	Company Name	District/City	Type of Industry
1	PT Keramik Diamond Industri	Gresik	Ceramic floor
2	PT Manna Jaya Makmur	Mojokerto	Metal processing
3	PT Mermaid Textile Industri	Mojokerto	Textile
4	PT Sky Indonesia	Mojokerto	Metal processing
5	PT Sunrise Steel	Mojokerto	Metal processing
6	PT Santos Jaya Abadi	Sidoarjo	Food
7	PT Charoen Pokphand Indonesia	Sidoarjo	Animal food
8	Somerset Hotel	Sidoarjo	Hotel
9	PT Omya Indonesia	Sidoarjo	Chemical
10	PT Unichemi Candi Industri	Sidoarjo	Chemical
11	RSAL Ramelan	Surabaya	Hospital
12	RS St. Vincentius A. Paulo	Surabaya	Hospital
13	PT Sepanjang Baut Sejahtera	Surabaya	Metal Processing
14	RSUD Dr. Sutomo	Surabaya	Hospital
15	PT New Simomulyo	Surabaya	Metal Processing
16	Bumi Surabaya Hotel	Surabaya	Hotel

(*Source: PROPER by Ministry of Environment)*

Furthermore, when we look through those graphs above, the graphs are most likely shown significant fluctuation between location 3, 4, 5, where at location 3 (Perning Bridge) the graph extremely increase and thoroughly decrease at point 4 (Legundi Bridge) and rise again at point 5 (Bambe Bridge). This deviation is caused by the exact location where BBWS monitor the quality itself. Location 3 and 5 are not located in the middle of Surabaya River itself (figure 4.5). Instead of located in the middle of Surabaya River itself, location 3 and 5 are located in small rivers, where a lot of industries and housing has been built along these monitoring locations. This caused a lot of contaminations flow to

Surabaya River, impact on huge deviation between Perning Bridge, Legundi Bridge, and Bambe Bridge.

Figure 4. 18 Exact location of Bambe Bridge and Perning Bridge

4.4. Assessment of the monitoring system in Surabaya River

The data for assessment of the monitoring system is obtained from Basin Authority in Brantas River (BBWS) as the sub-directorate of Water Resources and Water Stewardship, Ministry of Public Works. BBWS is responsible for tracking Brantas River, including the Surabaya River. The exact location of existing points of water quality monitoring can be seen in Appendix.

4.4.1. Evaluation of the existing points

As it is shown in sub-chapter 4.3, there are 13 points to monitor the quality of Surabaya River, starting from Perum Jetis Permai Bridge (point number 1) and split at Joyoboyo Bridge (point number 7). Using Google earth, figure 4.6 shows the location map of monitoring along Surabaya River. This also shown the villages and industries that dispose the wastewater to Surabaya River.

Figure 4. 19 Location of monitoring point in Surabaya River

Each segment can be found in Appendix. The length of each segment can be measured as it shown on table 4.6.

Table 4. 6 Monitoring Segment

Segment	Start Point	Finish Point	Length (Km)	Average Slope (%)
I	Surabaya River Upstream	Perum Jetis Permai Bridge	3.4	0.8
II	Perum Jetis Permai Bridge	Legundi Bridge	15	0.6
III	Jetis IV Bridge	A	1.6	0.9
IV	Perning Bridge	B	0.32	2.45
V	Legundi Bridge	Bambe Bridge	12.2	0.55
VI	Bambe Bridge	Karang Pilang Bridge	3.41	0.7
VII	Karang Pilang Bridge	Joyoboyo Bridge	8.23	0.75
VIII	Joyoboyo Bridge	Jagir Wonokromo Bridge	0.27	0.95
IX	Joyoboyo Bridge	Bungkuk Bridge	0.61	1.4
X	Bungkuk	Yos Sudarso Bridge	4.81	1
XI	Yos Sudarso	Petekan Bridge	6.1	0.8
XII	Petekan Bridge	Entering Java Sea	2.97	1.2
XIII	Jagir Wonokromo Bridge	Nginden Inten Bridge	4.64	1.2
XIV	Nginden Inten Bridge	Tambangan Wonorejo	2.1	1
XV	Tambangan Wonorejo	Entering Java Sea	7.1	0.5

Although there is no standard and principle on how to establish the precious location to determine the most efficient point to have a monitoring, some approaches will therefore be used in order to optimize the location.

Sub-chapter 4.1 has discussed the villages that flow the domestic wastewater toward the Surabaya River. A particular amount of BOD loads and the wastewater discharge are flowing everyday, eventually affects the quality of the water. Table 4.5

also shown the industries excessing the allowable industries wastewater as it stipulated by the Governemnt. Therefore, in this part, evaluation of the existing locations are done in order to check whether or not the locations can cover and control the wastewater flows.

This approaching has resulting some villages with BOD loads among the small rivers, flowing towards Surabaya River, without any point to monitor water quality (e.g. Ngabar Village, Jetis Village, and Canggu Village, etc). On the other side, there are some industries that might not fully monitored yet by these locations (e.g. PT Keramik Diamond Industri, PT Charoen Pokphand Indonesia, etc). Table 4.7 shows all the villages and industries that have not fully monitored yet.

Table 4. 7 Villages and industries with no monitoring

Villages		Industries	
Name	**Location**	**Name**	**Location**
Jetis Village	Mojokerto	PT Keramik Diamond Industri	Gresik
Canggu Village	Mojokerto	PT Charoen Pokphand Indonesia	Sidoarjo
Mlirip Village	Mojokerto	PT Omya Indonesia	Sidoarjo
Mojolebak Village	Mojokerto		
Bendung Village	Mojokerto		
Ngabar Village	Mojokerto		
Kupang Village	Mojokerto		
Bakung Pringgodani Village	Sidoarjo		
Sidomulyo Village	Sidoarjo		
Karangandong Village	Gresik		
Mojosarirejo Village	Gresik		
Driyorejo Village	Gresik		
Banbe Village	Gresik		

4.4.2. Evalation by government's law and Indonesia National Standard

The result of the water quality in Brantas River that has been held by BBWS can be found in Appendix. This data came from 2015 as the latest data that they used and published.

Table 4. 8 Time and Location of Water Quality Monitoring in Brantas River

No	Place / Location	Time to do Quality Monitor (2015)		
		First Interval	Second Interval	Third Interval
1	Sumber Brantas	March	July	October
2	Brantas Bridge	March	July	October
3	Pendem Bridge	March	July	October
4	Sengguruh Bridge	March	July	October
5	Brawijaya Bridge	March	July	October
6	Trisula Kademangan Bridge	March	July	October
7	Karangrejo Bridge	February	July	October
8	Tambangan Maesan	February	July	October
9	Jong Biru Bridge	February	July	October
10	Kertosono - Jombang Old Bridge	February	July	October
11	Tambangan Ngrombot	February	July	October
12	Begendheng Bridge	February	July	October
13	Munung Bridge	February	July	October
14	Ploso Jombang Bridge	February	July	October
15	Tambangan Pabrik Cheil Jedang	February	July	October
16	Tambangan Betro Mojokerto	January	July	September
17	Lesa Padangan Bridge	January	July	September
18	Pulorejo Bridge	March	July	October
19	Mojokerto Highway Birdge	March	July	October
20	Ngoro Bridge	March	July	September
21	Carat Bridge	March	July	September
22	Porong Bridge	March	July	September
23	Tambangan Tlocor	March	July	September
24	Perum Jetis Permai Bridge	March	July	September
25	Jetis IV Bridge	February	July	September
26	Perning Bridge	February	July	September
27	Legundi Bridge	January	July	September
28	Bambe Bridge	January	July	September
29	Karangpilang Bridge	January	July	September
30	Joyoboyo Bridge	January	July	September
31	Jagir Wonokromo Bridge	January	July	September
32	Nginden Intan Bridge	January	July	September
33	Tambangan Wonorejo	January	July	September
34	Bungkuk Bridge	January	July	September
35	Yos Sudarso Bridge	January	July	September
36	Petekan Bridge	-	July	September

Table 4.8 shows he frequency when the BBWS do the monitor. It can be seen that not all the location have the same distribution frequencies. For example, Yos Sudarso Bridge has 6 months gap from first interval to second interval and 2 months gap from second interval to third interval, meanwhile Sumber Brantas has 4 months interval gap from first interval and 3 months interval from second interval to third interval.

According to Indonesia National Standard on Sampling Procedures for Monitoring Water Quality in River Drainage Area (Chapter 6), determination for monitoring frequencies has to be taken into account due to various situation of water quality that changes inconstantly. For a needed preliminary study, the requirement frequencies can be divided into 4 ways:

a. Every weeks in a year
b. Every day in a row in one week; repeated once on every 13 weeks in a year
c. 4 hours a day in every week; repeated once on every 13 weeks in a year
d. Every hours in a day, repeated once on every 13 weeks in a year

If the preliminary study has not conducted yet, therefore as a general standard requirement, a river should be monitored every 2 weeks.

It can be inferred that unequal distribution of time of monitoring frequencies as it shown in Table 4.8 still does not reach the expected standard, either for the preliminary study standard requirement or the standard requirement. This data cannot fully show the general quality condition in both of Brantas River and Surabaya River.

Table 4.9 shows the equipment that Basin Authority in Brantas River used to execute each parameter. It also shows the method that BBWS uses until now.

Table 4. 9 Equipment and analysis method for each parameter

Parameter	Unit	Using Equipment	Analysis Method
Temperature	°C	Thermometer	SNI 06-6989.23-2005
Turbidity	NTU	Nephelometer	SNI 06-6989.25-2004
Conductivity		Conductivitymeter	SNI 06-6989.1-2004
TSS	mg/L	Analytical Balance	SNI 06-6989.3-2004
TDS	mg/L	Analytical Balance	SNI 06-6989.27-2005
PH	-	pH meter	SNI 06-6989.11-2004
DO	mg/L	Dissolved oxygen meter	SNI 06-6989.14-2004
BOD	mg/L	BOD appartus	S.M.P.5210.B2005
COD	mg/L	Spektrofotometer	SNI 06-6989.2-2004
Ammonia	mg/L	Spektrofotometer	SNI 19-6964.3.2003
Nitrate	mg/L	Spektrofotometer	SNI 06.2480.2004
Nitrite	mg/L	Spektrofotometer	SNI 06-6989.9-2004
Phosphat	mg/L	Spektrofotometer	SNI 19-2483-1991

4.5. Discussion and Result

From sub-chapter 4.4 above, the main problems in Surabaya River monitoring are about the location and the time-frequency.

As mentioned in the previous chapter (Chapter 1: Introduction), the author has made some interview with Mrs. Dian A. Prayitno S.T, M.T., as the Head of Division of Water Quality in BBWS in order to strongly support the reasons why the location and time-frequency have been being the main problems these past years. To sum up, below are some explanations of main problems with the monitoring system:

a. The existing monitoring locations are not integrated yet thus cannot give a general reflection on the real condition of water quality in East Java province, including Surabaya River. Although there are no standard principles on how to choose specific to be monitored, some approaches can be implemented to make a better reflection. However, the approach of some potential monitoring depending on what kind of objectives is needed.

b. Since 2013, the monitoring process cannot be conducted frequently due to old ages of machines. The ideal condition for monitoring the quality of the water is every day, or every hour. More intense the monitoring, more pollutant can be controlled.
c. Lack of funding from the government makes the Basin Authority in Brantas more difficult to update the equipment and tools to monitor the water quality although it follows the Indonesia Standard Method, causing a bit of inaccuracy of the data. The evidences provided in Appendix shows that at some parameters, some data are arguably at the state of an unfeasible value. For example, on January it is shown that the value of BOD is 0, which is impossible. Zero BOD means that no aquatic life will live in the water. Therefore, the feasibility of the tools and equipment should be checked and a solution is needed to optimize the monitoring system.
d. Limitation of the human sources gives an obstacle on execution. Basin Authority in Brantas has 36 points to monitor the quality of Brantas River (including 13 points In Surabaya River). As it is shown in sub-chapter 4.4.1 Table 4.4.1.1, some of the points has a really long distance between each other, which means that it needs a lot of human resources and a long time period of execution of the water quality monitoring. Limitation of the human resources can cause human error and can lead to incomplete monitor to all locations, which can also be supported by the data error in Appendix.
e. Huge discharge with a lot of rubbish and garbage stagnate in surface water is still the main problem in almost every river in Indonesia. This might be caused by lack of awareness by the community. Despite of industrial wastewater and domestic wastewater, garbage

stagnate makes even the quality of Surabaya River decreased.

From the statements above, it can be concluded that point (a) is most likely the main reason why some villages and industries have not been monitored yet as it stated in sub-chapter 4.1. Point (b), (c), (d) are most likely the main reasons why time-frequency is very limited and the reason why there are some missing-data during the monitoring period as it shown in Appendix 3. Despite of industrial and domestic wastetwater, point (e) also the reason why the quality of the water in Surabaya River more even poor during the time.

4.6. Solution to optimize the monitoring system

4.6.1. Adding more location to monitor the quality water

Adding more location to monitor the water quality in Surabaya River can be implemented to optimize the monitoring system. This recommendation based on some approaches that have been undergone in chapter IV (data and analysis). There are two potential locations included and one of them is considered to be a critical point. These can be added as new locations in order to control the water quality more intensively in the future. These location will be explained below:

A. Critical location

Point 1 and 2 are considered as both critical and potential locations. These points located along Marmoyo River and Lamong River. These points are considered because 2 reasons: there is no existing points in which stakeholders can monitor the water quality and some villages and industries located along this Surabaya River sub-branches. Furthermore, the downstream of Lamong River meets Surabaya River next to Karang Pilang Bridge, where one of the local drinking takes the water sample and use the water to be processed as drinking water. Along Marmoyo River and Lamong River, there are several villages that becomes the source of the domestic wastewater. These villages include Mlirip Village, Penambangan Village, Ngelok Village, Sidomulyo Village, and Tempel Village, and some industries. Point 1 and 2 can be seen on figure below. Hence, point 2 can be the start point (before the waterwater flows) and point 3 as the finish point (after the wastewater flows and contaminates) to control the water quality.

Figure 4. 20 New potential locations: point 1 and point 2
(Yellow line is Marmoyo River and Lamong River)

B. Potential location

Point 3 is considered to be a potential location. Point 1 is located in the middle of Segment II, where the length of its segment is 15 kilometers and three river flows meet. In other words, this point can also be a new location because it covers few villages that have not been monitored yet, including Bendung Village, Mojolebak Village, Kupang Village, Ngabar Village, Jetis Village, and Canggu Village as it is mentioned on previous sub-chapter (Table 4.6). Point 3 can be seen on figure below.

Figure 4. 21 New potential location: Point 3

SWOT analysis on adding more location:

Strength

- Possibility to control the water quality more efficiently
- More water quality data to be assessed
- Approaching more location as source of pollutant

Weakness

- Fixed location and need to be adjusted by some statistic and algorithm approach in order to be fully integrated with old locations
- Need more human resources to execute

Opportunities

- Potential source of information for the stakeholders to control wastewater and pollution

Threats

- Need more operational cost

4.6.2. Data logger as a first step to indicate the pollution

Data logger is an electronic instrument that records measurement at set intervals over a period of time. Depending on the particular data logger, measurement can include air temperature, differential pressure, water temperature, water level, dissolve oxygen, etc. Data loggers are typically compact, battery-powered devices equipped with an internal microprocessor, data storage, and one or more sensor. They can be deployed underwater and can record data for up to months at a time, unattended.

Data logger can be one of methods to indicate whether or not the water is contaminating during the time. Once the water contaminates, a huge deviation will appear over the graph.

In this research project, the author tries to find some data logger that might be fit with Surabaya River condition. The requirements for the needed data logger will be explained below:

- The data logger can be unattended, give real-time data, and has a capability to transfer the data into PC or Smartphone immediately;

- The data logger is relatively cheap and able to measure some physical parameters in one equipment;
- The data logger can be used in a stream river and surface water and can efficiently reduce the human resources to operate thus save some operation cost

In this case, data logger can be placed at Bambe Bridge, Perning Bridge, and point 3 for future recommendation. The author thinks that those locations are potentially to be monitored by data logger as three points that can show the institution the time when the water is being contaminated by some pollutants. Beside, as it discussed in sub-chapter 4.3 it is shown almost all parameters have high result at Perning Bridge and Bambe Bridge. Therefore, adding a data logger to be first step to indicate the pollutant can be one of ways to optimize monitoring system in Surabaya River.

One of the data logger that mostly meets the requirement criteria above comes from company called In-Situ Inc and the product called Aqua TROLL 600 Multi Parameters. This product offers some features including measure up to 8 parameters (temperature, conductivity, turbidity, dissolved oxyen, water level; ammonium, chloride, and nitrate as additional options). The feature also offers a connection to smartphone and PC, long-last power battery, and can be applied in surface water, groundwater, freshwater and salt water.

Figure 4. 22 Locations where data logger can be applied as a first step to indicate contamination

Figure 4. 23 Example of data logger (Aqua TROLL 600 Multi Parameters by In-Situ Inc. Company)

SWOT analysis
Strength:

- Time-efficiency and unattended, data loggers use battery for the power and can be left in the field during the monitoring
- Usually data logger can be set for every hour, every second, or every minutes depending on what users need
- Many companies offer data logger that can measure few parameters in one equipment
- Automatically transfer the data into PC/smartphone

Weakness:

- Relatively expensive
- Usually basic data logger can only measure physical parameters
- Although data loggers can be unattended, some of them need a cable to apply

Opportunities:

- With its last-long battery power, data logger can be placed in some locations where the status is heavily contaminated or critical point as a first step to indicate the time when the water is being polluted

Threats:

- While the cost is relatively expensive, data logger can be stolen by irresponsible community

4.6.3. Biological monitoring (biomonitoring)

One of the recommendations to optimize the monitoring system in Surabaya River is implementation of biomonitoring as further monitoring.

Biological monitoring, as known as biomonitoring, is the use of biological responses to assess changes in the environment, generally changes due to anthropogenic causes in which the objectives may be qualitative, semi-quantitative, or quantitative with addition of valuable assessment tool that is receiving increased use in water quality monitoring programs of all type (Watershedds, n.d.). In the operational context, the term aquatic biomonitoring is used to refer to the gathering of biological data in both the laboratory and the field for the purposes of making some sort of assessment, or in determining whether regulatory standards and criteria are being met in aquatic ecosystems (Hohls, 1996). Biomonitoring involves the use of indicators, indicator species or indicator communities. These indicators are generally benthic macro invertebrates, fish, and/or algae. (Phillips and Rainbow, 1993; Batiuk et al., 1992 cited in Watershedds, n.d.)

Advantages:

- Measure effects in which the bioavailability of the compound(s) of interest is integrated with the concentration of the compounds and their intrinsic toxicity;
- Most biological measurement form the only way of integrating the effects on a large number of individual and interactive processes;
- Cheaper, more precise and more sensitive than chemical analysis to detect adverse conditions in the environment.

However, the disadvantages of biological effect measurements are that sometimes it is very difficult to relate the observed effects to specific aspects of pollution. Furthermore, in view of the present chemical oriented pollution abatement policies and to reveal chemical specific problems, biological effects analysis will never totally replace chemical analysis.

The use of biomonitoring provides information that can be used in various ways. These data therefore can help the users to understand what particles are existed in the environment within its relative hierarchical. Furthermore, this hierarchical shown how it changed by the time and what sectors in particular population who have high unusual exposure related to certain compound(s). In addition, this activity can be used to evaluate health risk related to material pollutant(s). There are several various biomonotoring: metal biomonitoring, organic particle biomonitoring, liquid waste biomonitoring, air pollutants biomonitoring, acidication biomonitoring, and human's health biomonitoring

Biomonitoring can be implemented in Surabaya River in which collaborated with biological analysts and/or experts during the monitoring to evaluate its water quality. This kind of monitoring can help the users, both the government and responsible stakeholders, to discover whether there are kind of pollutant(s) that needs to be considered as basic standard parameters in order to make new government's policy. Furthermore, it helps stakeholders such as BBWS and Jasa Tirta to not only improve the water quality but also saving aquatic life from toxic and other chemical contaminations. Biomonitoring can be utilized not only to make a better water quality but also saving human and inhibitant's life in the future.

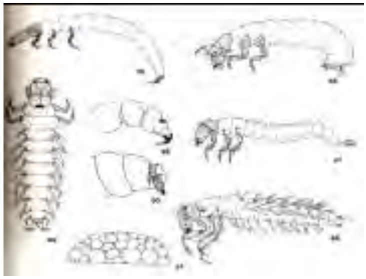


Figure 4. 24 Example of biomonitoring

(Left side: Biomonitoring participated by community, held by NGO Ecoton; Right side: Example of invertebrates to assess chemical compound(s) by Biomonitoring)

SWOT analysis of biomonitoring

Strength:

- Relatively cheap
- Chance to predict a new chemical contamination during time
- Can be applied everywhere, anytime

Weakness:

- Need biological specialist/experts to determine the right species
- Need specific laboratory to process biomonitoring
- Cannot assess inorganic chemical (organic chemical particles only)
- Takes a long time to analyze the right parameter
- Still need lab-based assessment to analyze all the parameters of the quality

Opportunities:

- Persuade the community to get involved during the observation
- Awareness of the community to take care of the environment

Threat

- Depends on the environmental, because it needs particular species that can be means to determine which parameters is contaminated the water

4.6.4. Creative water quality sensor

Creative water quality sensor is an original idea from the author itself. This idea inspired by Floating Garden that has been conducted on some research in Netherlands in which the prototype has already implementated in Rotterdam, Netherlands. While the floating garden has a capability to help the water self-cleaning, some sensors or data logger can be attached into this floating garden, making a creative water quality sensor.

Floating garden itself comes as a new innovation inspired by Bangaldesh condition, when the water covers some area during the monsoon season and the people who live in this certain area can not grow crops. Floating garden becomes a clever solution that employs the use of the water hyacinth, which is collected to construct a raft. This is then covered with soil and cow dung, in which vegetables can be planted.

In 2015, Europe's first floating island in the project "Floating Greenery" (*Dutch: Drijveren Groen)* has unveiled. The project, devised by Tieme Haddeman, is in response to the wishes of Mayor Aboutaleb, who is busy making the ciry greener place. Haddeman, owner of Urban Green, focuses on two goals; to improve spatial planning and enhance the quality of the water. The first prototype itself unveiled in the Dokhaven of RDM Rotterdam on March 2015.

Figure 4. 25 Idea of creative water quality sensor

This floating garden can be a future solution to monitor the water quality. The idea is to attach the water quality data logger / sensor into the structure while its plants can provide a a cleaning function. Another idea is to fit variery of sculptures of animals (or other objects) into this floating garden that could react with the quality of the water. The idea of these sculptures inspired by pink flamingo that turns to pink when they eat something that is contaminated by Caretonoids substrate or like the algae that grows quickly that indicates high amount of phosphate. These sculptures could be as complex as a skin containing a substance/chemical that is flushed with the local water and changes color according to water quality, or could be as simple as repainting or changing the 'skin' or the structure or object after carrying out a water quality monitoring test.

Some options / steps to implementate this creative water quality will be explanated below:

- Select optimal implementation locations
- Create floating garden foundations and fixation points
- Add plants
- Add variety of sculptures/objects
- Use and attach water quality monitoring equipment (data logger and/or sensor)
- The appearance / color of sculptures/object can react with the quality of water, depending on the parameters
- This creative water quality monitoring can moving from location toward the pollutant source if needed

However, this idea is needed to be observed further. This idea can also be implemented by adapting the way under-drone monitoring works.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1. Conclusion

This study was conducted for the purpose of determine the pollutant source and optimize the monitoring system in Surabaya River. As a part of research team that conduct this research project, the author concern on evaluating monitoring system in Surabaya River thus giving some alternatives to optimize the current monitoring. Quantitive method of research has been done and the field observation, interview, and case study was used for gathering the data.

The conclusion of this thesis project will be explained below.

1. Surabaya River as one of sub-branches of Brantas River is flowing through 3 districts and 1 city, within more than 80 villages dispose domestic wastewater both directly and directly to Surabaya River. As it assumed that population with and without sanitation contributes the highest value of the domestic wastewater (based on World Health Organization, Indonesia National Standard, and previous research in 1994), it can be predicted that approximately 15207.7 m3 of domestic wastewater discharge and 7794.34 kgs of BOD loads flow into Surabaya River in a day. While the average BOD concentration is estimated 482.97 mg/L**,** the analysis shown that there is an increasing of BOD concentration inconstantly. This can be concluded as the impact of industrial development, population growth, and even distribution of population in East Java.
2. From 12 measure parameters, 6 parameters achieve the standard and the others still do not achive. 16 industries are also excessing the allowed wastewater as it stipulated

by the government. This leads into the state of the water is heavily contaminated.

3. BBWS as one of the insitutions that is responsible to Surabaya River has also contiributed to monitor the quality of the water in a certain period. In fact, old ages of machine, lack of funding from the government, and limitation of human resources have been the main serious obstacles, impacting on very limited time-frequency to execute the monitoring in a year that even does not reach the standard as it stipulated by Indonesia National Standard. Furthermore, although there are 36 locations of monitoring in Brantas River (including 13 locations in Surabaya River), it is stated that these locations are not fully integrated thus can not really reflect the general condition of quality of the Surabaya River itself. This is proven by 13 villages that is potentially dispose domestic wastewater and 3 industries that is exceed the allowed capacity as it stipulated by the government have not been being monitored yet by the existing locations. In addition, most of the graphs that shows the quality of the River in particular parameters shown significant fluctuations between Perning Bridge, Legundi Bridge, and Bambe Bridge. This is caused by the exact locations itself that is chosen in small rivers near to industrial area.
4. While time and location can be argued as the main problem occur in monitoring system, some solutions have been offered to optimize the monitoring. Adding some locations (including critical location and potential location) can be implemented to control the areas that have not been controlled yet. Use of particular data logger(s) can be applied as a first step of indicate the pollutant, preventing lack of time-frequencies and efficiency of human resources. Biomonitoring can be conducted in order to track new toxic and/or particular contaminations during urban development in East Java.

Last, creative water quality system as a new sustainable monitoring system can be established in order to control the quality of the water with a friendly way, cost-saver, time-efficiency, and in addition to increase the capability of the water to purify itself during the time. However, due to limidity of the time, further research about creative water quality sensor is strongly needed in order to make it real and possible to be implementated. SWOT analysis of every solutions have been explained to give some insight of pro's and con's.

5.2. Recommendation

Due to limidity of the time and lack of the data, and after undergone the analysis, some recommendations are needed. This will be explained below:

- Real discharge calculation of Surabaya River is needed in order to analyse the further and deeper correlation between each parameter against the surface water, how the characteristic of contamination(s) affect the quality of the water during certain time, and the relation between river discharge and wastewater.
- More data are needed to make the calculation more accurate thus can really do the hydrological analysis (i.e. river discharge, evapotranspiration, water balance, etc.)
- On-site investigation and real time data of the measure parameters are needed in order to gain more accurate data.
- The analysis of wastewater is not only the domestic wastewater but the industrial wastewater, fertizilation wastewater, and other wastewater that contaminates Surabaya River are needed in order to calculate and analyze the allowed capacity of contamination load(s) can be accepted by Surabaya River (i.e. BOD, COD, Nitrite, etc).

- Not only adding some locations, but also redesign a networking system of water quality monitoring locations is needed to be conducted as a futher integration of monitoring locations thus can approach the general condition of Surabaya River itself better.
- Trial of use of data logger and implementation of biomonitoring needs to be held in order to evaluate whether or not these solutions will optimize the monitoring system and reducing the main problem.
- Further and future research about creative water quality sensor needs to be conducted in order to make this solution becomes real and possible to implementate.

Improving Surabaya River is not a simple way to undergo, it takes a long time and contributes both the government with its responsible institutions and the community and people itself. While the urban development is being wider, the concern of controlling the quality of significant rivers including Brantas River and Surabaya River are strongly needed. A lot of researches, millions of idea, and everlasting discussions and evaluation might have been undergone but the main key is despite of what researcher(s) and government have done to improve the Surabaya River, we ourselves as the people and the community who use this resources strongly need to more aware and take care of the environment seriously. Hence, this will lead into a synergic-dynamic process to develop Indonesia in the future.

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APPENDIX

APPENDIX 1 Monitoring Locations

No	Place, Location, City/District	No	Place, Location, City/District
1	**Sumber Brantas**	11	**Tambangan Ngrombot**
	Brantas River Upstream		Central Brantas River
	Sumber Brantas Village, Batu		Ngrombot Village, Patianrowo Sub-District, Nganjuk
2	**Brantas Bridge**	12	**Begendheng Bridge**
	Brantas River Upstream, Mulyorejo Village		Widas River Estuary, Sub-Branch Central Brantas River
	Pujon, Batu City		Begendheng Village, Jatikalen Sub-District, Nganjuk
3	**Pendem Bridge**	13	**Munung Bridge**
	Brantas River Upstream		Beng River Estuary, Sub-Branch Central Brantas River
	Batu City		Munung Village, Jatikalen Sub-District, Nganjuk
4	**Sengguruh Bridge**	14	**Ploso Jombang Bridge**
	Brantas River Upstream		Brantas River Downstream
	Sengguruh Dam, Kepanjen, Malang District		Ploso, Jombang
5	**Brawijaya Bridge**	15	**Tambangan Pabrik Cheil Jedang**
	Brantas River Upstream		Brantas River Downstream
	Ngembul Vullage, Binangun Sub-Distric, Blitar		Jatigedong, Ploso, Jombang
6	**Trisula Kademangan Bridge**	16	**Tambangan Betro Mojokerto**
	Brantas River Upstream		Brantas River Downstream
	Blitar		Kesamben Village, Kemlagi Sub-District, Mojokerto
7	**Karangrejo Bridge**	17	**Lesa Padangan Bridge**
	Ngrowo River Estuary, Sub-Branch Central Brantas River		Brantas River Downstream
	Karangrejo Village, Karangrejo Sub-District, Tulungagung		Pandangan, Mojokerto
8	**Tambangan Maesan**	18	**Pulorejo Bridge**
	Central Brantas River		Brangkas River Estuary, Sub-Branch Brantas River Downstream
	Maesan Village, Mojo Sub-District, Kediri		Pulorejo, Mojokerto
9	**Jong Biru Bridge**	19	**Mojokerto Highway Birdge**
	Central Brantas River		Brantas River Downstream
	Jong Biru Village, Gampangrejo Sub-District, Kediri		Mojokerto
10	**Kertosono - Jombang Old Bridge**	20	**Ngoro Bridge**
	Central Brantas River		Sadar River Estuary, Porong Sub-Branch River
	Border of Kertosono - Jombang		Sukoanyar Village, Ngoro Mojokerto Sub-District

No	Place, Location, City/District
21	**Carat Bridge**
	Kambeng River Estuary, Porong Sub-Branch River
	Gempol, Bordery of Pasuruan - Sidoarjo
22	**Porong Bridge**
	Porong Central Sub-Branch River
	Porong main road, Sidoarjo
23	**Tambangan Tlocor**
	Porong River Estuary, Brantas Sub-Branch River Downstream
	Sidoarjo
24	**Perum Jetis Permai Bridge**
	Surabaya River Upstream, Brantas Sub-Branch Downstream
	Jetis Permai Real Estate, Mojokerto
25	**Jetis IV Bridge**
	Marmoyo River Estuary, Sub-Branch of Surabaya River
	Jetis Village, Mojokerto
26	**Perning Bridge**
	Kwangen River Estuary, Sub-Branch of Surabaya River
	Jetis Village, Mojokerto
27	**Legundi Bridge**
	Central Surabaya River, Sub-Branch of Brantas Downstream
	Legundi, Krian Sub-District, Sidoarjo
28	**Bambe Bridge**
	Central River Estuary, Sub-Branch of Surabaya River
	Bambe Sub-District, Gresik
29	**Karangpilang Bridge**
	Surabaya River Downstream, Sub-Branch of Brantas Downstream
	Bordery of Sidoarjo - Surabaya
30	**Joyoboyo Bridge**
	Surabaya River Estuary, Sub-Branch of Brantas Downstream
	Joyoboyo, Wonokromo Sub-District, Surabaya
31	**Jagir Wonokromo Bridge**
	Wonokromo River Upstream, Sub-Branch of Surabaya River
	Surabaya
32	**Nginden Intan Bridge**
	Central Monokromo River, Sub-Branch of Surabaya River
	Nginden Intan, Surabaya
33	**Tambangan Wonorejo**
	Wonokromo River Estuary, Sub-Branch of Surabaya River
	Wonorejo, Surabaya
34	**Bungkuk Bridge**
	Central Mas River, Sub-Branch of Surabaya River
	Ngagel, Surabaya
35	**Yos Sudarso Bridge**
	Central Mas River, Sub-Branch of Surabaya River
	Yos Sudarso Main Road, Surabaya
36	**Petekan Bridge**
	Mas River Estuary, Sub-Branch of Surabaya River
	Perak, Surabaya

Annotate:

= Start Points of Surabaya River

= Split into 2 Sub-Branches

= Mas River

= Wonokromo River

APPENDIX 2: Water Quality Data

Parameter	Period	Location Point												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Turbidity	1st Interval	101	121	44.3	36.7	320	70.1	46.3	42.6	59.3	35.8	44	33.9	25.2
	2nd Inteval	15.1	7.7	197	14.9	25.8	32.2	26.4	27.2	23.7	12.9	24.7	44.6	29.4
	3rd Interval	8.03	25.7	188	5.26	10.3	15.9	10.6	10.6	16.2	17.1	13.5	51	52.4
	Standards	25	25	25	25	25	25	25	25	25	25	25	25	25
TSS	1st Interval	156	169	22	106	256	101	76	71	99	76	97	56	60
	2nd Inteval	3	20	48	14	16	23	8	17	14	3	23	27	19
	3rd Interval	86	31	70	1	10	6	5	3	2	4	13	23	53
	Standards	50	50	50	50	50	50	50	50	50	50	50	50	50
TDS	1st Interval	230	329	496	238	556	241	276	277	251	261	273	263	270
	2nd Inteval	225	306	801	230	648	241	249	251	254	272	245	252	251
	3rd Interval	212	304	876	225	897	242	253	252	293	629	253	259	276
	Standards	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
DHL	1st Interval	479	677	1004	491	1251	498	575	573	519	539	563	540	546
	2nd Inteval	466	631	1617	478	1334	500	515	520	526	560	497	519	523
	3rd Interval	440	624	1740	464	1809	498	522	523	597	1264	521	536	569
	Min. Standards	20	20	20	20	20	20	20	20	20	20	20	20	20
	Max. Standard	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
PH	1st Interval	7.2	7.19	7.68	7.51	7.13	7.6	7.7	7.81	6.7	7.52	7.7	7.9	7.52
	2nd Inteval	0	7.98	7.18	0	7.81	0	0	0	0	0	0	0	0
	3rd Interval	8.02	7.86	6.88	7.88	7.63	7.82	7.69	7.79	7.77	7.8	7.71	7.88	7.77
	Min. Standards	6	6	6	6	6	6	6	6	6	6	6	6	6
	Max. Standard	9	9	9	9	9	9	9	9	9	9	9	9	9

Parameter	Period	Location Point												
		1	2	3	4	5	6	7	8	9	10	11	12	13
DO (mg/L)	1st Interval	6.69	6.59	4.21	5.66	6.32	4.27	3.52	5.06	5.62	5.31	4.39	4.73	3.14
	2nd Inteval	7.33	8.36	1.81	5.69	3.51	4.5	4.99	5.8	6.53	5.57	4.51	4.65	7.29
	3rd Interval	7.31	7.09	2.08	5.08	3.6	5.01	4.63	4.59	4.56	5.28	4.7	5.07	3.27
	Standards	4	4	4	4	4	4	4	4	4	4	4	4	4
BOD (mg/L)	1st Interval	0	0	0	0	0	0	0	0	0	0	0	0	0
	2nd Inteval	5.2	11	40	0.9	28	20	2.3	7.4	6.3	5	4.6	13	0.2
	3rd Interval	11	6.3	43	6.8	10	14	8	1.5	4.6	11	1.3	5.5	8.9
	Standards	3	3	3	3	3	3	3	3	3	3	3	3	3
COD (mg/L)	1st Interval	26	5	39	36	38	25	13	14	10	52	12	40	39
	2nd Inteval	2	17	65	1	34	4	2	4	2	1	1	2	1
	3rd Interval	2	2	133	30	58	24	63	6	6	5	8	2	6
	Standards	25	25	25	25	25	25	25	25	25	25	25	25	25
Ammonia (mg/L)	1st Interval	0.11	0.16	1.3	0.18	1	0.08	0.22	0.8	0.09	0.03	0.03	0.8	0.32
	2nd Inteval	0.13	0.03	9.6	0.2	2.7	0.23	0.34	0.7	1.7	1.3	0.46	1.7	0.9
	3rd Interval	0.08	0.22	23	0.1	10	0.05	0.8	0.6	1.9	0.6	0.9	1.1	0.9
	Standards	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Nitrate (mg/L)	1st Interval	1.3	1.4	7.8	1.2	1.7	1.9	8	7	7	8	5	8	9
	2nd Inteval	2.2	0.9	6.6	1.8	0.5	1.6	1.8	2.1	2.3	2.2	2.3	2.4	2
	3rd Interval	1.6	0.3	5	1.6	3	2.4	2.4	1	1.6	1.1	1.3	1.2	1.7
	Standards	10	10	10	10	10	10	10	10	10	10	10	10	10
Nitrite (mg/L)	1st Interval	0.013	0.013	0.015	0.012	0.107	0.135	0.85	0.43	0.66	0.54	1.24	0.78	0.97
	2nd Inteval	0.06	0.015	0.13	0.024	0.009	0.167	0.053	0.143	0.121	0.111	0.108	0.162	0.194
	3rd Interval	0.108	0.025	0.6	0.079	0.36	0.065	0.086	0.068	0.136	0.132	0.72	0.134	0.246
	Standards	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Phospat (mg/L)	1st Interval	0.9	1.63	8.6	0.93	0.96	0.88	1.25	1.2	0.89	1.78	1.18	1.15	1.13
	2nd Inteval	0.8	0.75	30	0.84	5.1	0.77	1.2	0.73	1.12	1.06	0.79	0.96	1.28
	3rd Interval	0.73	0.96	53.6	0.83	0.27	0.89	0.92	0.94	1.09	1.02	0.91	0.88	1.32
	Standards	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

APPENDIX 3: Location and population along Surabaya River in 2016

Area	Sub-District	Village	District / City	Total Population (2016)	Percentage Population in Zone 500 m (%)	Population in Zone 500 m	Population without sanitation (%)	Total Population without Sanitation	Area	Total Population With Sanitation Facilities	BOD Load (kg/day)	Q load (m3/day)	BOD Concentration (mg/L)	Zone Area
A	B	C	D	E	F	G = E x F	H	I = G x H	A	J = G - I	K	L	M	N
Mlirip into Marmoyo River	Jetis	Jetis (40%)	Mojokerto District	2429	100.00	2429	23.86	580	Mlirip into Marmoyo River	1850	55.61	116.60	476.93	D1
		Canggu	Mojokerto District	11575	49.96	5783		1380		4403	132.39	277.59	476.93	
		Mlirip		6972	24.94	1739		415		1324	39.81	83.48	476.93	
	Tarik	Kramat Temanggung	Sidoarjo District	2224	50.17	1116	9.85	110		1006	24.57	53.56	458.78	D2
	Balungbendo	Singkalan		2971	29.97	890	10.28	92		799	19.63	42.74	459.34	
Marmoyo River	Jetis	Jetis (60%)	Mojokerto District	3644	100.00	3644	23.86	869	Marmoyo River	2774	83.42	174.90	476.93	D3
		Perning (30%)		1217	100.00	1217		290		926	27.85	58.39	476.93	
		Mojolebak		5018	70.65	3545		846		2699	81.16	170.18	476.93	
		Bendung		4694	29.96	1406		336		1071	32.20	67.51	476.93	
		Ngabar		5948	40.35	2400		573		1828	54.95	115.21	476.93	
		Kupang		5090	39.94	2033		485		1548	46.53	97.57	476.93	
		Banjarsari		4795	6.98	335		80		255	7.66	16.07	476.93	
Marmoyo River into Lamong River	Jetis	Perning (70%)	Mojokerto District	2839	100.00	2839	23.86	677	Marmoyo River into Lamong River	2161	64.98	136.25	476.93	D4
	Wringin Anom	Sumberrame	Gresik District	3783	49.89	1887	0	0		1887	40.41	90.59	446.03	
		Kedaung Anyar		2747	69.99	1923		0		1923	41.16	92.29	446.03	
	Balungbendo	Kedung Sukodani	Sidoarjo District	2838	39.94	1134	10.28	117		1017	24.99	54.41	459.34	
		Bakung Pringgodani		3661	45.08	1650		170		1481	36.39	79.22	459.34	
		Bogempinggir		2552	44.99	1148		118		1030	25.31	55.11	459.34	
	Wringin Anom	Pasinan Lemah Putih (50%)	Gresik District	3060	59.99	1835	0	0		1835	39.29	88.09	446.03	D5
		Sumengko		6551	49.97	3273		0		3273	70.08	157.12	446.03	
		Lebani Waras		2846	100.00	2846		0		2846	60.93	136.61	446.03	
		Wringin Anom		4429	85.07	3768		0		3768	80.67	180.86	446.03	
	Balungbendo	Penambangan	Sidoarjo District	5966	29.96	1787	10.28	184		1603	39.40	85.78	459.34	
		Jeruk Legi		3405	30.01	1022		105		917	22.53	49.05	459.34	
	Krian	Sidomulyo	Sidoarjo District	5686	44.97	2557	8.76	224		2333	56.13	122.73	457.37	
Lamong River	Wringin Anom	Kesambenkulon	Gresik District	5798	39.55	2293	0	0	Lamong River	2293	49.10	110.07	446.03	D6
		Suko		3585	15.06	540		0		540	11.56	25.91	446.03	
		Jembung		3232	19.92	644		0		644	13.78	30.90	446.03	
		Pedagangan		4535	50.04	2269		0		2269	48.58	108.92	446.03	
		Wastetanjung		3954	9.95	393		0		393	8.42	18.88	446.03	
		Pasinanlemah Putih (50%)		3060	60.06	1837		0		1837	39.34	88.20	446.03	

Area	Sub-District	Village	District / City	Total Population (2016)	Percentage Population in Zone 500 m (%)	Population in Zone 500 m	Population without sanitation (%)	Total Population without Sanitation	Area	Total Population With Sanitation Facilities	BOD Load (kg/day)	Q load (m3/day)	BOD Concentration (mg/L)	Zone Area
A	B	C	D	E	F	G = E x F	H	I = G x H	A	J = G - I	K	L	M	N
Kedondong River	Driyorejo	Karangandong	Gresik District	2951	100.00	2951	3.74	110	Kedondong River	2841	63.87	141.65	450.87	D6
		Banjaran		5499	59.91	3294		123		3171	71.30	158.14	450.87	
Lamong River into Central River (right side)	Krian	Tempel	Sidoarjo District	7329	100.00	7329	8.76	642	Lamong River into Central River (right side)	6687	160.90	351.79	457.37	D7
		Barengkrajan		8409	19.95	1677		147		1530	36.83	80.52	457.37	
	Taman	Petapan Madu Retno	Sidoarjo District	4120	15.16	625	2.96	18		606	13.49	29.99	449.86	
		Tanjungsari		6392	59.95	3832		113		3718	82.74	183.93	449.86	D8
		Krembangan		4124	75.07	3096		92		3004	66.85	148.60	449.86	
Central River	Driyorejo	Mojosarirejo	Gresik District	2107	35.03	738	3.74	28	Central River	711	15.97	35.43	450.87	D9
		Sumput		8426	74.98	6318		236		6082	136.73	303.27	450.87	
		Kesamben Wetan		3925	49.90	1958		73		1885	42.38	94.00	450.87	
		Petiken		10422	29.98	3124		117		3007	67.62	149.97	450.87	
		Tenaru		2748	35.07	964		36		928	20.85	46.25	450.87	
		Mulung		2552	39.95	1020		38		981	22.07	48.94	450.87	
Lamong River into Central River (left side)	Driyorejo	Driyorejo	Gresik District	6632	100.00	6632	3.74	248	Lamong River into Central River (left side)	6384	143.53	318.34	450.87	
		Cangkir		4583	100.00	4583		171		4412	99.18	219.98	450.87	
		Banbe		3568	100.00	3568		133		3435	77.22	171.26	450.87	
		Krikilan		1671	100.00	1671		62		1609	36.16	80.21	450.87	
Central River into Kedurus River (left side)	Karangpilang	Karangpilang	Surabaya City	11741	100.00	11741	1.16	136	Central River into Kedurus River (left side)	11605	310.42	563.57	550.81	D10
		Warugunung		8872	100.00	8872		103		8769	234.56	425.86	550.81	
	Taman	Tawangsari	Sidoarjo District	2998	59.97	1798	2.96	53		1745	38.82	86.30	449.86	D11
		Ngelok		5005	75.09	3758		111		3647	81.15	180.39	449.86	
		Wonocolo		9198	59.99	5518		163		5355	119.15	264.87	449.86	

Area	Sub-District	Village	District / City	Total Population (2016)	Percentage Population in Zone 500 m (%)	Population in Zone 500 m	Population without sanitation (%)	Total Population without Sanitation	Area	Total Population With Sanitation Facilities	BOD Load (kg/day)	Q load (m3/day)	BOD Concentration (mg/L)	Zone Area
A	B	C	D	E	F	G = E x F	H	I = G x H	A	J = G - I	K	L	M	N
Central River into Kedurus River (right side)	Taman	Bebekan	Sidoarjo District	8162	50.03	4083	2.96	121	Central River into Kedurus River (right side)	3962	88.17	196.00	449.86	D12
		Sepanjang		11458	50.02	5731		170		5562	123.76	275.10	449.86	
	Karangpilang	Kedurus	Surabaya City	29314	100.00	29314	1.16	340		28974	775.03	1407.07	550.81	
		Kebraon		29023	85.00	24668		286		24382	652.20	1184.07	550.81	
	Jambangan	Pagesangan	Surabaya City	4842	25.07	1214	0.04	0		1214	31.99	58.27	549.02	
		Kebonsari		10242	20.05	2054		1		2053	54.13	98.59	549.02	D13
		Jambangan		10176	29.68	3020		1		3019	79.60	144.98	549.02	
		Karah		17893	14.98	2680		1		2678	70.61	128.62	549.02	
Kedurus River	Wiyung	Jajartunggal	Surabaya City	12390	70.01	8675	0	0	Kedurus River	8675	228.58	416.38	548.96	D14
		Gunungsari		14249	50.01	7126		0		7126	187.78	342.06	548.96	
		Wiyung		19975	100.00	19975		0		19975	526.34	958.80	548.96	
		Babadan		7750	100.00	7750		0		7750	204.21	372.00	548.96	
		Balasklumprik		3819	25.05	957		0		957	25.20	45.91	548.96	
	Lakarsantri	Lidahwetan	Surabaya City	11127	100.00	11127	0.08	9		11118	293.26	534.10	549.09	
		Lidahkulon		16123	100.00	16123		13		16110	424.94	773.90	549.09	
		Jeruk		4713	100.00	4713		4		4709	124.22	226.22	549.09	
Kedurus River into Ngagel	nocolo (Gayung	Ketintang	Surabaya City	17371	10.03	1743	0	0	Kedurus River into Ngagel	1743	45.92	83.65	548.96	D15
	Wonokromo	Sawung Galing	Surabaya City	28751	30.00	8626	1.42	122		8504	228.23	414.05	551.22	
		Wonokromo		44735	19.99	8942		127		8815	236.58	429.19	551.22	
		Jagir		23739	3.17	752		11		741	19.89	36.07	551.22	
		Darmo		16581	1.84	304		4		300	8.05	14.61	551.22	
										TOTAL	7749.34	15207.70		

Note: Yellow data is the data with statistic calculation (growth population)

APPENDIX 4: Growth Population

Years	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Population Growth Rate		0.007	0.007	0.007	0.007	0.007	0.007	0.0076	0.0076	0.0076	0.0076	0.0076
Total Population	2346	2362	2379	2396	2412	2429	2446	2465	2484	2502	2521	2541
	3062	3083	3105	3127	3149	3171	3193	3217	3242	3266	3291	3316
	2761	2780	2800	2819	2839	2859	2879	2901	2923	2945	2968	2990
	3377	3401	3424	3448	3473	3497	3521	3548	3575	3602	3630	3657
	2521	2539	2556	2574	2592	2610	2629	2649	2669	2689	2710	2730
Population Growth Rate		0.007	0.007	0.007	0.007	0.007	0.007	0.0076	0.0076	0.0076	0.0076	0.0076
Total Population	3353	3376	3400	3424	3448	3472	3496	3523	3550	3577	3604	3631
	2347	2363	2380	2397	2413	2430	2447	2466	2485	2504	2523	2542
	2180	2195	2211	2226	2242	2257	2273	2290	2308	2325	2343	2361
	3048	3069	3091	3112	3134	3156	3178	3202	3227	3251	3276	3301
	1427	1437	1447	1457	1467	1478	1488	1499	1511	1522	1534	1545
Population Growth Rate		0.007	0.007	0.007	0.007	0.007	0.007	0.0076	0.0076	0.0076	0.0076	0.0076
Total Population	4275	4305	4335	4365	4396	4427	4458	4492	4526	4560	4595	4630
	6972	7021	7070	7119	7169	7219	7270	7325	7381	7437	7494	7550
	4136	4165	4194	4223	4253	4283	4313	4346	4379	4412	4445	4479
	12171	12256	12342	12428	12515	12603	12691	12788	12885	12983	13081	13181
	6620	6666	6713	6760	6807	6855	6903	6955	7008	7062	7115	7169
Population Growth Rate		0.007	0.007	0.007	0.007	0.007	0.007	0.0076	0.0076	0.0076	0.0076	0.0076
Total Population	3262	3285	3308	3331	3354	3378	3401	3427	3453	3480	3506	3533
	4026	4054	4083	4111	4140	4169	4198	4230	4262	4295	4327	4360

2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0.0076	0.0076	0.0076	0.0076	0.0076	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
2560	2579	2599	2619	2639	2656	2674	2692	2710	2728	2747
3341	3367	3392	3418	3444	3467	3490	3514	3537	3561	3585
3013	3036	3059	3082	3105	3126	3147	3168	3190	3211	3232
3685	3713	3741	3770	3798	3824	3849	3875	3901	3927	3954
2751	2772	2793	2814	2836	2855	2874	2893	2912	2932	2951
0.0076	0.0076	0.0076	0.0076	0.0076	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
3659	3687	3715	3743	3771	3797	3822	3848	3873	3899	3925
2561	2581	2600	2620	2640	2657	2675	2693	2711	2729	2748
2379	2397	2415	2433	2452	2468	2485	2502	2518	2535	2552
3326	3351	3377	3402	3428	3451	3474	3498	3521	3545	3568
1557	1569	1581	1593	1605	1616	1627	1638	1648	1660	1671
0.0076	0.0076	0.0076	0.0076	0.0076	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
4665	4700	4736	4772	4808	4841	4873	4906	4938	4972	5005
7608	7666	7724	7783	7842	7894	7947	8000	8054	8108	8162
4513	4548	4582	4617	4652	4683	4715	4746	4778	4810	4842
13281	13382	13484	13586	13689	13781	13873	13966	14060	14154	14249
7224	7279	7334	7390	7446	7496	7546	7597	7647	7699	7750
0.0076	0.0076	0.0076	0.0076	0.0076	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
3560	3587	3614	3641	3669	3694	3718	3743	3768	3794	3819
4393	4427	4460	4494	4528	4559	4589	4620	4651	4682	4713

APPENDIX 5: Population with Sanitation Facilities in Surabaya

No	Nama Kabupaten	Nama Kecamatan	Identitas Data (Data aktual ter-entry / Data di BPS)		Baseline					Kemajuan				
			Jumlah Desa/Kel	Jumlah KK	JSP	JSSP	Sharing	BABS	% Akses Jamban	JSP	JSSP	Sharing	BABS	% Akses Jamban
					KK	KK	KK	KK		KK	KK	KK	KK	
1	SURABAYA	SAMBIKEREP	4/4	16.764/17.469	16.641	56	67	0	100.00	16.641	56	67	0	100.00
2	SURABAYA	WIYUNG	4/4	18.723/19.751	16.687	879	302	32	99.77	17.877	809	37	0	100.00
3	SURABAYA	GAYUNGAN	4/4	14.055/13.273	12.310	1.353	842	316	98.26	12.959	715	381	0	100.00
4	SURABAYA	JAMBANGAN	4/4	14.286/14.286	13.293	303	143	223	98.34	13.835	303	143	5	99.96

5	SURABAYA	LAKARSANTRI	6/6	16.638/16.170	16.454	148	2	34	99.81	16.474	146	2	16	99.92
6	SURABAYA	TAMBAKSARI	8/8	33.193/66.147	30.249	1.647	1.263	34	99.90	30.249	1.647	1.263	34	99.90
7	SURABAYA	DUKUH PAKIS	4/4	15.960/17.708	12.192	3.103	20	645	95.96	12.812	3.103	20	25	99.85
8	SURABAYA	TEGALSARI	5/5	17.466/31.298	13.599	2.000	1.726	91	99.48	13.674	2.000	1.726	66	99.68
9	SURABAYA	PABEAN CANTIAN	5/5	22.925/24.550	16.475	6.243	114	93	99.52	16.475	6.243	114	93	99.52

20	SURABAYA	TENGGILIS MEJOYO	4/4	16.434/16.707	10.677	617	1.980	243	97.91	13.865	617	1.765	187	98.53
21	SURABAYA	BUBUTAN	5/5	34.258/31.203	29.306	3.969	594	389	99.05	29.113	3.969	594	582	98.48
22	SURABAYA	SAWAHAN	6/6	57.757/58.189	53.349	2.165	334	1.369	96.99	55.771	868	350	768	98.41
23	SURABAYA	SIMOKERTO	5/5	26.996/29.353	16.581	2.149	1.463	261	98.66	23.345	1.608	1.558	485	98.11
24	SURABAYA	WONOCOLO	5/5	23.424/23.013	14.106	29	44	277	98.22	22.708	18	141	557	97.61

25	SURABAYA	GENTENG	5/5	19.509/18.512	15.093	2.671	674	1.071	95.17	15.631	2.671	674	533	97.31
26	SURABAYA	KREMBANGAN	5/5	37.335/33.610	23.299	1.415	1.607	773	97.71	29.210	3.466	3.255	1.404	96.92
27	SURABAYA	GUNUNG ANYAR	4/4	16.265/15.639	15.659	0	0	606	95.82	15.718	0	0	547	96.18
28	SURABAYA	SEMAMPIR	5/5	48.097/49.136	15.694	7.431	1.868	1.992	94.03	36.468	7.136	1.601	2.892	93.00
29	SURABAYA	BENOWO	4/4	14.683/16.101	14.128	365	6	184	95.32	14.008	365	5	305	92.72

APPENDIX 6: Population with Sanitation Facilities in Gresik

No	Nama Kabupaten	Nama Kecamatan	Identitas Data (Data aktual ter-entry / Data di BPS)		Baseline					Kemajuan				
			Jumlah Desa/Kel	Jumlah KK	JSP	JSSP	Sharing	BABS	% Akses Jamban	JSP	JSSP	Sharing	BABS	% Akses Jamban
					KK	KK	KK	KK		KK	KK	KK	KK	
1	GRESIK	BALONGPANGGANG	25/25	14.232/15.898	8.882	2.536	1.072	1.235	91.01	10.598	3.210	424	0	100.00
2	GRESIK	BENJENG	23/23	17.201/17.182	5.202	8.084	653	2.683	83.80	15.811	1.230	160	0	100.00
3	GRESIK	WRINGINANOM	16/16	21.662/19.169	16.403	1.874	79	3.306	84.35	20.465	1.130	67	0	100.00
4	GRESIK	KEBOMAS	21/21	26.699/28.801	19.928	103	2.897	320	97.89	24.386	18	2.200	95	99.37

5	GRESIK	PANCENG	14/14	13.615/13.296	9.395	2.467	781	968	92.57	11.380	1.557	568	110	99.33
6	GRESIK	MENGANTI	22/22	33.276/31.340	24.334	1.089	683	2.917	89.71	31.942	935	143	256	99.15
7	GRESIK	CERME	25/25	21.048/18.616	16.505	1.682	910	2.000	89.76	20.296	244	339	169	99.11
8	GRESIK	DUKUN	26/26	16.675/16.812	13.586	1.105	133	1.508	92.79	16.135	241	195	104	98.86
9	GRESIK	SIDAYU	21/21	10.716/11.064	11.003	257	219	384	95.66	10.459	57	24	176	98.73
10	GRESIK	KEDAMEAN	15/15	18.568/17.488	5.306	6.310	2.871	2.622	84.06	12.769	4.241	1.392	166	98.43

11	GRESIK	SANGKAPURA	17/17	15.341/13.768	10.810	3.277	1.375	533	96.36	12.252	1.873	926	290	97.99
12	GRESIK	MANYAR	23/23	26.748/26.190	21.667	2.615	597	1.869	88.03	23.031	2.677	719	321	97.94
13	GRESIK	UJUNGPANGKAH	13/13	13.752/12.152	7.729	2.708	446	1.325	91.67	10.536	2.491	297	428	97.81
14	GRESIK	TAMBAK	13/13	6.998/6.546	6.529	644	248	278	96.08	6.368	280	150	200	97.52
15	GRESIK	GRESIK	21/21	22.849/21.121	19.043	1.118	376	1.134	94.77	22.011	115	108	615	97.35

16	GRESIK	DRIYOREJO	16/16	26.299/32.217	13.320	9.778	818	2.382	90.64	15.840	9.221	351	887	96.26
17	GRESIK	DUDUKSAMPEYAN	23/23	13.710/12.023	8.840	284	735	2.033	80.94	11.733	390	1.178	409	96.08
18	GRESIK	BUNGAH	22/22	22.673/13.380	16.003	3.603	380	2.687	80.65	20.930	419	589	735	95.05

APPENDIX 7: Population with Sanitation Facilities in Mojokerto

No	Nama Kabupaten	Nama Kecamatan	Identitas Data (Data aktual ter-entry / Data di BPS)		Baseline					Kemajuan				
			Jumlah Desa/Kel	Jumlah KK	JSP	JSSP	Sharing	BABS	% Akses Jamban	JSP	JSSP	Sharing	BABS	% Akses Jamban
					KK	KK	KK	KK		KK	KK	KK	KK	
1	MOJOKERTO	DAWAR BLANDONG	18/18	12.093/14.496	3.481	7.947	632	33	99.71	3.544	7.920	629	0	100.00
2	MOJOKERTO	MOJOSARI	19/19	24.724/21.353	13.737	6.187	384	4.365	87.38	17.921	3.417	1.399	1.987	95.00
3	MOJOKERTO	TRAWAS	13/13	9.087/9.013	6.659	641	1.325	462	91.66	6.680	639	1.367	401	92.38
4	MOJOKERTO	SOOKO	15/15	18.279/19.052	13.979	1.082	1.366	1.750	88.24	14.640	873	1.246	1.520	90.26

5	MOJOKERTO	NGORO	19/19	33.755/22.542	18.206	7.285	0	8.032	82.03	18.223	7.290	5	8.237	81.35
6	MOJOKERTO	GEDEK	14/14	13.764/16.887	6.248	2.724	809	3.696	71.04	7.766	2.296	1.022	2.680	80.06
7	MOJOKERTO	KUTOREJO	17/17	16.793/17.541	9.387	2.926	872	3.386	77.78	9.894	2.924	831	3.144	79.29
8	MOJOKERTO	PURI	16/16	18.819/19.821	13.853	1.099	132	3.735	79.14	13.853	1.099	132	3.735	79.14
9	MOJOKERTO	JETIS	16/16	21.715/23.867	10.498	3.856	1.474	5.887	74.86	10.741	3.864	1.517	5.593	76.14

15	MOJOKERTO	KEMLAGI	20/20	15.110/15.661	5.204	3.104	1.309	5.456	65.44	5.761	3.413	1.174	4.762	70.14
16	MOJOKERTO	JATIREJO	19/19	9.456/11.907	4.296	1.059	320	4.591	51.73	4.535	917	508	3.496	55.47
17	MOJOKERTO	GONDANG	18/18	12.416/12.213	5.630	735	0	6.051	49.69	5.705	740	5	5.966	51.20
18	MOJOKERTO	BANGSAL	17/17	14.076/14.241	5.084	1.062	283	7.647	47.46	5.205	1.057	334	7.480	48.60

10	MOJOKERTO	PACET	20/20	16.690/17.423	9.983	845	1.241	4.621	73.69	10.250	845	1.251	4.344	75.76
11	MOJOKERTO	MOJOANYAR	12/12	13.787/13.491	8.786	152	869	3.980	70.03	9.301	207	1.026	3.253	75.54
12	MOJOKERTO	DLANGGU	16/16	14.709/15.189	8.193	0	2.226	4.666	70.35	8.317	0	2.190	4.202	72.90
13	MOJOKERTO	PUNGGING	19/19	20.048/20.896	10.435	2.474	692	5.945	69.56	10.985	2.828	692	5.543	71.79
14	MOJOKERTO	TROWULAN	16/16	19.196/21.462	8.690	5.280	60	4.602	74.10	8.944	4.904	150	5.198	71.76

APPENDIX 8: Population with Sanitation Facilities in Sidoarjo

No	Nama Kabupaten	Nama Kecamatan	Identitas Data (Data aktual ter-entry / Data di BPS)		Baseline					Kemajuan				
			Jumlah Desa/Kel	Jumlah KK	JSP	JSSP	Sharing	BABS	% Akses Jamban	JSP	JSSP	Sharing	BABS	% Akses Jamban
					KK	KK	KK	KK		KK	KK	KK	KK	
1	SIDOARJO	TANGGULANGIN	19/19	23.550/22.863	18.363	0	515	13.148	66.80	22.711	0	654	185	99.07
2	SIDOARJO	BUDURAN	15/15	24.033/22.598	19.700	0	384	646	95.74	23.636	0	125	272	98.45
3	SIDOARJO	SIDOARJO	24/24	56.026/50.617	24.496	3.811	748	27.751	57.67	52.730	0	2.059	1.239	97.45
4	SIDOARJO	TAMAN	24/24	52.081/55.862	39.972	0	7.803	9.224	81.42	38.671	0	11.996	1.414	97.04

5	SIDOARJO	GEDANGAN	15/15	33.209/38.315	24.659	531	1.931	5.653	79.88	30.576	0	1.925	708	97.02
6	SIDOARJO	SUKODONO	19/19	28.458/29.160	23.404	117	48	2.066	89.37	25.600	0	1.894	964	95.61
7	SIDOARJO	KRIAN	22/22	30.399/33.496	23.295	159	399	9.857	69.43	23.178	174	4.479	2.568	91.24
8	SIDOARJO	TARIK	20/20	19.206/18.872	11.321	0	132	10.099	52.61	15.830	224	1.347	1.805	90.17
9	SIDOARJO	WONOAYU	23/23	22.396/19.908	13.088	189	2.303	6.617	70.11	18.464	153	1.466	2.313	90.04
10	SIDOARJO	BALONG BENDO	20/20	24.101/20.334	11.787	129	568	3.915	82.82	15.416	0	5.938	2.747	89.77

11	SIDOARJO	SEDATI	16/16	27.756/25.512	20.105	457	477	6.624	71.78	25.068	238	763	1.687	88.70
12	SIDOARJO	CANDI	24/24	39.027/34.778	30.604	4.136	2.031	5.627	85.25	30.775	264	1.984	6.004	84.76
13	SIDOARJO	JABON	15/15	18.490/11.814	11.036	0	0	5.768	70.59	14.632	232	591	3.035	83.98
14	SIDOARJO	PRAMBON	20/20	21.811/18.926	8.405	0	1.681	10.633	48.30	16.109	102	1.225	4.375	80.34
15	SIDOARJO	KREMBUNG	19/19	15.581/17.136	8.501	0	240	9.268	51.79	10.492	0	1.404	3.685	79.38

16	SIDOARJO	PORONG	18/18	20.758/20.177	9.481	1.369	3.082	6.826	66.07	11.246	1.369	3.781	4.362	76.52
17	SIDOARJO	TULANGAN	22/22	23.156/23.952	10.517	2.644	2.537	6.196	71.33	13.075	2.793	1.524	5.764	74.72
18	SIDOARJO	WARU	17/17	50.157/54.809	27.063	4.848	142	17.715	62.64	32.730	0	5	17.422	63.82

APPENDIX 9: Segments Points of Monitoring Locations

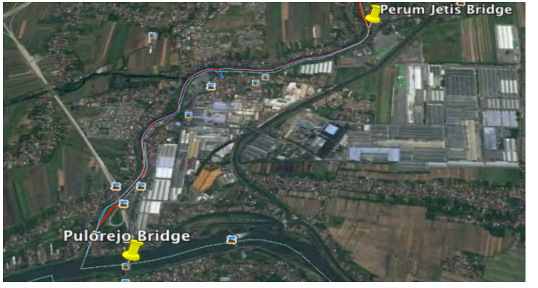

Figure 1 Segment 1

Figure 2 Segment II (Redn Line)

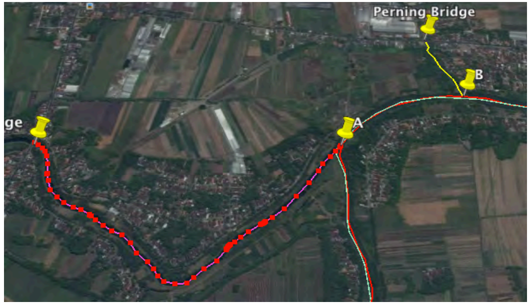

Figure 3 Segment III (Red Dots-Line)

Figure 4 Segment IV (red dots-line)

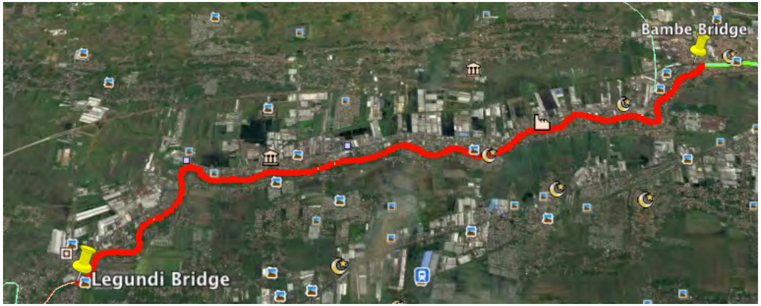

Figure 5 Segment V

Figure 6 Segment VI

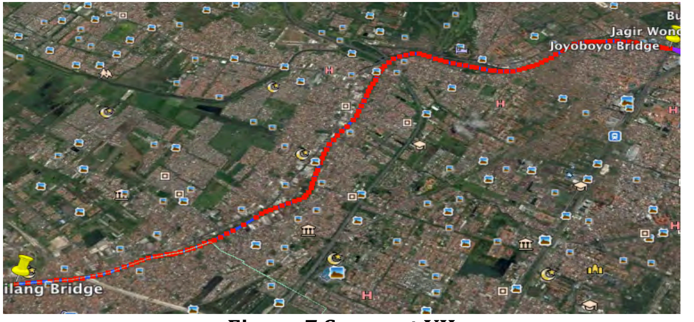

Figure 7 Segment VII

Figure 8 Segment VIII (purple line, red dots)

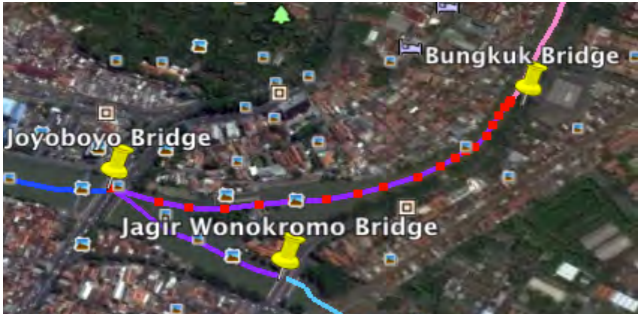

Figure 9 Segment IX (purple line, red dots)

Figure 10 Segment X

Figure 11 Segment XI

Figure 12 Segment XII

Figure 13 Segment XIII

Figure 14 Segment XIV

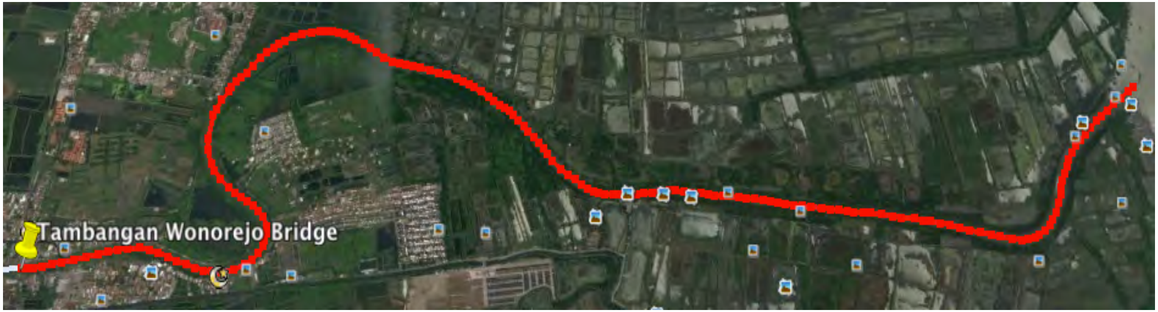

Figure 15 Segment XV

APPENDIX 10: Documentation

 

(left side: Gunug Sari Floodgate; right side: current condition of Surabaya River, April 2017)

(Nusantaram Team in interview with Basin Authority in Brantas River a.k.a BBWS, April 2017)

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BIOGRAPHY

The author, Nurmala Devianti Sukmania who usually called as Devi, was born on 26 March 1995 in Bandung, West Java, Indonesia to her mother Nuri Nurhayati and her father Hariawan Sukma Dewanto. Currently living at Galaksi Selatan III Street Blok U2 No. 116, Bandung. She attended her first education at Assalam kindergaten followed by her elementary education at Margahayu Raya I2 elementary school. She also attended her junior-high-school education at SMPN 7 Bandung and her high-school education at SMAN 5 Bandung. In 2013, she continued her undergraduate bachelor in Civil Engineering Department, Faculty of Civil Engineering and Planning, Sepuluh Nopember Institute of Technology, Surabaya, with identity number 3113100138. She also pursued double-degree program which was led her to continue her final year at Hanze University of Applied Sciences, Groningen, Netherlands, started from 2016 and finished her study in 2017. She was also active on committee activities in Keluarga Mahasiswa ITS and joined student organizations as Head of Bureau Media and Information Deparment, Himpunan Mahasiswa Sipil FTSP ITS, period 2015-2016. In the end her 6th semester, she attended internship at Pelabuhan Indonesia III in storage tank project for a month then moved to Netherlands to continue her study.

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