Study of Physicochemical of Rivers in DKI Jakarta Province

E Prihatinningtyas¹*, T Jasalesmana¹, R Novianti¹, E Nafisyah¹

Research Centre for Limnology, Indonesian Institute of Science, Cibinong Science Center, Jl. Raya Bogor Km 46, Cibinong, West Java, Indonesia

*ekap@limnologi.lipi.go.id

Abstract. Most of inland water in DKI Jakarta Province are highly polluted caused by the increase in urbanization, industrialization development and reclamation process. This research intend to conduct an initial characterization of the water quality in Jakarta. The survey was conducted in 9 location namely Kali Sunter 1, Kali Sunter 2, Cakung Drain, POM Vyle Pluit, Waduk Pluit, Museum Bahari, WTC Mangga Dua, Mookenvart and Pesanggrahan. Based on the level of salinity, the rivers are categorized into fresh water (Cakung Drain, WTC Mangga Dua, Mookenvart and Pesanggrahan) and brackish water (Kali Sunter 1, Kali Sunter 2, Pluit Village, Waduk Pluit, and Museum Bahari). The physicochemical measurement using Water Quality Checker reported turbidity and Total Dissolved Solid (TDS) concentration were very high at all sampling locations. The Oxidation Reduction Potential (ORP) value can be used to determine the pollution status. Pesanggrahan is the only river with a positive ORP value of 22 mV. It can be said that the pollution level of the Pesanggrahan is very low. The other rivers have a negative ORP value and the largest is in Kali Sunter 2. Serious efforts need to be made in dealing with inland waters pollution located in Jakarta.

1. Introduction
Coastal areas and small islands are areas that are vulnerable to clean water and climate change. There are about 17 thousand small islands and occupy 7% of the earth's area [1]. At this location, about 60% of the world's population lives in an area 60 km wide from the coast. This number is expected to increase to 75% by 2025 [1]. The northern part of Jakarta is a coastal area and is bordered by the Java Sea.

There are 13 rivers flowing in DKI Jakarta Province i.e. Mookenvaart, Angke, Pesanggrahan, Grogol, Krukut, Kali Baru Barat, Ciliwung, Kali Baru Timur, Cipinang, Sunter, Buaran, Jati Kramat and Cakung. The estuary of all these rivers is the Jakarta Bay. Jakarta Bay is located in the north of DKI Jakarta Province. Similar to pollution in coastal areas, the level of pollution in Jakarta Bay is also very high. This is caused by urbanization, industrialization and reclamation. The project include increased turbidity, seawater intrusion, suspended and dissolved solids. It is certainly a challenge in providing clean water.

During the last 4 years, the potential production capacity of clean water establishments in DKI Jakarta in 2019 has decreased quite significantly, especially when compared to 2018. A decrease in production reached 13.7 percent from 2018 and 1.6 percent from 2017[2]. The decline of production capacity cannot be separated from the supply of standard water as a water supply. From 13 rivers that flow in Jakarta, only Krukut River and Cengkareng Drain River have water which is suitable for raw material. Even then the two water sources indicate that their water quality is decreasing.
Clean water consumption for all customers was increased every year but raw water was not fully available in Jakarta. The rivers in Jakarta was polluted, its required very high cost to be the source of raw water. The source of raw water in Jakarta 97 percent was came from the outside of Jakarta Province, Jati Luhur reservoir, Cisadane and Cikokol. Only 3 percent of raw water was supplied by the river in Jakarta (Krukut and Pesanggrahan) [2].

This research aimed to study physico chemical parameter of rivers in DKI Jakarta Province. The results of this physico-chemical study will be used as a basis for determining an appropriate alternative to clean water treatment technology.

2. Methodology

2.1. Sample collection

Samples were taken from 9 location. The nine locations represent all rivers located in DKI Province. Detailed sampling points can be seen in Table 1 dan Figure 1.

| Location         | Coordinate          |
|------------------|---------------------|
|                  | South latitude      | East longitude   |
| Kali Sunter 1    | 6.109.845           | 106.906.920     |
| Kali Sunter 2    | 6.112.120           | 106.898.507     |
| Cakung Drain     | 6.149.590           | 106.940.825     |
| Muara Angke      | 6.106.935           | 106.77.498      |
| Pluit Village    | 6.115.913           | 106.784.457     |
| Waduk Pluit      | 6.116.243           | 106.795.225     |
| Museum Bahari    | 6.128.161           | 10.680.9650     |
| (Kali Krukut)    |                     |                  |
| WTC Mangga Dua   | 6.134.996           | 106.83.163      |
| Mookenvart       | 6.154.826           | 106.72.946      |
| Pesanggrahan     | 6.190.728           | 106.75.721      |

2.2. Physico-chemical testing

Measurement of physical and chemical parameters has been carried out at 9 selected sampling locations at listed above. These parameters include pH, conductivity, salinity, turbidity, total dissolved solid and Oxidation Reduction Potential (ORP). All parameters were measured using water quality checker Horriba type U40.
3. Results and Discussion

Based on salinity, the water bodies in DKI Jakarta Province categorized into 3 groups: seawater (Muara Angke), brackish water (Kali Sunter 1, Kali Sunter 2, Pluit Village, Waduk Pluit, Museum Bahari) and fresh water (Cakung Drain, WTC Mangga Dua, Mookenvart and Pesanggrahan).

3.1. Seawater

First sampling site is Muara Angke. The observation site at Muara Angke is located around the port. At this location, no measurements of physico-chemical parameters were carried out. Because of its location, Muara Angke has a high salinity (seawater).

Seawater reverse osmosis (SWRO) is the commonly technology used to treat sea water into clean and or drinking water. This process requires high cost, especially for membrane maintenance and the energy required. Several research were conducted to find low energy reverse osmosis. Ye designed a device namely Rotary Vane Energy Recovery Device (RVERD) to recovery energy from seawater reverse osmosis[3]. Thus it can reduce energy consumption. Solar [4,5], wave [6] and wind [4] are the three primary source of natural energy that are continuously considered.

3.2. Brackish water

Second is brackish water. There are five location indicated to be brackish water, namely Kali Sunter 1, Kali Sunter 2, Pluit Village (POM Vyle), Waduk Pluit and Museum Bahari (Figure 2). The salinity of brackish water ranges from 0.5 ppt to 30 ppt. Table 1 showed that Kali Sunter has the lowest salinity of 0.6 ppt and Pluit Village has the highest salinity of 9.9 ppt. Pluit is located in North Jakarta, which borders the Java Sea. This leads to high salinity.
Table 2. Physico-chemical parameters in brackish water site

| Sampling point | pH   | Conductivity (mS/cm) | Turbidity (NTU) | TDS (g/L) | Salinity (ppt) | ORP (mV) |
|----------------|------|----------------------|-----------------|-----------|----------------|----------|
| Kali Sunter 1  | 6,31 | 1,21                 | 79,8            | 0,771     | 0,6            | -314     |
| Kali Sunter 2  | 6,85 | 5,16                 | 81,4            | 2,8       | 3,22           | -359     |
| Pluit Village  | 6,88 | 15,95                | 60,55           | 10,4      | 9,9            | -343     |
| (Banjir Kanal Barat) | 7,85 | 1,9                  | 99,5            | 1,21      | 1              | -272,5   |
| Museum Bahari (Kali Krukut) | 7,40 | 1,61                 | 226             | 1,03      | 0,8            | -110     |

Table 2 reported that all sampling site in brackish area have been polluted. Turbidity gives a rough indication of the quantity of undissolved matter in water and is easily measured [6]. As seen on table 2, all sampling site high turbidity. The highest turbidity is in Museum Bahari and the lowest in Pluit Village. In addition to the number of solid particles, turbidity also affects the aesthetic value of water bodies.

Total dissolved solid (TDS) indicates the concentration of organic and inorganic material that is soluble in water. The presence of dissolved solids in the water also affects the solubility of oxygen. Electrical conductivity can be used as a measure of the total dissolved solids in a water sample such as salinity. Table 2 showed that the value of TDS, conductivity and salinity are positively correlated. The higher the TDS, the higher the salinity and conductivity, and vice versa.

There are several technology to treat brackish water into clean water such as reverse osmosis, electro-cagulation and adsorption. The electrocoagulation mechanism depends on the redox reactions and the deposition process occurs in the reactor as a result of the passing of electric current through the electrodes that are usually made of aluminum and/or iron [7,8,9,10]. Metal cations, such as Al3+ or Fe2+ are released due to the dissolution of the anode, while the hydrogen gas and hydroxyl ions (OH) are generated at the cathode. Electro-coagulants, such as Al(OH)3, are formed due to the chemical reactions that occur between different ions. There are several advantages of electro
coagulation such as simple apparatus, less reaction time, no chemicals added, low consumption of energy and electrodes, requires only simple equipment and less time of treatment [10].

Adsorption is a process that occurs when a fluid (liquid or gas) is bound to a solid and forms a thin layer on its surface [11]. Adsorbent is a solid substance capable of absorbing certain components of a fluid phase. Zeolite is a natural material that is commonly used as an adsorbent in reducing the salinity of brackish water [12,13,14,15].

3.3. Freshwater
Salinity of freshwater ranging from 0 to 0.5 ppt. The survey result reported that 4 location i.e Cakung Drain, Mangga Dua, Mookenvart and Pesanggrahan have low salinity and categorized as freshwater (Figure 3). The four sampling sites showed high turbidity of 91.5; 95.3; 111 and 66 NTU at Cakung Drain, Mangga Dua, Mookenvart and Pesanggrahan respectively (Table 3). The salinity will increase with the rising of conductivity and Total Dissolved Solid (TDS).

Table 3. Physico-chemical parameters in freshwater site

| Sampling point  | pH  | Conductivity (mS/cm) | Turbidity (NTU) | TDS (g/L) | Salinity (ppt) | ORP (mV) |
|-----------------|-----|----------------------|-----------------|-----------|----------------|----------|
| Cakung Drain    | 7,22| 0,561                | 91,5            | 0,416     | 0,3            | -263     |
| Mangga Dua      | 7,79| 0,317                | 95,3            | 0,206     | 0,1            | -79      |
| Mookenvart      | 7,18| 0,595                | 111             | 0,381     | 0,3            | -292     |
| Pesanggrahan    | 7,25| 0,265                | 66              | 0,172     | 0,1            | 22       |

Domestic wastewater is one of source of pollutants in Jakarta’s water bodies. Domestic wastewater contains many bacteria such as E. coli and coliform. Oxidation reduction potensial (ORP) is an indicator of pollution. Oxidation Reduction Potential is the ability of the system to oxidation-reduction reactions in the water. The higher the ORP, the shorter the time required to demolish E. coli and Salmonella spp. bacteria in drinking water [16]. Hazma stated that an increase in ORP will reduce e coli and coliform bacteria[17]. Table 3 described that Pesanggrahan is the river which has the lowest pollution levels.

Fresh water can be processed into clean water by using a combination of coagulation and disinfection technology. Coagulation is done by adding a chemical coagulant. This process could
remove turbidity. The addition of coagulant in optimal dosage largely determines the efficiency of coagulation.

4. Conclusion
Generally all water bodies in DKI Jakarta Province have been polluted. ORP as one of the indicators of pollution shows a negative value. This means that the oxidation reaction to demolish E. coli bacteria is difficult to occur. For this reason, efforts and enforcement of regulations are needed so that the level of pollution can be handled properly.

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