Physicochemical Characteristic of Municipal Wastewater in Tropical Area: Case Study of Surabaya City, Indonesia

I M W Wijaya, E S Soedjono

Environmental Engineering Department, Faculty of Civil Engineering and Planning, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

Email: wijaya16@mhs.enviro.its.ac.id

Abstract. Municipal wastewater is the main contributor to diverse water pollution problems. In order to prevent the pollution risks, wastewater have to be treated before discharged to the main water. Selection of appropriated treatment process need the characteristic information of wastewater as design consideration. This study aims to analyse the physicochemical characteristic of municipal wastewater from inlet and outlet of ABR unit around Surabaya City. Medokan Semampir and Genteng Candi Rejo has been selected as wastewater sampling point. The samples were analysed in laboratory with parameters, such as pH, TSS, COD, BOD, \( \text{NH}_4^+ \), \( \text{NO}_3^- \), \( \text{NO}_2^- \), P, and detergent. The results showed that all parameters in both locations are under the national standard of discharged water quality. In other words, the treated water is securely discharged to the river.

1. Introduction

Surabaya is the second largest city in Indonesia, and become a business centre in east part of Java Island. It is a reason of high population living in Surabaya City. Increasing of population in Surabaya City is in line with the water demand and impacting wastewater generation. In addition to industries, municipal wastewater which is discharged from the households or domestic activities is also the main contributor of wastewater. Domestic wastewater effluent is the main contributor to diverse water pollution problems. Domestic wastewater management is a big problem particularly with improvement in living standard of community [1]. Grey water is generated as result of living habits, used product, and artificial installation [2]. Even today, domestic wastewater is disposed to drainage, river, or lake without proper treatment before [3]. Some of problems caused by wastewater, such as eutrophication, increasing water treatment cost, decreasing recreational value of water, health risks to humans and livestock, loss of oxygen and undesirable changes in aquatic ecosystem. In order to prevent the pollution risks, wastewater have to be treated before discharged to the water body. Selection of appropriated treatment process need the properties of wastewater as the references.

The option of reusing treated wastewater is becoming necessary and possible. It is as the result of increased climate change, thus leading to droughts and water scarcity, and the fact that wastewater effluent discharge regulations have become stricter leading to a better water quality [4]. Wastewater treatment unit which is commonly used in Surabaya City is anaerobic baffled reactor (ABR). ABR is a series up-flow anaerobic sludge blanket (UASB) which has simple design and low cost in operation and maintenance [5]. It is one of treatment unit with communal system and serves 50-100 households. The wastewater flows up and down in the ABR pass through the baffles and causes the flow of influent have more intensive contact with an anaerobic biomass. It improves processing performance.
for biodegradable matter [6]. This communal system has been applied in several areas in Surabaya City. For example, in Medokan Semampir and Genteng Candi Rejo Sub-District. Domestic wastewater from the households in both area is treated in ABR unit and the effluent is reused for watering and discharging to water body. It is important to determine the characteristic of the pre-treated and post-treated wastewater in explaining its impact to the main water.

Chemical compositions in the domestic wastewater are highly diverse substances from simple compounds to complex polymers. Types and amount of substances show the characteristic of domestic wastewater. Characterization at the overall substances is important to expand the knowledge in selecting appropriate wastewater treatment processes or models [7,8]. Determination of characteristic of domestic wastewater is very important in order to evaluate the existing treatment plants and selection of appropriate treatment plant. Besides that, it also necessary to determine the utilization of treated or untreated wastewater based on their contents [8]. The concentrations and ratios between various parameters in wastewater influent can influence the selection and function of treatment processes. The quality of treated wastewater are important for evaluating WWTP performance and subsequent impacts or risks on human health, surrounding environment and design of advanced wastewater treatment and/or reclamation processes. Consequently, it is critical to conduct systematically analyses on wastewater quality parameters of municipal WWTPs [9]. Wastewater characteristic is related to water quality standard that is aimed to protect the designated use of water body [10].

Generally, the characteristics of domestic wastewater are specifically represented by some physicochemical parameters, such as pH, chemical oxygen demand (COD), biochemical oxygen demand (BOD), total dissolved solid (TDS), total suspended solid (TSS), dissolved oxygen (DO), total nitrogen (TN), total phosphate (TP), and potassium. The other minority substances such as metal, toxic material, detergent, and bacteria (4,9,11–14). Huang [7] has investigated the characteristic of organic matters in domestic wastewater showed that fibre (20,64%) was the largest group of organic matters and followed by proteins (12,38%) and sugar (10,65%) were next largest. The sources of wastewater influent are mainly from municipal wastewater and industrial streams, and also possible mixture of storm water and surface water. In other word, wastewater influent quality can also be affected by the discharge of industrial streams, storm water, surface runoff, etc. (9,15). Grey wastewater is defined as wastewater without any input from toilets, which means that it corresponds to wastewater produced from bathtubs, showers, hand basins, laundry machines and kitchen sinks, in households, office buildings, schools, etc. It is less polluted than black wastewater which is contained wastewater from toilet, such as faces and urine [8].

Water will become the most strategic resource in many parts of the world within the next decades. The identification of critical limit in water quality parameters and their concentrations provide an opportunities for improving sustainable water utilization in the future [9]. According to the Indonesia discharge quality standard of pollutant for municipal wastewater, the quality standard for pH, BOD, TSS and oil and grease corresponding are 6-9, 100 mg/L, 100 mg/l, and 10 mg/L, respectively. The treated wastewater from WWTP will be discharged into the water body for reutilization. Indonesia government has been classified the water quality level to determine the appropriate utilization for each water classes. There are four water classes and each has water quality index involved some water quality parameters. The aim of present study was to investigate the physicochemical characteristic of municipal wastewater in urban area in case of Surabaya City. Those physicochemical characteristic would be presented as pH, COD, BOD, DO, TSS, Nitrogen, Phosphorus, and detergent.

2. Materials and Methods

2.1. Domestic Wastewater Sampling Point

The objective of this study is analysing the characteristic of municipal wastewater from communal wastewater treatment plant in Surabaya City. Domestic wastewater was taken from inlet and outlet of 2 communal ABR in Surabaya City. Location of the ABR was in Medokan Semampir (MS) and Genteng Candi Rejo (GCR) Sub-District. ABR in MS with 2 compartments is serving about 175 households while in GCR with 5 compartments is serving more. Santosa [22] has been classified all
areas in Surabaya based on the health risk level. Both selected locations of study are belong to low risk level of wastewater service area. Those samples were analysed in Laboratorium Pemurnian Air, Department of Environmental Engineering, Faculty of Civil Engineering and Planning, Institut Teknologi Sepuluh Nopember.

2.2. **Physical parameters**

Physical parameters that measured in this study were TSS and pH. TSS was measured based on the gravimetric method. The samples were vaporized on temperature 105°C in the oven then substances were weighed on digital scale. pH was measured by pH meter.

2.3. **Chemical parameters**

The chemical characteristics of domestic wastewater in this study were presented by DO, COD, and BOD. The number of BOD and COD indicates the level of oxygen depletion due to degradation of organic matter [6]. COD was measured based on the closed reflux method. Chemical oxygen demand (COD) determination was carried out by refluxing using potassium dichromate K2Cr2O7 as the oxidant in the presence of HgSO4 and H reagent and then titrating excess K2Cr2O7 against Fe(NH4)2·(SO4)2·6HO using ferroin indicator [16,17]. BOD was measured the BOD5 method according to standard method.

2.4. **Nutrient content and detergent**

Nutrient concentration is also important in determining wastewater characteristic. Wastewater with high nutrient content increase the risk of eutrophication in water body. Concentration of nutrient should be reduce to a level protective of the receiving stream [17]. Nitrogen and phosphorus become two kind of nutrient that were measured in this study. Form of nitrogen, such as ammonium, nitrite, and nitrate was measured according to standard method. Phosphorus in this study was measured as orthophosphate and determined using a spectrophotometric method. LAS was observed in all sample as the representative of detergent substance in wastewater. LAS concentration measured by using MBAS method. MBAS will respond to any molecule with an anionic centre capable of forming a stable ion pair with methylene blue and a hydrophobic group to allow the dye complex extraction into the chloroform phase [18].

3. **Results and Discussion**

3.1. **Physical characteristic**

A pH less than 7 in wastewater influent is an indication of septic conditions while values less than 5 and greater than 10 indicating the presence of industrial wastes and do not appropriate with biological treatment process. The pH range for suitable biological life is quite narrow (typically 6-9) [4]. Low pH level may influenced by the methanogen bacteria activity. High level of carbonates influenced calcium and magnesium ions become insoluble minerals leaving sodium as the dominant ion in solution. High alkalinity water can intensive soil conditions, which will have implications for agriculture [12]. Alkalinity is an important indicator when selecting grey water treatment in term of anaerobic system. Lowering pH is dangerous for microorganism in organic substance [3]. The pH analysis for both influent samples were 6,85 and effluent were 7,15 and 6,95, respectively. The value was following the pH range similar with result [4].

TSS potentially increase the sedimentation in water body and cause depletion of oxygen. TSS is essential for controlling the treatment process and compliance with effluent regulations [16]. The results of the present study show that the TSS ranged from 18 mg/L for both influents wastewater. After passing through the treatment process, the treated water has TSS about 15 mg/L for MS and 12 mg/L for GCR area. The difference of TSS concentration between MS and GCR was not significant, even though ABR in MS has 2 compartments while GCR has 5. It shows that ABR in GCR has longer hydraulic retention time (HRT) than ABR in MS. However the TSS concentration in treated water did not exceed the general standard of 50 mg/L stipulated by the rule of water quality control. The low of
TSS concentration in influent and effluent indicates that it has been reduced in the sewer stream. The TSS in influent were extremely lower than TSS in previous research conducted by Hahn and Figueroa, with 510 mg/L of TSS [5].

3.2. Chemical characteristic

Domestic waste water from kitchen sinks and dishwashers contributes most of the biodegradable organic substances and particulate nitrogen. The presence of large biodegradable organic substances, kitchen waste water is more contaminated by the thermal tolerant coliforms than other sources [2]. Oxygen demand may be in the form of BOD or COD, is the amount of oxygen used by microorganisms in degrading organic material in wastewater. According to Hudson [16] BOD may cause oxygen depletion in water body and lead to nuisance odor and fish kills. It is involved the measurement of dissolved oxygen used by microorganisms in the biochemical oxidation of organic matter. COD is number of oxygen which is consumed by oxidisable matter in the wastewater [19].

The COD will always be higher than the BOD. This is because the COD measures substances that are both chemically and biologically oxidized. The ratio of COD:BOD figures the proportion of organic material contain in wastewaters. Some polysaccharides, such as cellulose, can only be degraded anaerobically, so they will not be involved in the BOD [4]. COD is more resistance to treatment and may accumulate include humic residues, detergents, phenols, cyanide, residual hormones, pharmaceuticals and pesticides [16]. High organic matter can lead the high oxygen consumption by the aerobic bacteria and competing with the aquatic organism [15].

BOD is amount of organic content in the wastewater which is biologically degradable with oxygen consumption. BOD usually indicate as 5 days oxidation of biodegradable organic matter at 20°C by microorganism [19]. BOD in the influent and effluent in MS measured of 9 mg/L and 5 mg/L, respectively. According to COD measurement, the BOD/COD ratio for influent and effluent was 0,6 and 0,55, respectively. It indicates that the wastewater contained more biodegradable organic matter. It was similar with organic matter concentration in Genteng since the result showed that 8,00 mg/L and 3,00 mg/L of BOD for inlet and outlet, respectively. COD concentration in influent and effluent was 15 mg/L and 6 mg/L, respectively. In this case, decreasing of COD concentration needs to investigate because ABR classified as biological treatment process. The value of BOD and COD for both location is still under the rule of water quality control for discharge of effluent on water stream.

| Parameter | Medokan Semampir | Genteng |
|-----------|------------------|---------|
| pH        | 6.85             | 6.95    |
| TSS       | 18               | 18      |
| Nitrit    | 0                | 2.18    |
| Nitrat    | 0                | 0.92    |
| Ammonium  | 12.82            | 38.91   |
| Orthophosphate | 1.08   | 0.44    |
| COD       | 15.00            | 15      |
| BOD       | 9.00             | 8       |
| Detergent (LAS) | 0.46 | 0.34    |

3.3. Nutrient and detergent

Municipal activities, agriculture, and rapid urbanization led to increased nitrogen and phosphorus discharge to water system. More often, the effluents from municipal wastewater treatment plant fail to meet the national standard for effluent quality [20]. Excess nutrients, mostly N and P is main cause of eutrophication which is result in oxygen depletion, biodiversity reduction, fish kills, odor, and increased toxicity [16]. Bathroom grey water discharge contain both of nitrogen and phosphorus due
to exclusion of urine and feces [2]. Nitrogen appears in municipal wastewater as ammonia (NH₃), nitrate (NO₃⁻) and nitrite (NO₂⁻). Organic nitrogen is decomposed to ammonia. Urea and protein are the major source of nitrogen in municipal wastewater [21].

In the septic tank process, organic nitrogen is converted to total ammonium nitrogen in anaerobic condition and due to low oxygen present, amount of it is converted to nitrate. The concentrations were much higher than the safe limit of 1.0 mg/L for long term exposure of aquatic macro organisms [15]. Organic and inorganic forms of nitrogen can generate eutrophication impact in lake, river, estuarine and coastal waters. Nitrogen sources in domestic wastewater are food waste, soap, and fertilizer. In complete nitrogen cycle, ammonia is oxidized to nitrate, creating an oxygen demand and low dissolved oxygen in surface waters. Nitrogen in the form of ammonia is toxic to fish and exerts an oxygen demand on receiving water by nitrifiers [4]. Ammonium results of influent and effluent water in MS is lower than in GCR with concentration of 12.82 mg/L and 38.91 mg/L, respectively. Generally, it caused by the service area in GCR is larger than in MS.

Phosphorus appears in wastewater as orthophosphate, polyphosphate and organically bound phosphorus. The last two components counted usually for up to 70% of the influent phosphorus. Microbes utilize phosphorus during cell synthesis and energy transport [21]. Phosphorus was investigated in the present study as orthophosphate. This phosphate is dissolved the water as dominant phosphorus substance in anaerobic condition. In the present study, orthophosphate in the inlet and outlet from MS is 1.08 and 0.25 mg/L, respectively. Different result showed from Genteng area which is the outlet concentration is higher than in the inlet. It indicates that there was another phosphorus source which is contribute in the higher phosphorus, such as detergent. Surfactants are the mayor ingredients of detergent which is commonly used in laundering activity. The presence of surfactants that is belong to synthetic compounds in natural water body leads an aesthetic loss caused by foam. Surfactants may be toxic to the organism in soil or water [3]. Study from Braga and Varesche [3] showed that LAS concentration in specific laundry wastewater is 163.65 mg/L. This result is very higher than LAS concentration in this research that is 0.46 mg/L in MS and 0.15 mg/L in GCR. LAS concentration is contribute to the presence of phosphorus. Detergent is also the source of phosphorus due to the presence of phosphorus-five in detergents [2].

4. Conclusion

Municipal wastewater in Medokan Semampir and Genteng Candirejo characteristically has low concentration of physico-chemical. All test results are showed still under the national standard of waste water quality. Treated wastewater which is discharged to the stream has been controlled by using communal wastewater treatment plant.

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