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Characterisation of Laboratory Wastewater for Planning Wastewater Treatment Plants in a University Campus in Indonesia

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ABSTRACT

Numbers of parameter are referenced to determine the characteristics of wastewater. Biodegradability and toxicity are determined based on the biological oxygen demand (BOD) to chemical oxygen demand (COD) ratio. Contaminant monitoring in wastewater is an important consideration in choosing among alternative waste management systems. Information relating to wastewater parameters can be used to improve the efficiency and effectiveness of wastewater treatment plants (WWTP). This research focused on identifying parameter conditions and classifying the biochemical oxygen demand (BOD) to chemical oxygen demand (COD) ratio of laboratory wastewater at the University of XYZ, Indonesia. Sampling of laboratory wastewater from two faculties or Department in the University of XYZ the Faculty of Agricultural Technology and the Faculty of Pharmacy, was carried out using a grab sampling method. The wastewater quality parameters of temperature, pH, turbidity, total suspended solids (TSS), COD, BOD, and heavy metals were observed and the results obtained were compared with quality standards contained in Regulation of Environment and Forestry Ministry No. 5, 2014. Wastewater characterisation was then identified based on the results of BOD/COD calculations. The results showed that the quality parameters of pH, BOD, COD, TSS and total dissolved solids (TDS) in laboratory wastewater exceeded the quality standards set. The BOD/COD ratio of wastewater taken from the laboratory of the Faculty of Agricultural Technology was 0.3 and for the Pharmacy Faculty was 0.4, indicating that both were biodegradable. The wastewater treatment recommendation was a combination of physical (biofilter) and biological (phytoremediation) methods. The results of this investigation were used as considerations for the construction of a wastewater treatment plant (WWTP) at the University of XYZ which would meet both aesthetic and environmental requirements.

Key words: *Standard, Preliminary analysis, Biodegradable and toxic, Physical and biological treatment*

Introduction

Laboratory wastewater is produced from analytical processes and chemical use and from the washing of laboratory equipments. The characterisation of wastewater such as this is based on physical, chemical and biological parameters (Sugiharto, 1987; Sperling, 2007; Henze and Comeau, 2008). Laboratory wastewater can contain hazardous components such as iron (Fe), manganese (Mn), chromium (Cr) and mercury (Hg) and can be classified as hazardous/toxic based on its characteristics (Suprihatin and Indrasti, 2010; Herman *et al.*, 2017). Wastewater toxicity can be deleterious to human and environ-

([1]Research Lecturer, [2] Research Scholar) mental health (Raimon, 2011: 18–19).

The characterisation of laboratory wastewater uses a comparison or ratio of biodegradable and nonbiodegradable organic matter. The biodegradable and nonbiodegradable (toxic) characteristics are referred to as the value of the BOD/COD ratio (Abdalla and Hammam, 2014; Azadi *et al.,* 2015; Saha *et al.,* 2017). Unbiodegradable wastewater (toxic) has characteristics such as high acidity, high alkalinity, dissolved salts, chlorides, sodium carbonate and ammonia, while biodegradable wastewater contains biodegradable organic matter. Wastewater from laboratories is classified as nonbiodegradable or toxic if it has BOD/COD of less than 0.1 and as biodegradable if it has BOD/COD of more than 0.1 (Samudro and Mangkoedihardjo, 2014).

University of XYZ is a higher education and research institution located in Jember Regency which has laboratories for educational and analytical activities among its facilities. These laboratories continuously produce wastewater which, if not treated, will reduce the quality of the environment around the university campus by impacting on the environment through damage to soil structures, threats to the survival of aquatic and terrestrial ecosystems and damage to human health.

Results of environmental monitoring by Mitralab (2019) and Pradana (2018) show that the characteristics of organic material based on BOD/COD values of laboratory wastewater from the Faculty of Agricultural Technology, Department of Agricultural Product Technology and Agricultural Engineering exceeded the quality standards set by Ministry of Environment and Forestry Regulation No. 5, 2014 and the Governor of East Java's Regulation No. 5, 2014. Treatment based on wastewater characteristics is therefore a consideration in the prevention and control of environmental pollution (Sperling, 2007; Henze and Comeau, 2008; Tangahu *et al.,* 2019).

Wastewater treatment is determined based on the values of quality parameters and the type of contaminant material present (Valipour *et al.,* 2015). The monitoring of contaminant material in wastewater is an important consideration in choosing between alternative waste treatment methods used in wastewater treatment plants (WWTPs) (Choi *et al.,* 2013; Abba and Elkiran, 2017). This research focuses on identifying the parameter conditions and classifying the BOD/COD of laboratory wastewater at the University of XYZ.

Materials and Methods

The sample for this study was wastewater from laboratories of the Faculty of Agricultural Technology and the Pharmaceutical Chemistry Laboratory. Sampling of wastewater was carried out by grab sampling (Novita *et al.,* 2018; Pradana *et al.*, 2018). The research procedure was homogenisation and analysis of the samples, comparison of samples with quality standards, and calculation of BOD/COD. The results of the analysis of quality parameters of wastewater were compared with the quality standards referred to in Ministry of Environment Regulation No. 5, 2014. Water-quality analysis was carried out for temperature (thermometer), pH (electrometry), turbidity (spectrometric), BOD (titration-Winkler), COD (spectrometric), TSS (gravimetric), TDS (gravimetric), chromium (spectrometric), and total coliform and *E. coli* (MPN method). Identification of wastewater characteristics used BOD/COD ratio (Equation 1).

Ratio: BOD/COD .. (1)

Results and Discussion

Wastewater characterisation

Based on Table 1, several quality-parameter results for the laboratory wastewater produced by the Faculty of Agricultural Technology exceeded the quality standards set out in Regulation of the Ministry of Environment of the Republic of Indonesia No. 5, 2014. These parameters are pH, BOD, COD, TSS, and TDS, with values of 4.28, 84.18 mg/l, 251.6 mg/l, 542.5 mg/l, and 605 mg/l, respectively. In general, sample analysis at the Faculty of Agricultural Technology was from food and agricultural industry wastewater, and chemical material tests. It was predicted that elements contained would include manganese (Mn), chromium (Cr), strong acids, strong bases, zinc (Zn), sulphate (SO_4), nitrate (NO_3-N) and copper (Cu) (Deegan *et al.,* 2011; Dong *et al.,* 2014).

BOD of 58.28 mg/l and COD of 148.2 mg/l exceed the quality standard set up in Ministry of Environment of the Republic of Indonesia regulation No. 5, 2014. Generally, the analysis of samples was of wastewater from the manufacture of drugs, testing of drug levels, and drug-test components. The pollutants in the Pharmaceutical Chemistry Laboratory (PF) wastewater are derived from drugs being studied or solvents being used.

Biochemical oxygen demand (BOD) and chemical oxygen demand (COD)

From Table 1 it can be seen that the BOD value is smaller than the COD value. Biochemical oxygen demand (BOD) is the amount of oxygen needed by microorganisms to reduce biodegradable organic matter. BOD is the amount of oxygen needed in water to degrade biodegradable organic matter contained in it. Chemical oxygen demand (COD) is the amount of oxygen needed to degrade total organic matter with biodegradable and nonbiodegradable characteristics in water bodies or wastewater (Henze and Comeau, 2008; Atima and Taher, 2015; Azadi *et al.*, 2015; Novita *et al.*, 2019). High BOD and COD will adversely affect water bodies and rivers. Excessive COD and BOD will reduce Dissolved Oxygen (DO) content and pH so that water quality decreases (Supriyantini *et al.*, 2017). The BOD value depends on the source of waste or type of waste produced (Sperling, 2007; Pamungkas, 2016; Imron *et al.*, 2019).

Total suspended solids (TSS) and total dissolved solids (TDS)

The TDS and TSS values reflect organic, inorganic and microorganism solids contained in wastewater. These values for wastewater from the Faculty of Agricultural Technology laboratories had high values and exceeded quality standards. The dominant sample contained agricultural materials such as rice, moringa, cassava, and other foodstuffs. One of the Faculty of Agricultural Technology laboratories was testing the quality of wastewater produced by agriculture and industry and examining river-water quality. The operations of laboratory activities in Faculty of Agricultural Technology impacted solids suspended increasing in the wastewater. In the Faculty of Pharmacy samples, TSS and TDS values were low. This condition reflecting the practical activities and research taking place in pharmaceutical laboratories. A chemical laboratory produces wastewater with low amounts of suspended solids, generally in the form of deposits or used filter paper (Malayadi, 2017).

Turbidity value is directly proportional to TSS and TDS: the higher the TSS and TDS values, the higher the turbidity will be. Turbidity can be caused by the presence of mixed objects or colloids in the water and wastewater (Chopra and Sharma, 2013). The higher the turbidity, the more microorganisms or aquatic plants will die because their growth processes are inhibited. The lack of incoming sunlight in such waters can affect the photosynthesis processes of phytoplankton and adversely affect the aquatic ecosystem (Jewlaika *et al.*, 2014). Higher values of TSS and turbidity will cause resistance to sunlight entering the waters (Wisha *et al.*, 2016)

Value of pH

The acidity of a substance is indicated by the pH parameter. From Table 1, it can be seen that the pH value for Faculty of Agricultural Technology wastewater is 4 indicating that it is acidic. However, the waste is not corrosive and so does not endanger the environment and living organisms. Wastewater is considered corrosive if its pH value is very low (pH

Table 1. Preliminary examination of wastewater from laboratories at Jember University

Parameter	Units	Faculty of Agricultural Technology	Pharmacy Faculty	Std I*)	Std II*)
Temperature	°C	26	27	38	40
pH	-	4.28	7.02	6–9	6–9
Turbidity	NTU	31.2	11.9	-	-
BOD	mg/l	84.18	58.28	50	150
COD	mg/l	251.6	148.2	100	300
TSS	mg/l	542.5	13.6	200	400
TDS	mg/l	605	120.2	2000	4000
Total chromium	mg/l	<0.0168	<0.0168	0.5	1
Total coliform	MPN/100 ml	220	900	1000	1000
E. coli	MPN/100 ml	170	350	-	-
Ratio of BOD and COD		0.3	0.4		

Std = Standard; *) refers to Regulation of Environmental and Forestry Ministry No.5. 2014

< 3) or very high (pH > 12.5) (Imran *et al.*, 2019). The low pH value in these samples is caused by H_2SO_4, which is used as a testing material. Laboratory waste will be increasingly dangerous for the environment if many users are carrying out procedures using strong acid solutions, strong bases, oxidising agents and dehydrating agents (Malayadi, 2017).

Total coliform and *E. coli*

Bacteria develop and transmit disease through water and their presence is influenced by the type of bacterium and the environment (Genisa and Auliandri, 2018). Microorganism exposure in a water body causes degradation of water quality and raises the risk of the spread of digestive diseases if such water is used as a source of clean water. Table 1 shows total coliform value of Faculty of Agricultural Technology laboratories wastewater amounting to 220 MPN/100 ml and this does not exceed the specified quality standards. This condition is thought to be due to the low pH value of the wastewater. Sample testing in Faculty of Agricultural Technology laboratories uses strong acids such as H_2SO_4, and this acid is thought to inhibit the growth and development of microorganisms (Sarwar, 2011). The total coliform value of the Faculty of Pharmacy laboratory is 900 MPN/100ml. Again, this value does not exceed applicable quality standards.

The growth and development potential of total coliform and *E. coli* is relatively high. Microorganisms can survive for a long time at normal pH, however the pH of the Faculty of Pharmacy laboratory wastewater is 4. Bacteria will grow and multiply depending on temperature, aeration, pH and food sources (protein and carbohydrates) (Cirja *et al.*, 2007; Cydzik-Kwiatkowska and Zieliñska, 2016). Low pH can result in increased mortality and inhibit the metabolism of certain bacteria (Sarwar, 2011).

Chromium (Cr)

Heavy metals such as iron (Fe), manganese (Mn), chromium (Cr), lead (Pb) and cadmium (Cd) feature in the hazardous elements found in laboratory liquid waste. Heavy metals are very dangerous and can cause poisoning (toxicity) in living organisms. Pure chromium is not toxic, but its compounds can have various negative impacts on human health and the environment (Meirinna *et al.*, 2013). The chromium values of both laboratory sample do not exceed the specified quality standards (Table 1). The condition reflecting that chromium is little used in their sample testing.

BOD/COD ratio

Samudro and Mangkoedihardjo (2010) report that wastewater with BOD/COD value of less than 0.1 can be characterised as toxic. This is typically wastewater containing strong acids, strong bases, dissolved salts, chlorides, sodium carbonate and ammonia. For a BOD/COD of 0.1-1, wastewater is biodegradable as it contains biodegradable organic material. BOD/COD values of the Faculty of Agricultural Technology and the Faculty of Pharmacy have values of 0.3 and 0.4, respectively and so the wastewater from both of these analytical laboratories is biodegradable. Based on the calculated values of BOD/COD, treatment recommendation for the development of the planned WWTP is a combination of physical and biological methods. Biological treatments can reduce COD and BOD while TSS and TDS values that exceed quality standards can be reduced by physical processing. The WWTP planned at the University of XYZ uses a combination of physical systems as primary treatment and biological systems as secondary treatment.

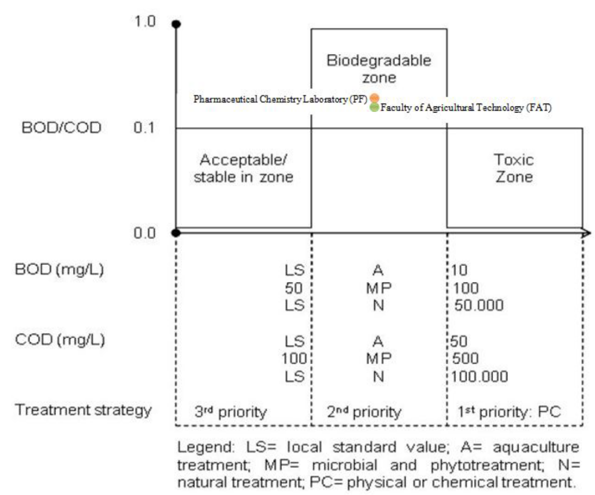

Fig. 1. Ratio BOD and COD

Conclusion

The laboratory wastewater quality parameters of TDS, TSS, turbidity, BOD and COD in the University of Jember did not meet the quality standards set out in Ministry of Environment Regulation No. 5, 2014. The BOD/COD value of wastewater from the laboratories of the Faculty of Agricultural Technology is 0.3 and for the Faculty of Pharmacy is 0.4.

These values indicate that wastewater from both laboratories is biodegradable. The WWTP planned at the University of XYZ will use a combination of a physical method as primary treatment and a biological method as secondary treatment.

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