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Artikel Penelitian

### Characterization of Wastewater in The University Campus: A Case Study in Universitas Andalas, Indonesia

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#### ABSTRACT

*This study aims to analyze wastewater characteristics at Universitas Andalas Campus Limau Manis Padang encompassing physical, chemical, and biological attributes, while comparing them to established quality standards and estimating mass loading. Wastewater samples were collected from various sources, including domestic and specific wastewater. Sampling locations and times were chosen based on peak activity. Physical analysis revealed temperature ranging from 27.32 to 31.5°C and TSS concentrations from 130.00 to 580.00 mg/L. Chemical parameters displayed significant variation, with pH values between 2.27 and 9.70, BOD<sub>5</sub> concentrations spanning 108.46 to 506.59 mg/L, COD levels from 162.70 to 1,428.00 mg/L, and oil and grease content from 0.20 to 84.31 mg/L. N-total ranged from 47.07 to 309.16 mg/L, sulfate from 72.70 to 1,480.00 mg/L, and phosphate from 1.14 to 98.15 mg/L. Biological attributes showed total coliform counts exceeding 10,000 colonies per 1,000 mL, all surpassing quality standards. Notably, the BOD<sub>5</sub>/COD ratio indicated low biodegradable quality (values <0.5) for certain wastewater sources. Greywater emerged as the primary pollutant, with substantial mass loadings. Eventually, this study underscores the vital need for wastewater treatment before environmental discharge.*

**Keywords:** Characteristics, Domestic Wastewater, Campus, Quality Standards, Hazardous Wastewater

#### 1. INTRODUCTION

Universitas Andalas, one of the state universities in West Sumatra, serves a diverse of activities. The wastewater generated by the university is categorically delineated as domestic wastewater, attributable to the presence of institutional facilities, commercial establishments, cafeterias, and dormitories. Furthermore, to support academic pursuits, Universitas Andalas operates laboratory facilities that produce wastewater with distinct characteristics compared to conventional domestic wastewater, due to differences in activities and sources. Laboratory wastewater is a significant source of environmental pollution due to the presence of various chemical and biological contaminants. These contaminants include heavy metals, pharmaceutical residues, and pathogenic microorganisms [Partal et al, 2020].

The characterization of laboratory wastewater involves analyzing the ratio of biodegradable to nonbiodegradable organic matter. This is typically expressed as the

BOD/COD ratio, which reflects the biodegradability and toxicity of the wastewater (Abdalla et al, 2014; Azadi et al., 2015; Saha et al., 2017). Nonbiodegradable (toxic) wastewater is characterized by properties such as high acidity, high alkalinity, and elevated levels of dissolved salts, chlorides, sodium carbonate, and ammonia. In contrast, biodegradable wastewater contains organic matter that can be biologically degraded. Laboratory wastewater is considered nonbiodegradable or toxic when the BOD/COD ratio is less than 0.1, whereas it is classified as biodegradable if the ratio exceeds 0.1 (Samudro et al, 2014).

The present study aims to assess the wastewater characteristics at Universitas Andalas, Limau Manis, Padang, encompassing physical, chemical, and biological attributes. The scope of wastewater targeted domestic wastewater and hazardous and toxic wastewater. The mass loading calculations drew from wastewater quantity data derived from prior research conducted by Komala et al, 2020. The findings of this study provide valuable

supporting data for the formulation of policies pertaining to wastewater management at Universitas Andalas Campus Limau Manis, Padang. By identifying these discrepancies, the study contributes essential information that can guide decision-makers in developing strategies and interventions to enhance wastewater management practices within the university campus. Eventually, this research serves as a crucial foundation for the development of policies and measures aimed at improving the environmental sustainability and compliance of wastewater management at Universitas Andalas Campus Limau Manis Padang.

## 2. METHODOLOGY

### *Sampling sites*

The samples were taken in several buildings in the Universitas Andalas Campus Limau Manis including Rectorate, Science and Social Faculty, classroom buildings, dormitories, student activity centre, mosque, sport facilities and cafeteria (**Table 1**). These buildings were chosen to represent the wastewater characteristics in each distinct building. The samples taken in this study were blackwater, greywater, and hazardous wastewater. Blackwater sample has taken from the inlet and outlet of the dormitories' septic tank at the peak time (7 a.m.). Meanwhile, the greywater samples were taken at the peak time to represent in the morning, in the afternoon, and in the evening time during the operational time each of building.

The hazardous wastewater was collected from chemical laboratories within representative departments. These included the Sumatran Biota Laboratory (Pharmacy Faculty), Basic Chemistry Laboratory (Mathematics and Science Faculty and Engineering Faculty), Biotechnology Laboratory (Agriculture Faculty and Agriculture Engineering Faculty), Ruminant Nutrition Laboratory and Cattle Laboratory (Animal Husbandry Faculty). In addition, the sample was also collected from the cleansing area of the bus campus. Sampling was conducted during practical activities.

### *Sampling methods*

The sampling methodology employed for blackwater, greywater, cattle laboratory, and the bus cleansing area involved duplicate sampling. Duplicate samples were obtained by collecting two samples consecutively from the same sampling points with a minimal time gap to ensure a high level of accuracy. The time interval between the two samples was maintained at one minute. The initial sample was gathered in a one-liter plastic

bucket, and after a one-minute interval, the second sample of the same volume was obtained. For the wastewater from chemical laboratories, a 24-hour sampling duration was adopted, and these samples were collected in plastic buckets. In the case of workshop wastewater (*lubricant*), sampling was carried out for a week, and the samples were collected in a bin.

The samples were stored in the cooling box at temperatures of 4°C during transportation to the laboratory and were promptly subjected to analysis, with the exception of metal analyses. For metal analysis, samples were preserved in sulfide acid (H<sub>2</sub>SO<sub>4</sub>) and stored at 4°C.

### *Laboratory Analysis*

The laboratory analyses were conducted at the Water Laboratory and Environment Microbiology Laboratory at the Department of Environmental Engineering at Unand. The parameters assessed and the analytical method for each wastewater source can be seen in **Table 2**. All laboratory analyses were conducted following the Standard Methods for the Examination of Water and Wastewater [APHA, 2005].

### *Estimation of Mass Loading*

The mass loading was estimated based on the pollutant concentration and the wastewater quantity. The equation as follows:

$$\text{Mass loading (kg/day)} = C \times Q$$

Where,

C = pollutant concentration (mg/L)

Q = wastewater quantity (L/s)

The mass loading was calculated by considering three parameters: TSS, BOD<sub>5</sub>, and COD. These parameters were chosen as they serve as primary indicators to represent both physical characteristics (TSS) and organic compounds (BOD<sub>5</sub> and COD) in the effluent.

## 3. RESULTS AND DISCUSSION

### *Wastewater characteristics*

The wastewater characteristics in from blackwater, greywater, and hazardous wastewater were observed (**Table 3 – Table 5**).

### *Physical Parameters*

#### *Temperature*

The finding shows that the temperature range of Universitas Andalas wastewater varied from 27.32°C to 31.50°C. The highest temperature was observed in lubricant wastewater, while the lowest was in greywater. Temperature of blackwater (inlet of septic tank, **Table 3**)

**Table 1.** Sampling sites and timing for blackwater and greywater collection

| Sources of Domestic Waswater | Sites and Times of Selected Sampling           |            |                                                                                         |                                           |
|------------------------------|------------------------------------------------|------------|-----------------------------------------------------------------------------------------|-------------------------------------------|
|                              | Blackwater                                     | Time (WIB) | Greywater                                                                               | Time (WIB)                                |
| Office and administration    |                                                |            | Rectorate, Animal Husbandry Faculty, and Social and Political Science Faculty buildings | 08.00; 12.30; 16.00.                      |
| Classroom buildings          |                                                |            | D and H buildings                                                                       | 08.00; 12.30; 16.00.                      |
| Student dormitories          | Student dormitories (Menpera I and Menpera II) | 07.00      | Menpera I dan Menpera II dormitories                                                    | 04.00; 07.00; 12.00; 17.00; 19.00; 22.00. |
| Student facilities           |                                                |            | Student Activity Center building                                                        | 08.00; 12.30; 16.00.                      |
| Places of worship            |                                                |            | Nurul Ilmi Mosque                                                                       | 05.00; 12.30; 16.00; 18.30                |
| Sport facilities             |                                                |            | Futsal building                                                                         | 08.00; 12.30; 16.00                       |
| Cafeteria                    |                                                |            | Business Centre building                                                                | 08.00; 12.30; 16.00                       |

**Table 2.** The parameters assessed for each wastewater source

| Parameters       | Analytical method                         | Domestic wastewater |           | Hazardous wastewater |             |                    |
|------------------|-------------------------------------------|---------------------|-----------|----------------------|-------------|--------------------|
|                  |                                           | Blackwater          | Greywater | Chemical Lab.        | Cattle Lab. | Bus cleansing area |
| Physical         |                                           |                     |           |                      |             |                    |
| Temperature      | Electrometric                             | ✓                   | ✓         | ✓                    | ✓           | ✓                  |
| TSS              | Gravimetric                               | ✓                   | ✓         | ✓                    | ✓           | ✓                  |
| Chemical         |                                           |                     |           |                      |             |                    |
| pH               | Electrometric                             | ✓                   | ✓         | ✓                    | ✓           | ✓                  |
| BOD <sub>5</sub> | Iodometric titration                      | ✓                   | ✓         | ✓                    | ✓           | ✓                  |
| COD              | Closed reflux-tritimetric                 | ✓                   | ✓         | ✓                    | ✓           | ✓                  |
| N-Total          |                                           | ✓                   |           | ✓                    | ✓           |                    |
| Nitrate          |                                           | ✓                   |           | ✓                    | ✓           |                    |
| Nitrite          |                                           | ✓                   |           | ✓                    | ✓           |                    |
| Ammonia          | Spectrophotometry                         | ✓                   |           | ✓                    | ✓           |                    |
| Sulfate          |                                           | ✓                   |           | ✓                    | ✓           |                    |
| Phosphate        |                                           | ✓                   |           | ✓                    | ✓           |                    |
| Oil and grease   | Gravimetric                               | ✓                   | ✓         |                      |             | ✓                  |
| Heavy metal      | Atomic Absorption Spectrophotometer (AAS) | ✓                   |           | ✓                    |             | ✓                  |
| Biological       |                                           |                     |           |                      |             |                    |
| Total Coliform   | Most Probable Number                      | ✓                   |           |                      | ✓           |                    |

**Tabel 3.** Characteristics of Blackwater

| Paramaters                       | Units        | Inlet of Septic Tank | Outlet of Septic Tank | Quality Standards |
|----------------------------------|--------------|----------------------|-----------------------|-------------------|
| Temperature                      | °C           | 31                   | 27.5                  | nd                |
| TSS                              | mg/L         | 580.00*              | 130*                  | 30                |
| pH                               | -            | 8.88                 | 7.47                  | 6-9               |
| BOD <sub>5</sub>                 | mg/L         | 506.59*              | 314.84*               | 30                |
| COD                              | mg/L         | 1,428.00             | 324*                  | 100               |
| N-Total                          | mg/L         | 309.16               | 47.07                 | nd                |
| Nitrate                          | mg/L         | 95.15                | 2.87                  | nd                |
| Nitrite                          | mg/L         | 31.2                 | 1.88                  | nd                |
| Ammonia                          | mg/L         | 182.81               | 42.32*                | 10                |
| Sulfate                          | mg/L         | 1,480.00             | 72.7                  | nd                |
| Phosphate                        | mg/L         | 98.15                | 1.14                  | nd                |
| Total Coliform (Jml/1,000)       | Total/100 mL | >10,000              | >10,000*              | 3000              |
| <b>Ratio BOD<sub>5</sub>/COD</b> |              | 0.35                 | 0.66                  |                   |

(\*) Exceeded the quality standard, (nd)Not determined, (a)Regulation of the Minister of Environmental and Forestry of Indonesia No. 68/ 2016 The Quality Standard for Domestic Wastewater

and lubricant wastewater (**Table 5**) were above 30°C, whereas others were less than 30°C.

#### *Total Suspended Solid (TSS)*

The TSS concentrations ranged from 130 to 580 mg/L across various sources, surpassing the established quality standards for river discharge. The highest TSS concentration was recorded in the blackwater at the septic tank inlet, reaching 580 mg/L. Despite a considerable decrease of 77.56% in the septic tank outlet, the TSS concentration of 130 mg/L did not meet the quality standards according to Minister of Environment and Forestry Regulation No. 68 of 2016 about domestic wastewater quality standards.

Greywater exhibited TSS concentrations ranging from 85.08 to 494.37 mg/L, with most sources exceeding the quality standard, excluding sport facilities. This characteristic closely mirrored TSS concentrations found in other educational institutions (40.00-340.00 mg/L) [Regulation of The Minister of Environment and Forestry of The Republic of Indonesia No. 68/2016] and a domestic area in West Java (54.00-226.00 mg/L). The consistency in TSS values indicates that wastewater from domestic activities generally shares similar characteristics. However, variations in activities within a facility contribute to higher TSS concentrations. Dormitory buildings, with diverse resident activities such as bathing, dishwashing, and floor cleansing, yielded elevated TSS levels compared to other buildings (**Table 4**). While TSS from other sources primarily originated from floor cleansing and dust/sludge generated by toilet usage, the cafeteria exhibited the highest TSS concentration due to wastewater from rinsing cutlery and crockery, containing suspended solids from leftover food or beverages.

Laboratories demonstrated TSS concentrations of 347.02 mg/L for the chemical laboratory and 466.00 mg/L for the cattle laboratory (**Table 5**). In the chemical laboratory, TSS originated from residual chemicals and objects used in practical or research activities involving solid materials, with suspended solids resulting from chemical reaction by-products. This aligns with a study at the Universitas Lambung Mangkurat, reporting TSS concentrations of 184.1 mg/L [Al Amin et al, 2011]. The cattle laboratory produced TSS from sewage containing food residue from cattle foods, categorized as falling into the high pollutant class (400.00 mg/L). Furthermore, the wastewater for car washing exhibited TSS concentrations of 492.04 mg/L, and lubricant wastewater had concentrations of 394.76 mg/L (**Table 5**).

## **Chemical Parameters**

### *Organic*

The presence of organic compounds in wastewater is reflected in the concentrations of BOD<sub>5</sub> and COD. BOD<sub>5</sub> and COD values are expressed in milligrams of oxygen required by microorganisms to degrade organic matter per liter of water. The correlation between BOD<sub>5</sub> and COD in wastewater underscores their role as essential metrics for assessing organic matter levels. The ratio of BOD<sub>5</sub> to COD serves as an indicator of the biodegradability of the wastewater [Buldeiz et al, 2020].

In the inlet of the septic tank, blackwater exhibited the highest concentrations of BOD<sub>5</sub> (506.59 mg/L) and COD (1,428.00 mg/L). However, in the septic tank outlet, BOD<sub>5</sub> and COD concentrations decreased by 57.59% and 77.31%, resulting in concentrations of 314.84 mg/L and 324.00 mg/L, respectively. This reduction is attributed to the anaerobic and facultative anaerobic bacterial decomposition of organic compounds in the septic tank [Nabil et al, 2010]. Although there was a decrease, the concentrations of organic compounds exceeded quality standards. The BOD<sub>5</sub>/COD ratio in the inlet was 0.35, indicating a reduced susceptibility to biological treatment (considered not easily treatable by biological means as it is below 0.4 [Tchobanoglous et al, 2014]). Furthermore, a lower BOD<sub>5</sub>/COD ratio indicates greater toxicity and reduced biodegradability of organic matter. Research on various organic compounds, such as formaldehyde and triclosan, has demonstrated that these substances, frequently found in household items, are associated with low BOD<sub>5</sub>/COD ratios and significant toxicity [Al-Rosyid et al, 2019]. In the septic tank outlet, the BOD<sub>5</sub>/COD ratio increased to 0.66, indicating improved biodegradability for discharge into the environment. Similar findings were reported for BOD<sub>5</sub>/COD ratios in septic tank effluents, ranging from 0.3 to 0.69 [Oyem et al., 2021; Al-Sulaiman et al, 2018].

Greywater BOD<sub>5</sub> and COD concentrations ranged from 60.04 to 216.49 mg/L and 88.67 to 382.67 mg/L, respectively (**Table 4**). Based on quality standards, BOD<sub>5</sub> exceeded the maximum limit except for office and administration, college, sports, and worship buildings. The average concentrations of BOD<sub>5</sub> and COD in greywater were found to be 108.46 mg/L and 162.70 mg/L, respectively. The resulting BOD<sub>5</sub>/COD ratio of about 0.667 (or 66.7%) suggests that the organic matter present in the greywater is relatively biodegradable. This ratio is consistent with findings from studies by Albalawneh et al. (2015) which reported ratios ranging from 0.31 to 0.71 and Oteng et al. (2018) found that the

ratio, indicating a similar range of biodegradability in various types of wastewaters.

The BOD<sub>5</sub>/COD ratios in domestic wastewater indicate that greywater is more biodegradable than blackwater. Greywater typically has a higher concentration of soluble and easily biodegradable organic compounds when compared to blackwater. This characteristic makes greywater more suitable for biological treatment, as it is composed of substances that microorganisms can readily break down. In contrast, blackwater often contains more complex, non-biodegradable, and potentially toxic compounds due to its origin from toilets and associated waste [Todt et al, 2015].

Chemical laboratory wastewater exhibited BOD<sub>5</sub> and COD concentrations of 425.35 mg/L and 1,341.00 mg/L, respectively (**Table 5**), exceeding quality standards. The elevated values are attributed to the use of organic matter in practical applications, such as alcohol compounds in Biotechnology and Biota Sumatera Laboratories, and support chemicals like detergents. Cattle laboratory wastewater had BOD<sub>5</sub> and COD concentrations of 419.03 mg/L and 1,362.2 mg/L, respectively. High values in cattle laboratory wastewater originate from organic compounds in animal sewage generated from metabolic residues.

Wastewater from bus cleansing exhibited BOD<sub>5</sub> and COD concentrations of 140.62 mg/L and 192 mg/L, while lubricant wastewater had concentrations of 239.08 mg/L and 496.00 mg/L, respectively. Organic compounds in bus cleansing wastewater originated from detergent use, while organic substances like oil and grease and phenol were found at 4.76 mg/L in lubricant wastewater. TSS in wastewater for car washing resulted from sludge and soil washed during bus cleansing, while TSS in lubricant wastewater originated from the composition of oil, including carbon residue, asphaltenic matter, and other by-products produced during machine lubrication.

Oil and grease concentrations, measured only in greywater, ranged from 0.20 to 84.31 mg/L, with an average of 13.33 mg/L (**Table 4**). The concentration of oil and grease was influenced by the types of activities in each building, evident in the differences between cafeteria and other building wastewater. Cafeteria wastewater had the highest concentration of oil and grease, resulting from food and dish-related oil and grease matter, while other buildings produced lower concentrations. Comparable research reported concentrations ranging from 51 to 153 mg/L [Tchobanoglous et al, 2014], with Universitas Andalas wastewater values lower due to the dominance of institutional activities.

### *Inorganic*

The results of this study revealed a pH range of 2.27 – 9.70 in Universitas Andalas wastewater, with all pH values met the quality standard except for chemical laboratory and lubricant wastewater. The pH of black water, on the other hand, decreased from 8.88 to 7.47 (**Table 4**), indicating a biodegradation process of organic compounds in the septic tank. Changes in pH affect the forms, reactivities, active sites, degradation pathways, and product toxicities of organic pollutants during water decontamination. [Zhang et al, 2024].

Chemical laboratory wastewater exhibited high acidity levels with a value of 2.27 (**Table 5**). Liu (2013) reported that shown pH values as low as 0.85 in acid chemical wastewater. The low pH in chemical laboratory wastewater is attributed to the use of chemicals containing acid compounds. On the contrary, lubricant wastewater showed an alkaline pH of 9.70, while other wastewater sources generally exhibited neutral pH values. Furthermore, Nitrogen (N-total), sulphate, and phosphate were measured only in blackwater (inlet and outlet) and chemical laboratory wastewater. Sequential concentrations were 309.16 mg/L, 1,480.00 mg/L, and 98.15 mg/L, respectively. These compounds originated from urine (nitrogen) and protein residue and dead cells (phosphorus). In the septic tank outlet, these compounds underwent approximately 90% removal, except for ammonia, which showed a removal efficiency of 75.85%. This removal is attributed to the decomposition of organic and inorganic compounds, where nitrogen and phosphorus serve as nutrients for anaerobic microorganisms.

Chemical laboratory wastewater showed N-total 139.4 mg/L, sulphate 326.75 mg/L, and phosphate 93.03 mg/L, originating from the use of sulphate, nitrate, and phosphate reagents. Cattle laboratory wastewater had N-Total 206.44 mg/L, sulphate 1,160.00 mg/L, and phosphate 65.94 mg/L, generated from animal sewage comprising urine and faeces. Concentrations of nitrate, nitrite, sulphate, phosphate, and ammonia exceeded river entry standards. Heavy metal concentrations in chemical laboratory wastewater exceeded hazardous and toxic standards, except for zinc. These metals, including Cu, Na, Cd, Co, Cr, Fe, Mn, K, Ca, Pb, and Zn, originated from the use of cation-cation reagents. Lubricant wastewater also exceeded quality standards for hazardous and toxic metals, with concentrations of Cu, Na, Cd, Co, Cr, Fe, Pb, and Zn exceeding acceptable limits. These metals originated from the composition of oil.

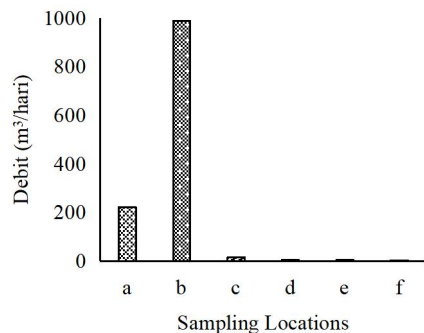
**Table 4.** Characteristics of domestic wastewater (greywater)

| Parameters                       | Unit | Buildings                 |                    |                   |                    |                   |                  |             |             | Quality Standards <sup>a</sup> |
|----------------------------------|------|---------------------------|--------------------|-------------------|--------------------|-------------------|------------------|-------------|-------------|--------------------------------|
|                                  |      | Office and administration | Classroom building | Student dormitory | Student Facilities | Places of worship | Sport facilities | Cafeteria   | Average     |                                |
| Temperature                      | °C   | 26.96                     | 26.88              | 27.02             | 27.00              | 26.38             | 27.00            | 30.00       | 27.32       | nd                             |
| TSS                              | mg/L | 105.79*                   | 106.93*            | 148.29*           | 112.43*            | 109.48*           | 85.08            | 494.37*     | 166.05      | 30                             |
| pH                               | -    | 6.95                      | 7.15               | 7.26              | 6.87               | 6.88              | 7.11             | 7.94        | 7.17        | 6 – 9                          |
| BOD <sub>5</sub>                 | mg/L | 80.82*                    | 60.04*             | 117.14*           | 109.47*            | 86.23*            | 89.00*           | 216.49*     | 108.46      | 30                             |
| COD                              | mg/L | 123.78*                   | 88.67              | 174.00*           | 153.17*            | 111.25*           | 105.33*          | 382.67*     | 162.70      | 100                            |
| Oil and grease                   | mg/L | 1.76                      | 0.29               | 4.56              | 1.68               | 0.20              | 0.50             | 84.31*      | 13.33       | 5                              |
| <b>Ratio BOD<sub>5</sub>/COD</b> |      | <b>0.65</b>               | <b>0.67</b>        | <b>0.67</b>       | <b>0.71</b>        | <b>0.77</b>       | <b>0.8</b>       | <b>0.56</b> | <b>0.66</b> |                                |

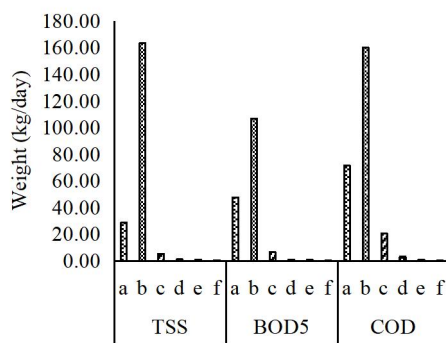
(\*) Exceeded the quality standard, (nd) Not determined, (a) Regulation of the Minister of Environmental and Forestry of Indonesia No. 68/ 2016 The Quality Standard for Domestic Wastewater

### Mass Loading

The quantity and the wastewater characteristics at Universitas Andalas can be seen in **Figure 1**.



(a)



(b)

**Figure 1.** (a) The Quantity and (b) The Wastewater characteristic at Universitas Andalas. Note: a) inlet of septic tank, b) greywater, c) chemical laboratory, d) cattle laboratory, e) Wastewater from car washing, f) lubricant wastewater

The maximum volume of wastewater was observed in greywater, reaching 988.92 m<sup>3</sup>/day. Greywater also exhibited the highest mass loading for TSS, BOD<sub>5</sub>, and COD, accounting for 163.45 kg/day, 106.76 kg/day, and 160.15 kg/day, respectively. Conversely, the minimum wastewater volume was found in the bus cleansing area with the value of 1.99 m<sup>3</sup>/day. The bus cleansing area presented the lowest mass loading for TSS, BOD<sub>5</sub>, and COD, where wastewater from car washing accounted for 0.97 kg/day, 0.28 kg/day, and 0.38 kg/day, respectively, and lubricant wastewater contributed 0.004 kg/day, 0.002 kg/day, and 0.03 kg/day, respectively.

Blackwater exhibited a wastewater volume of 221.79 m<sup>3</sup>/day, with mass loading for TSS, BOD<sub>5</sub>, and COD reaching 28.70 kg/day, 48.3 kg/day, and 71.53 kg/day, respectively. The chemical laboratory contributed 15.35 m<sup>3</sup>/day of wastewater, with mass loading for TSS, BOD<sub>5</sub>, and COD measuring 5.30 kg/day, 6.50 kg/day, and 20.49 kg/day, respectively. The cattle laboratory generated a wastewater volume of 2.25 m<sup>3</sup>/day, and the mass loading for TSS, BOD<sub>5</sub>, and COD were 1.04 kg/day, 0.94 kg/day, and 3.05 kg/day, respectively. The variations in mass loading among the different sources were influenced by the respective activities associated with each source.

**Table 5.** Characteristics of hazardous wastewater

| Parameters                       | Units | Laboratory |                 |         |                 | Workshop           |                 |           |                 |
|----------------------------------|-------|------------|-----------------|---------|-----------------|--------------------|-----------------|-----------|-----------------|
|                                  |       | Chemical   |                 | Cattle  |                 | Bus Cleansing Area |                 | Lubricant |                 |
|                                  |       | Results    | QS <sup>a</sup> | Results | QS <sup>b</sup> | Results            | QS <sup>c</sup> | Results   | QS <sup>a</sup> |
| Temperature                      | °C    | 27.75      | nd              | 466*    | nd              | 29.5               | nd              | 31.5      | nd              |
| TSS                              | mg/L  | 347.02*    | 200             | -       | 400             | 492.04*            | 200             | 394.76*   | 200             |
| pH                               | -     | 2.27*      | 6-9             | -       | 6-9             | 7.8                | 6-9             | 9.7*      | 6-9             |
| BOD <sub>5</sub>                 | mg/L  | 425.35*    | 50              | -       | 150             | 140.62*            | 50              | 239.08*   | 50              |
| COD                              | mg/L  | 1,341.00*  | 100             | -       | 300             | 192.00*            | 100             | 496*      | 100             |
| Phenol                           | mg/L  | 28.17*     | 0.5             | -       | nd              | -                  | nd              | 4.76*     | 0.5             |
| N-Total                          | mg/L  | 139.4      | nd              | -       | nd              | -                  | nd              | -         | nd              |
| Nitrate                          | mg/L  | 13.27*     | 20              | -       | 30              | -                  | nd              | -         | 20              |
| Nitrite                          | mg/L  | 3.7*       | 1               | -       | 3               | -                  | nd              | -         | 1               |
| Ammonia                          | mg/L  | 122.43*    | 1               | -       | 5               | -                  | nd              | -         | 1               |
| Sulfate                          | mg/L  | 326.75     | nd              | -       | nd              | -                  | nd              | -         | nd              |
| Phosphate                        | mg/L  | 93.03      | nd              | -       | nd              | -                  | nd              | -         | nd              |
| Cu                               | mg/L  | 19.83*     | 2               | -       | nd              | -                  | nd              | 5.76*     | 2               |
| Na                               | mg/L  | 4.24       | td              | -       | nd              | -                  | nd              | 0.98      | nd              |
| Cd                               | mg/L  | 2.42*      | 0.05            | -       | nd              | -                  | nd              | 35.75*    | 0.05            |
| Co                               | mg/L  | 0.97*      | 0.4             | -       | nd              | -                  | nd              | 3.54*     | 0.4             |
| Cr                               | mg/L  | 1.89*      | 0.5             | -       | nd              | -                  | nd              | 12.28*    | 0.5             |
| Fe                               | mg/L  | 18.27*     | 5               | -       | nd              | -                  | nd              | 92.73*    | 5               |
| Mn                               | mg/L  | 2.17*      | 2               | -       | nd              | -                  | nd              | -         | 2               |
| K                                | mg/L  | 11.75      | nd              | -       | nd              | -                  | nd              | -         | nd              |
| Ca                               | mg/L  | 4.88       | nd              | -       | nd              | -                  | nd              | -         | nd              |
| Pb                               | mg/L  | 0.8*       | 0.1             | -       | nd              | -                  | nd              | -         | nd              |
| Zn                               | mg/L  | 1.51       | 5               | -       | nd              | -                  | nd              | 12.01*    | 0.1             |
| Total Coliform                   | mg/L  | -          | nd              | >10.000 | nd              | -                  | nd              | 2.39      | 5               |
| Total/1.000 mL                   |       | -          | nd              | -       | nd              | -                  | nd              | -         | nd              |
| <b>Ratio BOD<sub>5</sub>/COD</b> |       | 0.31       |                 | 0.31    |                 | 0.73               |                 | 0.48      |                 |

(\*) Exceeded the quality standard. <sup>(nd)</sup>Not determined. <sup>(\*)</sup> Not measured. <sup>(a)</sup> Government Regulation No. 22/2021 about Implementation of Environmental Protection and Management <sup>(b)</sup> Regulation of the Minister of Environmental and Forestry of Indonesia about Wastewater quality standard <sup>(c)</sup> West Sumatra Governor Regulation No. 41/2008 on Determination of Liquid Waste Quality Standard Workshop Activities in West Sumatra.

#### 4. CONCLUSION

The findings related to the physical characteristics revealed temperature variations within the range of 27.32-31.5°C and Total Suspended Solids (TSS) concentrations ranging from 130.00 to 580.00 mg/L. Regarding the chemical characteristics, the pH values ranged from 2.27 to 9.70; BOD5 concentrations varied between 108.46 and 506.59 mg/L; COD concentrations ranged from 162.70 to 1,428.00 mg/L; oil and grease concentrations were observed between 0.20 and 84.31 mg/L; N-total concentrations ranged from 47.07 to 309.16 mg/L; sulfate concentrations varied from 72.70 to 1,480.00 mg/L; and phosphate concentrations were in the range of 1.14 to 98.15 mg/L. In terms of biological characteristics, the total coliform count exceeded 10,000 jml/1,000 mL. All of these characteristics surpassed established quality standards, except for the pH levels in domestic wastewater, cattle laboratory, and bus cleansing area, as well as zinc concentrations in chemical laboratory and lubricant wastewater. The BOD5/COD ratios of blackwater in the inlet of the septic tank, laboratory wastewater, and lubricant wastewater were all below 0.5, indicating low biodegradability of the wastewater. Greywater emerged as the highest polluter, with mass loadings of 163.45 kg/day for TSS, 106.76 kg/day for BOD5, and 160.15 kg/day for COD. The on-site sanitation system in Unand Limau Manis Padang, utilizing septic tanks, was found to be inadequate in properly treating wastewater, as evidenced by pollutant concentrations exceeding quality standards. Therefore, wastewater from various sources in Unand Limau Manis Padang requires treatment before discharge into the environment. A recommended approach is the development of a comprehensive master plan for wastewater treatment.

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#### Author Contributions

Yenni Ruslinda conceptualization, data curation, writing—reviewing and editing; Ansiha Nur, and Puti Sri Komala: conceptualization, investigation, and methodology; Leni: collecting sample and analysis; Regina Mardatillah and Rinda Andhita Regia: data analysis, interpretation of the results, and writing the original draft. All authors have read and agreed to the published version of the manuscript.

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#### Conflicts of Interest

The authors declare no conflict of interest.

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