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Research Article

Evaluation of Total Hardness and Qualitative Analysis of Boiler Water at the Food Jam Industry, Tangerang, Indonesia

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Abstract. Food industry is one of the most crucial and rapidly growing economic sectors in Indonesia. One of the examples is the food jam industry. This industry was located in Tangerang, Indonesia. The majority of the food jam industry uses its own source of water, so this part is also important to water producers in Indonesia. Water used in the food jam industry should meet the requirements of at least drinking water quality, so the factories need to treat the water. Good quality water is water that requires good physical, chemical, and bacteriology properties. Hard water is a term known for water that contains a high concentration of minerals such as Calcium (Ca) and Magnesium (Mg). Moreover, water with very high degrees of hardness is harmful to health. In this study, we want to evaluate and determine the pH, total hardness, and total dissolved solids (TDS) at three different times namely morning, midday, and afternoon. The results obtained in the range of pH analysis are 6.98 to 7.99 with all cover times. The total hardness in the boiler water and the TDS are around 252.6 to 388.2 mg/L and 310 to 406 mg/L, respectively. These results indicated that it has fulfilled the requirements for total hardness values under the Minister of Health Regulations (Permenkes) No. 492/Menkes/Per/IV/2010.

Keywords: Total Hardness, Boiler Water, pH, TDS, Food Industry

1. Introduction

Industrialization is the backbone of national development. However, industrial pollution is a serious problem all over the world (Braio and Granhem, 2007). In all industrial activities, even though a large amount of sludge is generated by biological treatment, the food sector consumes the most water per unit of production. In fact, the food sector produces more waste than any other industrial activity (Tikariha and Sahu, 2014). The food jam industry is an example of this sector. The food industry is one of the major industries in development countries like Indonesia.

Recently, the demand for resources is increasing due to the population growth and urbanization. To meet demand, industrial growth will occur, leading to increased wastewater production (Baig et al., 2019; Anandan et al., 2020). One example can be affected by the quality of water. Water is an important substance in our life. All living things are depended on water. Since 70% of the substances that make up the human body are made up of water, the human need for water is absolute or necessary. In addition, water is used in several fields of economy and industry. Therefore, it is subject to the regulations that control the market (Becker, 2016). The food sector produces large amounts of sludge from biological wastewater treatment (Braio and Granhem, 2007).

A boiler is a common device that produces high quality steam to maintain operating temperature and to supply power to marine engineering department of a ship. A boiler is a container filled with water which the water evaporates continuously and forms steam from the heating coming from the furnace. Moreover, steam is utilized for power generation and processing purposes in the food jam industry as the main driving force for the turbine systems.

The quality of water is evaluated using a number of parameters such as total ion content, pH, total dissolved solids (TDS), organic compounds, and water hardness. Total hardness is frequently defined as the accumulative of the high concentrations of Ca^{2+} and Mg^{2+} in the water. In general, the hardness of water is usually reported as milligrams of calcium carbonate per liter solution (Pal et al., 2018). Furthermore, pH plays a key role in remediation process and also affects microbial growth (Wadhawan et al., 2020; Varjani and Upsani, 2017). A pH of the wastewater depends on the type of dye and salts used during the dying process and based on that it can be neutral acidic, or alkaline (Varjani et al., 2020). A high remediation rate can be achieved by (i) selection of microorganism that is able to grow at pH of effluent or (ii) adjustment of effluent pH that supports dye degrader growth.

In this research, the assessment will be carried out by conducting a qualitative analysis using chemical and microbiological methods, namely analysis of pH, TDS, and total hardness. The aims of this research are to determine the quality of water used in the food jam industry, before being mixed into the ingredients on the whole process.

2. Method

2.1. Research location

This research was conducted in the Food Jam Industry, Tangerang, Indonesia and Department of Chemical Engineering, Institut Teknologi Indonesia, Indonesia. The research was started on the 1st until 31th of March 2022.

2.2. Determine pH in the boiler water

The analytical procedure for determined pH in the boiler feed water is to put the boiler feed water into the beaker as much as 25 mL, take a universal indicator paper, and dip it into boiler feed water, and checked that's colors by using universal indicator paper.

2.3. Determine total hardness in the boiler water

The analytical procedure for obtaining the total hardness is collected the 50 mL of boiler water into the Erlenmeyer flask. Then, the buffer solution with pH 10 was added to the Erlenmeyer flask to be homogenized. Further, by using EBT (Eriochrome Black T) indicator solution was added 3 drops into the Erlenmeyer flask. The titration with standard EDTA solution until the titration point was reached and the colour was changed into a clear blue.

2.4. Measurement of the TDS in the boiler water

The analysis procedure for determining TDS in sample water is as follows, rinse the TDS meter electrode with distilled water and dry the electrode with laboratory tissue paper, put 100 ml of water into a beaker, then insert the TDS meter electrode into the sample from boiler water. In the last, read the numbers which were obtained on the TDS meter.

3. Result and Discussion

3.1. The effect of pH value

The relationship between time observation and pH value of the 7 days observation on the boiler water was shown in Figure 1. The time observations were selected three times such as morning (09:00), midday (13:00), and afternoon (17:00). We collected the pH data for seven days which shown on the Table 1. Based on the morning data, the pH obtained started from 6.98 to 7.33. On the other hand, during the midday time the value of pH increased significant. Furthermore, at the afternoon was range from 7.21 to 7.83. It can be concluded that during the midday, the water contained in the boiler water collects of the particles, solids, and other substances from the previous boiler tank. At that time, the process was the peak of the whole production at the food jam industry and would result in significant increase in pH value. These pH data were fulfilled with the obligation of the Minister of Health Regulations (Permenkes) No. 492/Menkes/Per/IV/2010.

Table 1. Observation of the time effect (morning, midday, and afternoon) on the pH value of boiler water.

Time Observation		Number of Observation (day)								
		1	2	3	4	5	6	7	8	9
09:00	pH value	7.01	7.19	7.2	6.98	7.11	7.26	7.24	7.33	7.29
13:00		7.67	7.99	7.45	7.50	7.77	7.69	7.25	7.48	7.46
17:00		7.32	7.83	7.36	7.4	7.47	7.55	7.23	7.39	7.21

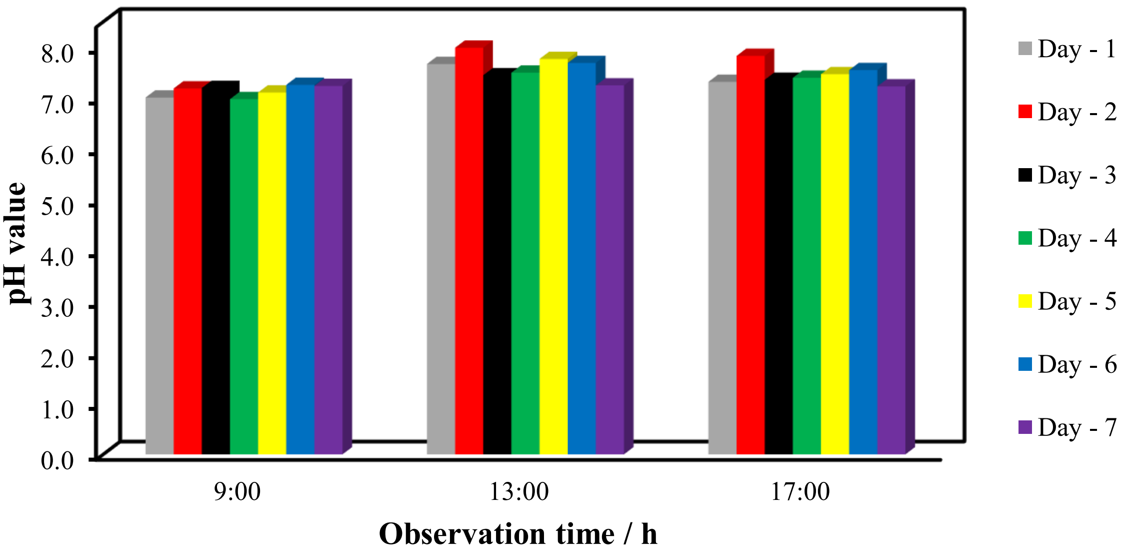

Figure 1. The relationship between observation time and pH value of the 7 days observation on the boiler water.

3.2. The effect of TDS value

Figure 2 shows the relationship between observation time and TDS value from 7 days of observation of boiler water. The determined time were observed three times such as morning at 09:00, midday at 13:00, and afternoon at 17:00. According to Figure 2, the TDS value of 323 to 390 mg/L was observed in the morning hours. The TDS value at midday and afternoon were 318 to 406 mg/L and 310 to 389 mg/L, respectively. The midday hours have a highest TDS value than the two other observation times. This can be concluded that TDS is closely related to the influence of temperature and weather conditions. The weather condition like a rainy can affect the results of the TDS. Because of their many organic and inorganic compounds such as minerals and salts that are dissolved in water and carried into the boiler water. In addition, TDS values were collected from 310 to 406 and were suitable for the obligation of the Minister of Health Regulations (Permenkes) No. 492/Menkes/Per/IV/2010.

3.3. The effect of total hardness value

Figure 3 show the relationship between observation time and total hardness the 7 days observation on the boiler water. The time observation was selected three times such as morning (09:00), midday (13:00), and afternoon (17:00).

We can see from Figure 2, the total hardness of morning section was 223 to 292 mg/L. On the other hand, total hardness for midday and afternoon section were 218 to 306 mg/L and 228 to 289 mg/L, respectively. All these data look pretty much the same for all sessions including morning, midday, and afternoon. However, the midday section has a highest data in compare with two others. The hardness in water is strongly influenced by the presence of chemical elements such as Ca and Mg and react with CO_2. CO_2 is a gas that is easily dissolved in water either directly by rainwater or by the respiration of aquatic plants and animals from the process of decomposition of organic matter (Effendi, 2003). Carbonic acid (H_2CO_3) is produced by the reaction of H_2O and CO_2. This carbonic acid reacts with Ca and Mg as it passes through the bottomed water of the limestone to form $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$, making the water very hard.

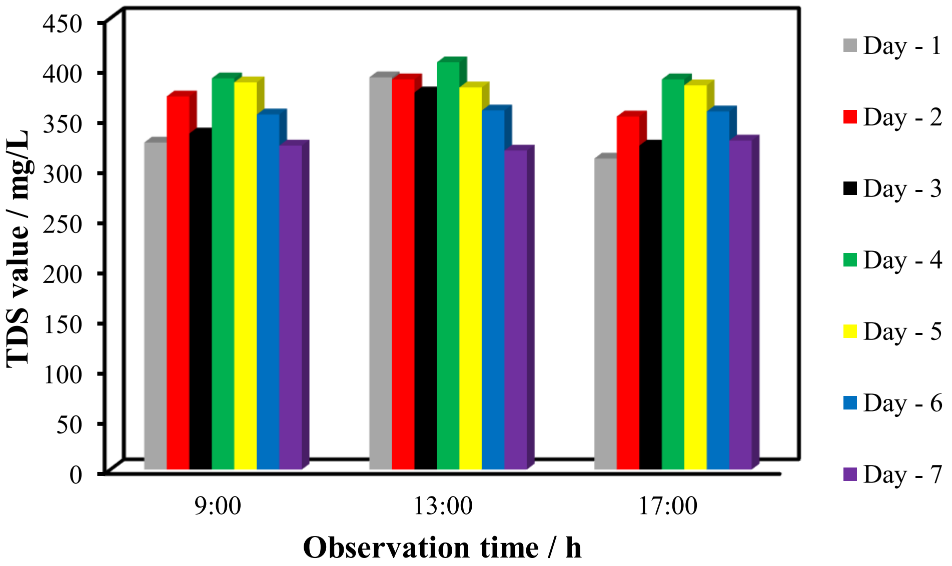

Figure 2. The relationship between observation time and TDS value of the 7 days observation on the boiler water.

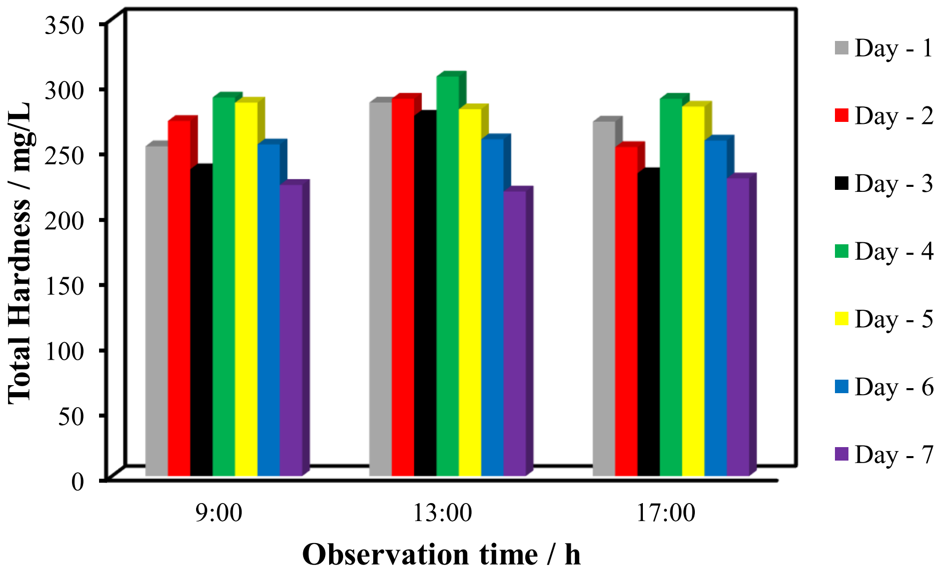

Figure 3. The relationship between observation time and total hardness of the 7 days observation on the boiler water.

4. Conclusion

The TDS, total hardness, and pH values were successfully measured in the boiler water of Food Jam Industry in Tangerang, Indonesia. The observation time were collected at three different times such as morning, midday, and afternoon. The pH analysis is 6.98 to 7.99 for all coverage times. The total hardness and TDS in the boiler water are around 252.6 to 388.2 mg/L and 310 to 406 mg/L, respectively. These results indicated that it has fulfilled the requirements for total hardness, pH, and TDS values under the Minister of Health Regulations (Permenkes) No. 492/Menkes/Per/IV/2010.

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