Study Risk Minimization of The Use Bottled Drinking Water (BDW) By Consumers Using Hazard Analysis Critical Control Point (HACCP) Method

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Abstract. Bottled drinking water (BDW) is an effort to meet the demand for drinking water needs of the community which continues to increase every year. BDW is the community's main choice because it can be consumed directly without the need to cook it first. The high demand for drinking water produced by bottled water requires a comprehensive, easy to apply, and standardized quality control method to maintain and improve the quality of the products produced so that they are safe for consumption by bottled drinking water customers. The suitable method for quality control is the method Hazard Analysis Critical Control Point (HACCP). This method is a risk analysis system by establishing an appropriate control and supervision system to avoid irregularities that can lead to poor quality of drinking water products produced, as well as producing quality bottled water products. The HACCP method can be applied to all aspects of production and aspects of human resources (HR) in bottled water starting from raw water management until the product is produced. In this method, there are 5 important principles used, such as analyzing the risk of hazards that can occur during the production process, determining the critical point of hazard risk analysis, determining critical limits, preparing monitoring system monitoring procedures, and finally preparing corrective actions to avoid deviations from critical limits. Based on the analysis of existing conditions at the BDW in Cirebon City, there are advantages and disadvantages on its own in the production process. For example, the poor performance of some treatment units and the need for control can be caused by replacing treatment units that exceed usage limits and irregular replacement schedules that can affect the water quality of these products. The HACCP method is needed in planning quality control to evaluate the performance of the BDW production processing unit, and determine the quality control of bottled drinking water products to minimize negative impacts for customers who consume them.

1. INTRODUCTION

The demand for drinking water in Cirebon City is increasing and is not proportional to the drinking water supply capacity of the local water company. Cirebon city has the potential for vulnerability to the availability of drinking water because it depends on water sources from Kuningan Regency, West Java. Local water company Cirebon City services reach 78% of the total population of Cirebon City, while the demand for drinking water has increased and has become a problem because people need drinking water (Local Water Company Cirebon City, 2014). To overcome this, people choose bottled drinking water for their daily needs. But it is necessary to be aware of the quality of water from the bottled water products used by the community. The quality needs to meet the applicable drinking water quality requirements listed in the Indonesian National Standard Number 3553 of 2015 and Regulation of the Minister of Industry of the Republic of Indonesia Number 78 of 2016. Therefore, the production process needs monitoring and controlling so that the product suitable for consumption and reducing the negative risk of bottled drinking water (Dahlan and Wahyunus, 2016). Therefore, the bottled drinking water (BDW) company, located in Cirebon City, seeks to apply the method Hazard Analysis Critical Control Point to fulfill monitoring and control measures, as well as to reduce the negative risk of
bottled water products.

2. METHODS

Collecting laboratory research data to support the HACCP method, conducted interview surveys and questionnaires containing aspects of production and aspects of human resources aimed at 6 expert judgments, which are Head of the production, Head and Co. Head of QA / QC, Head of Management Representative, Head of Maintenance, and Head of PPK. The research area was carried out at the BDW Company which is located on Wanasaba Kidul Village, Talun District, Cirebon City, West Java Province.

Figure 1. Location of Research Area, BDW Company
The pre-requisites method, the initial procedure supports risk analysis and preparation of critical points which aims to facilitate the identification of the causes of failure and the impact of the production process using the method fishbone analysis and Failure Mode and Effect Analysis. Fishbone analysis can find the main based on questionnaires sourced from expert judgments, surveys of the existing conditions of the production process and can be used as problems to be analyzed (Suryani, 2018). Identify potential failures in FMEA to assess aspects of failure based on incidence rate, severity, and detection, then obtain the RPN value for failure prevention efforts so that companies focus on dealing with problems identified as critical points, to reduce costs and increase the effectiveness of time and energy in solve problems (Sari, et al, 2011). These two methods consider the Indonesian government program regarding the appeal for HACCP implementation and as a method pre-requisite to guarantee the quality of bottled drinking water products based on SNI 01-4852-1998, ISO 9001 series, and ISO series 22000 (Fitrianti, 2016). HACCP is a quality assurance method that not only guarantees the safety of bottled drinking water without risk, but this method is based on the anticipation of hazards and supervision that prioritizes preventive measures rather than emphasizing final product testing with control measures to minimize negative risks and the occurrence of hazards (Daulay, 2014). The application of the HACCP method consists of 5 principles, such as risk and hazard analysis with the method pre-requisite, identification and determination of critical control points, determination of critical limits from critical control points, preparation of monitoring systems, and determination of corrective actions (SNI 01-4852, 1998).

3. RESEARCH RESULTS AND DISCUSSION

3.1. Identification of Risks and Hazard Cause of Failure

The sampling process was conducted once a day for 7 working days, starting on Monday, 17 February 2020 to Monday, 24 February 2020 which is a time series. Sampling in this study was carried out using a 250 mL beaker glass covered with aluminum foil. Meanwhile, the microbiological analysis of bacteria Escherichia Coli was using a 140 ml glass bottle. Following are the results of the analysis carried out at the Laboratory Quality Control of the BDW Company:

3.1.1. pH Analysis, Total Dissolved Solids, Turbidity, Ozone Remaining Levels, and E. Coli Microbiology

The pH analysis results obtained the highest pH value of 7.54 and the lowest of 6.99. These results are still by the quality standards in SNI 3553: 2015, which is 6.0 to 8.5. The results of TDS analysis obtained the highest TDS value of 184 mg/L and the lowest value of 177 mg/L. These results are still by the quality standards stipulated in SNI 3553: 2015, where the maximum of 500 mg/L. The results of the analysis of the highest turbidity were 0.86 NTU and the lowest was 0.45 NTU. These results are still within the quality standards in SNI 3553: 2015, where the maximum turbidity value allowed is 1.5 NTU. However, some irregularities were found in the fluctuation of the turbidity value on all laboratory analysis days. The increase in turbidity value is always in the carbon filter effluent, which should function to reduce turbidity, but there is an increase in the turbidity value of the carbon filter effluent. This requires further analysis related to problems that occur in the carbon filter unit. These problems can be caused by filter media and carbon filter membranes replacement that is not corresponded to the SOP, washing the media that is not based on the sanitation procedure of the carbon filter unit, or the lack of supervision and control of water quality by the production department (Permenperin Number 96 of
2011). The results of the analysis of ozone levels in bottled drinking water products obtained the value of residual ozone levels of 0.1 ppm or constant for all the products tested with UV irradiation unit contact time for 14 - 16 hours divided into 2 shifts work. The results of the analysis are still by the quality standards stipulated in the Regulation of the Minister of Industry of the Republic of Indonesia Number 78 of 2016, which is between 0.05 - 0.3 ppm. The results of the analysis of bacteria Escherichia Coli at the sampling point obtained that the bacteria content was negative or not detected (TTD). The negative results of the MPN analysis of the bacteria Escherichia Coli in the sample show that the bacteria were Escherichia Coli was not detected in the sample water. These results comply with the quality standards stipulated in SNI 3553 : 2015, where bacteria Escherichia Coli must be absent from the results of each sampling point.
3.1.2. Fishbone Analysis

The preparation of fishbone analysis is based on a questionnaire sheet is divided into two, namely the questionnaire sheet and the technical part of human resources. The technical section questionnaire sheet includes questions about raw water quality, carbon filter, microfilter, ozone injection, mixing tank, and ultraviolet light. Meanwhile, the human resources section of the questionnaire sheet includes questions about worker behavior and worker insights. The fishbone diagram, found that there are problems in the BDW production process such as the burning of raw water intake pumps, rotating blackouts by DWTP, washing media and replacing ozone generators that are not according to schedule and SOP as well as excessive use of the membrane cartridge in the microfilter processing unit.

![Fishbone Diagram Analysis](image)

Figure 2. Fishbone Diagram Analysis

3.1.3. Failure Mode and Effect Analysis (FMEA) Method

Weighting is adjusted to fishbone analysis and entity weighting aims to make it easier to determine the priority of HACCP critical points if there is the same RPN calculation (Wahyuningsih, 2018). Then, determining the value severity or the level of severity of the impact, the more severe the impact, the higher the value severity is. The limitation of the value of the severity analysis is 1 - 5. Furthermore, each scale of environmental conditions is described to ensure consistency in risk analysis (Fitrianti, 2016). Then the results of the estimation of the existing conditions can be known using equation (1) below and then in Table 1 is the result of the severity ranking of each entity.

\[
\text{Severity} = \frac{\text{Ideal Scale Value} - \text{Existing Scale Value}}{\text{Ideal Scale Value}} \times 100\%
\]

(1)

| Entity                  | Value Severity | Rating |
|-------------------------|----------------|--------|
| Raw Water               |                |        |
| Quality of raw water    | 0%             | 1      |
| Distance of raw water source to factory | 0% | 1 |
| Quality of pumps for water transportation | 60% | 3 |
| Carbon Filter           |                |        |
| silica sand replacement | 0%             | 1      |
| Washing silica sand     | 40%            | 3      |
| Size silica sand        | 0%             | 1      |
| Replacement gravel media| 0%             | 1      |
| Washing gravel media    | 40%            | 3      |
| size Gravel media       | 0%             | 1      |
| Replacement activated carbon | 0%  | 1 |
| Washing activated carbon| 40%            | 3      |
| type activated carbon   | 0%             | 1      |
| Micro Filter            |                |        |

Table 1. Rangking of each Entity
Occurrence or the rate of failure of the processing unit illustrated the number of events in 1 year, where the probability of failure was based on a scale of 1-5. A value of 5 means the level of high impact frequency or the number of frequent occurrences and a value of 1 means that the level of impact frequency is low or the number of events rarely occurs. Detection or the value of the ability to control failure is associated with the control based on the frequent failure that occurs. The value occurrence was performed because the number of failures became more frequent when using less effective methods of prevention. Assessment Detection has a scale range of 1 - 5. Scale 5 explains that the ability of the control device to detect the causes of failure is low (undetected) and scale 1, the control device can detect failure easily and with a certainty of detection (Wahyuningsih, 2018). In Table 2, the results of the Risk Priority Number are the multiplications of assessments severity, occurrence, and detection, to determine the potential failure that occurs as well as the critical point for the HACCP method. The RPN values are sorted from largest to smallest value. The largest RPN value is that the type of failure has a significant effect, has a high risk, requires handling, and a monitoring method to repair failure. The smallest RPN value represents the type of failure that never occurs, the risk of danger that does not have the potential to arise. It is not necessary but monitoring is still given to minimize the potential for failure. This type of failure has a significant and high-risk influence which is included as a critical control point whose RPN value is above 10, because it indicates that failure can disrupt the production process so that it affects the characteristics or quality of production water directly, such as laboratory analysis results that exceed quality standards. The results of the RPN analysis rated from 1 to 27 identified hazards and not all types of hazard failures can be used as critical control points. Determination of critical control points is only rated 1 - 6 which is controlled because it has a large RPN number or above 10 which can disrupt the production process, while ratings 7 - 27 do not need to be put into a critical control point because the RPN value is small and does not have the potential to cause failure in the production process. Potential failure occurs due to the membrane cartridge replacement in the microfilter unit and the ozone generator in the ozone injection unit which exceeds the period of use, the quality of the pump for raw water transportation that is often damaged, backwash media for silica sand, gravel, and activated carbon in the carbon filter unit that does not follow the applicable schedule or SOP. The above failures will be identified at the critical control point.
### Table 2. Result of Calculation Risk Priority Number

| Source                  | Type of Failure                                                                 | S | O | D | RPN | Priority for handling |
|-------------------------|---------------------------------------------------------------------------------|---|---|---|-----|-----------------------|
| Raw Water               | Quality of raw water                                                            | 1 | 1 | 1 | 1   | 23                    |
|                         | Distance source of raw water with factory                                       | 1 | 1 | 1 | 1   | 24                    |
|                         | Pump quality                                                                     | 3 | 3 | 3 | 27  | 3                     |
| Carbon Filter           | Replacement of silica sand                                                      | 1 | 1 | 1 | 1   | 14                    |
|                         | Backwash silica sand                                                            | 3 | 2 | 2 | 12  | 4                     |
|                         | Size of silica sand                                                             | 1 | 1 | 1 | 1   | 17                    |
|                         | Replacement of media gravel                                                     | 1 | 1 | 1 | 1   | 15                    |
|                         | Backwash media gravel                                                           | 3 | 2 | 2 | 12  | 5                     |
|                         | media size Gravel                                                               | 1 | 1 | 1 | 1   | 18                    |
| Carbon Filter           | Replacement activated carbon                                                     | 1 | 1 | 1 | 1   | 16                    |
|                         | backwash Activated carbon                                                       | 3 | 2 | 2 | 12  | 6                     |
|                         | Types of activated carbon                                                       | 1 | 1 | 1 | 1   | 19                    |
| Micro Filter            | Replacement cartridge microfilter                                               | 4 | 3 | 3 | 36  | 1                     |
|                         | Backwash membrane cartridge                                                     | 1 | 1 | 1 | 1   | 20                    |

3.2. Hazard Analysis Critical Control Point Method

After analyzing the risks and hazards, the second principle is the determination of a critical control point or a hazard prevention procedure that has been missed from the control, resulting in the emergence of a negative risk to
BDW. Then, a critical limit can be determined to facilitate risk control as the third principle (Hassan and Masduqi, 2016). The critical limit is a criterion that separates acceptable and unacceptable conditions for each critical control point so that it is not exceeded and to avoid loss of control in corrective efforts based on legislation, safety standards, and scientifically tested values. (Sudarmaji, 2015). Arrangement of a monitoring system as the fourth principle is to provide information before any deviation occurs so that corrective action can be taken and does not affect the entire BDW production system (SNI 01-4852, 1998). Monitoring activities include determining the person in charge of each production process, checking the critical control point handling procedure, testing the effectiveness of the critical control point control handling procedure, and determining critical limits to ensure that it is still on a safe level. The fifth principle is the establishment of corrective actions for each critical control point to deal with deviations that occur so as not to affect production results. If the critical limit is not within a tolerable level, corrective action is needed depending on the level of risk in each product production process to ensure that the product production process does not cause new potential hazards (Daulay, 2014). After all the principles of the HACCP method have been carried out, all the results of the analysis are entered in Table 3

| Table 3. Result of Hazard Analysis Critical Control Point Method |
|---------------------------------------------------------------|
| **Type Failure** | **Critical Control Point** | **Critical Limits** | **Monitoring System** | **Correction** |
|------------------|---------------------------|---------------------|----------------------|---------------|
| use of a membrane cartridge in the micro filter unit exceeds the usage power (RPN value = 36) | The membrane cartridge cannot filter fine water particles effectively. | Replacement and the period of use of the membrane cartridge in the micro filter unit | 1 Month Once | US-EPA 2005 on Membrane Filtration Guidance Manual | Check the condition of the membrane cartridge on all parts | Every week at the beginning of the production process | Head of QA/QC and the unit operator membrane filter cartridge be replaced at least 1 month |
| use of ozone generators at the injection unit of ozone that exceeds the period of the power usage (Value RPN = 36) | Power ozone generator so that pathogens went downhill and is not effective | period of the use of ozone generators at the injection unit ozone | 5 Once a Year | US-EPA 2011 Water Treatment Manual Disinfecton | Check the microbial parameter data E. Coli on the ozone injection effluent for 1 year with quality standards | Every year at the beginning of the production process | Head of QA/QC and ozone injection unit operator Replace ozone generator ozone injection unit at least once a year The |
| quality of the main pump is not up to standard and is damaged (RPN value = 27) | Raw water treatment for bottled drinking water production is hampered, disturbances in quality, quantity, and continuity | Available spare pumps and selection pump of the highest quality. | Once a month | PERMEN PERIND AG No. 705 of 2003 Concerning Technical Requirements for the BDW Industry | Check the condition of the main pump and the backup pump. Selection of the best pump for 1 month at least according to the rules | at the beginning of each production shift | Head of maintenance and operator unit ground raw water Pengecekan primary pump minimum conditions before the shift of production |
4. CONCLUSION

Based on the results of the analysis of the existing conditions at the BDW Company, the poor performance of the processing unit and the need for quality control monitoring is due to the replacement of the membrane cartridge on the microfilter and the ozone generator on ozone injection that exceeds the usage limit, the poor quality of the raw water transportation pump and backwash carbon filter media (silica sand, gravel, and activated carbon) that are not on the schedule.

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