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Identifying the Risk of Drinking Water Refill Stations in Surabaya Using Fishbone Method, Case Study in Sukolilo, Gubeng, Rungkut, and Wonocolo Subdistrict

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ABSTRACT

As time passes, the number of businesses to fulfill the need for clean water by opening a refill drinking water stations has been increasing. However, there are still many water quality refill stations which still do not meet the quality standard of Drinking Water which set by Indonesia Ministry of Health. Based on this situation, it is necessary to identify how to determine the priority of failure of each station. In order to obtain the cause of failure the results of the process of refill water in each station, a risk identify is required. To obtain the best quality of drinking water at refill stations (in accordance with Indonesia Ministry of Health Regulation, PERMENKES No. 492/2010, regarding Drinking Water Quality Requirements), required risk identifying tool using fishbone method. This method is one of systematic method by solving the problems that occur during processing at the stations by using some diagrams. Based on the result of risk assessment analysis with fishbone, it can be concluded that the low quality of refill water is caused by: 1. SOP (Standard Operating Procedure) of the drinking water refill stations management, 2. Raw water which used as a source of Drinking Water Refill, 3. Human Resources/Operators/ Owners/Workers at the Drinking Water Refills Stations, 4. Hygiene of the Drinking Water Refill Stations and 5. Maintenance of the drinking water treatment installation.

KEYWORDS: Fishbone, Identifying, Risk, Water Refill Stations

I. INTRODUCTION

In order to fulfill the drinking water consumption for the community, it lead to the competitiveness level of the community to obtain drinking water becomes increasing sharply. Many industries are trying to create business opportunities such as producing bottled drinking water and build drinking water refill stations. These businesses have their own advantages and disadvantages. The bottled drinking water businesses, they sell their product in higher price and have better drinking water quality. In the other hand, drinking water refill stations can fulfill the needs of community in cheaper price, although their quality is lower than the bottled drinking water.

In this case, it is necessary to concern and aware to the quality of the drinking water which are sold by the drinking water refill stations because the community prefer to use these products to fulfill their consumption such as cooking and drinking, because it is cheaper and easier to get than the bottled drinking water. The quality of the drinking water of water refill stations should pass the minimum standard of drinking water quality which is being regulated by Indonesia Ministry of Health with "PERMENKES No. 492/2010" [1]. In this regulation, there are many parameters such as the physics, chemical, and biological of the drinking water.

Based on this situation, it is necessary to find the cause of the quality of refill water that has not met the quality standard through "Assessment risk of the drinking water refill stations as the fulfillment of drinking water". One of the methods [2] that can be used for analyzing is the fishbone methods. Fishbone method aims to find the priority of the problem and the final results of this method can be used as the basis for improving the quality of water produced by drinking water refill stations using some diagrams.

In addition, fishbone method is used to analyze the SOP of the drinking water refill stations management, raw water which used as a source of drinking water refill, human resources/operators/owners/workers at the drinking water refill stations, the hygiene of the drinking water refill stations, and the maintenance of the drinking water treatment installation.

II. RESEARCH SCOPE

A. Research Object

Object of the research are drinking water refill stations which are located spreadly on four subdisctricts in Surabaya. The subdistrict are Sukolilo subdistrict, Rungkut subdisctrict, Gubeng subdistrict, and Wonocolo

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subdistrict. From these subdistricts, it choosen 8 drinking water refill stations and use them as the research objects.

B. Research Parameters

The research use three kinds parameters of drinking water quality standard which based on Indonesia Ministry of Health Regulation, PERMENKES No. 492/2010 [1]. Those parameters are physics (TDS, turbidity, temperature, and colour), chemical (ammonium, hadrness, ferrum, choride, and pH), and biological parameters (total coliform). Each parameter can be viewed on the Table 1 to Table 3.

Table 1.
Physics Drinking Water Parameters

Parameter	Unit	Value
Smell/Odor	-	No Smell/No Odor
Colour	TCU	15
Total Dissolved Solids (TDS)	mg/L	500
Turbidity	NTU	5
Flavours	-	No taste/no flavours
Temperature	°C	Air Temperature ± 3

Source: PERMENKES No. 492/ 2010, 2010

Table 2.
Chemical Drinking Water Parameters

Parameter	Unit	Value
Ammonium	mg/L NH_3-N	1.5
Hardness	Mg/L $CaCO_3$	500
Ferrum	mg/L Fe	0.3
Chloride	mg/L Cl	250
pH	-	6.5 – 8.5

Source: PERMENKES No. 492/ 2010, 2010

Table 3.
Biological Drinking Water Parameters

Parameter	Unit	Value
Total Colifrom	MPN/100 mL	0

Source: PERMENKES No. 492/2010, 2010

III. RESEARCH METHODS

A. Survey and Data Collection

The first step of the research is surveying and collecting data from each drinking water refill station of those sub districts. The data was collected by conducting direct survey by matching data of drinking water refill station from the internet with the field condition to get the exactly number of them. Collecting data are done by interviewing and filling out some questionnaires. The questionnaires contain the information.

B. Stations Selection

The second step is selecting drinking water refill stations which have been surveyed. Selection is using cluster sampling method and systematic sampling. Selected stations are represented as the object of the research. Selecting and sorting is conducted by each drinking water refill station’s treatment technology.

C. Laboratory Analysis

The third step is taking sample of each selected station and analyzing the quality of drinking water which are sold to the customers around those stations by using two simulations. The first simulation is collecting drinking water using sterilized bottle and use their SOP of selling. The second one, collecting drinking water by buying the drinking water using unsterilized galloon and use their SOP of selling. After collecting the drinking water, analyzing each parameter using laboratory standard methods. Each parameter has different method to be analyzed. The methods which have been used are shown on Table 4.

Table 4.
Parameter Analyzing Methods

Parameter	Method
Temperature	Thermometer
Colour	Spectrophotometry
Total Dissolved Solids (TDS)	Gravimetry
Turbidity	Turbidimetry
Ammonium	Spectrophotometry
Ferrum	Spectrophotometry
Hardness	Complexometric
Chloride	Argentometry
pH	pH meter
Total Coliform	Fermentation Multi Column

Source: Laboratory Analysis, 2017

D. Identifying and Analyzing Data

Analyzing data is conducted to determine the quality of the drinking water and compare the quality to PERMENKES No. 492/2010 quality standard. After determines the quality, analyzing data can be done and input the data to fishbone diagrams.

IV. RESULTS AND DISCUSSION

1) ***Survey and Collecting data***
Drinking water refill stations is being surveyed by some surveyor whom explore and come to each station to obtain some information about the raw water, technology, operational procedure, controll procedure, human resources data. The survey is divided into two part, the first part is to obtain those information and take some sample from the stations. The second part is to collect data for fishbone analysis.
2) ***Stations Selection and Sorting***
Selecting and sorting station can be conducted after survey and collects data of each stations. There are seven stations which are selected as the representative of each technology which they use and each subdistricts.
3) ***Laboratory analysis***
From 7 sample which have been collected, there are various result of the drinking water quality. The result shown on Table 5 to Table 11.

Table 5.
Drinking Water Quality of Station A

No	Parameter	Quality Standards	Sampling Case	
			A bottle	A galloon
1	TDS	500	104	110
2	Turbidity	5	0.54	0.48
3	Temperature	25	24	24
4	Colour	15	0	0
5	Ammonium	1.5	0.00	0.00
6	Hardness	500	71.43	85.71
7	Ferrum	0.3	0.03	0.03
8	Chloride	250	12.00	14.00
9	pH	6.5	7.30	6.90
10	Total Coliform	0	0	0

Source: Laboratory Analysis, 2017

Table 6.
Drinking Water Quality of Station B

No	Parameter	Quality Standards	Sampling Case	
			B bottle	B galloon
1	TDS	500	56	74
2	Turbidity	5	0.74	0.34
3	Temperature	25	25	24
4	Colour	15	0	0
1	Ammonium	1.5	0.00	0.00
2	Hardness	500	42.86	42.86
3	Ferrum	0.3	0.03	0.02
4	Chloride	250	8.00	12.00
5	pH	6.5	7.30	7.15
1	Total Coliform	0	7	170

Source: Laboratory Analysis, 2017

Table 7.
Drinking Water Quality of Station C

No	Parameter	Quality Standards	Sampling Case	
			C bottle	C galloon
1	TDS	500	100	114
2	Turbidity	5	0.59	0.32
3	Temperature	25	24	24
4	Colour	15	0	0
5	Ammonium	1.5	0.00	0.00
6	Hardness	500	57.14	71.43
7	Ferrum	0.3	0.02	0.04
8	Chloride	250	12.00	14.00
9	pH	6.5	7.25	7.25
10	Total Coliform	0	0	0

Source: Laboratory Analysis, 2017

Table 8.
Drinking Water Quality of Station D

No	Parameter	Quality Standards	Sampling Case	
			D bottle	D galloon
1	TDS	500	116	128
2	Turbidity	5	0.61	0.56
3	Temperature	25	25	24
4	Colour	15	0	0
5	Ammonium	1.5	0.00	0.00
6	Hardness	500	85.71	85.71
7	Ferrum	0.3	0.03	0.03
8	Chloride	250	16.00	18.00
9	pH	6.5	6.95	6.80
10	Total Coliform	0	0	0

Source: Laboratory Analysis, 2017

Table 9.
Drinking Water Quality of Station E

No	Parameter	Quality Standards	Sampling Case	
			E bottle	E galloon
1	TDS	500	110	114
2	Turbidity	5	0.44	0.35
3	Temperature	25	24	24
4	Colour	15	0	0
5	Ammonium	1.5	0.00	0.00
6	Hardness	500	85.71	85.71
7	Ferrum	0.3	0.02	0.03
8	Chloride	250	12.00	16.00
9	pH	6.5	7.40	6.90
10	Total Coliform	0	0	0

Source: Laboratory Analysis, 2017

Table 10.
Drinking Water Quality of Station F

No	Parameter	Quality Standards	Sampling Case	
			F bottle	F galloon
1	TDS	500	96	100
2	Turbidity	5	0.50	0.50
3	Temperature	25	24	24
4	Colour	15	0	0
5	Ammonium	1.5	0.00	0.00
6	Hardness	500	78.57	78.57
7	Ferrum	0.3	0.03	0.02
8	Chloride	250	18.00	14.00
9	pH	6.5	6.95	6.85
10	Total Coliform	0	9	11

Source: Laboratory Analysis, 2017

Table 11.
Drinking Water Quality of Station G

No	Parameter	Quality Standards	Sampling Case	
			G bottle	G galloon
1	TDS	500	96	94
2	Turbidity	5	0.40	0.40
3	Temperature	25	25	24
4	Colour	15	0	0
5	Ammonium	1.5	0.00	0.00
6	Hardness	500	71.43	71.43
7	Ferrum	0.3	0.02	0.02
8	Chloride	250	14.00	14.00
9	pH	6.5	7.05	6.95
10	Total Coliform	0	0	0

Source: Laboratory Analysis, 2017

From those seven tables above, we can conclude that there are no many different between the quality of drinking water of each sampling case simulation and some still pass the quality standard. Due to risk management which based on the unsprecified results, the quality of each parameter is variative through the time. Based on that statement, the research is continued by analizing four parameters, they are colour, turbidity, TDS, and Total Coliform. The results of each parameter can be simplified that shown on Table 12-15 below.

Table 12.
TDS quality of each station

Sample	Quality Standard	TDS	Status
A bottle	500	104	Good
A galloon	500	110	Good
B bottle	500	56	Good
B galloon	500	74	Good
C bottle	500	100	Good
C galloon	500	114	Good
D bottle	500	116	Good
D galloon	500	128	Good
E bottle	500	110	Good
E galloon	500	114	Good
F bottle	500	96	Good
F galloon	500	100	Good
G bottle	500	96	Good
G galloon	500	94	Good

Source: Laboratory Analysis, 2017

Table 13.
Turbidity quality of each station

Sample	Quality Standard	Tubidity	Status
A bottle	5	0.54	Good
A galloon	5	0.48	Good
B bottle	5	0.74	Good
B galloon	5	0.34	Good
C bottle	5	0.59	Good
C galloon	5	0.32	Good
D bottle	5	0.61	Good
D galloon	5	0.56	Good
E bottle	5	0.44	Good
E galloon	5	0.35	Good
F bottle	5	0.50	Good
F galloon	5	0.50	Good
G bottle	5	0.40	Good
G galloon	5	0.40	Good

Source: Laboratory Analysis, 2017

Table 14.
Colour quality of each station

Sample	Quality Standard	Colour	Status
A bottle	15	0	Good
A galloon	15	0	Good
B bottle	15	0	Good
B galloon	15	0	Good
C bottle	15	0	Good
C galloon	15	0	Good
D bottle	15	0	Good
D galloon	15	0	Good
E bottle	15	0	Good
E galloon	15	0	Good
F bottle	15	0	Good
F galloon	15	0	Good
G bottle	15	0	Good
G galloon	15	0	Good

Source: Laboratory Analysis, 2017

Table 15.
Total Coliform quality of each station

Sample	Quality Standard	Total Coliform	Status
A bottle	0	0	Good
A galloon	0	0	Good
B bottle	0	7	Not Passed
B galloon	0	170	Not Passed
C bottle	0	0	Good
C galloon	0	0	Good
D bottle	0	0	Good
D galloon	0	0	Good
E bottle	0	0	Good
E galloon	0	0	Good
F bottle	0	9	Not Passed
F galloon	0	11	Not Passed
G bottle	0	0	Good
G galloon	0	0	Good

Source: Laboratory Analysis, 2017

These parameters can be analyzed by an analysis using fishbone method.

4) Risk Determining

Risk is a probability which can occured some deviations of some expected result [3]. Based on this reference, the risk of the research can be defined as an incident or damage which can make the lower optimilization of treatment. The treatment's result is become lower and diverge from the expected results.
Due to the labaoratory analysis, there is a parameter which has unexpected results, it is Total Coliform quality. Total coliform is the main parameter which can be the indicator of E. Coli bacteria in the drinking water. This bacteria is very harmfull and make some diseases, such as diarrhea. As high as the sum of total coliform, it can indicate the other pathogen bacterias in the water.
From the survey and questionares which has been conducted to collect some datas, the datas can be used as the tools to find out the failure factors of the treatment, start from the raw materials; the internal and external problems; and treatment installation performance of each drinking water refill stations. The results of the questionarres and interviews will be given some scores. Scoring is conducted by giving the highest scale as 4 and the lowest scale is 1 to determine the drinking water refill station level. The scale can be shown on Table 16.

Table 16.
Score of each scale

No	Station Category	Score
1	Good	76 – 100
2	Average	56 – 75
3	Bad	40 – 55
4	Very Bad	< 40

Source: Data and Scoring Analysis, 2017

5) Analyzing using fishbone method

Every stage of risk identifications a systematic and sustainable process which must be done to identifying many probabilities of risks. The identification is the most important step because it can detect all of the risks. The identification must be done in sustain and accurate to get the best result and there is no risk which can be missed or not identified [4].
The steps are: risk identifying risk (analyzing the product quality from the sample), questionnares submitting, interviewing the operator/owner, and discussion to get some informations of the quality and some potential failures due to the tratment process.
Questionnares submitting is can be done by interviewing the operator/owner to get some informations. Each questionnares will be scored from 1 to 5. The results will be processed to find the average score of each questions and will be divided by the sum of the questions. Scoring formula is

Average score = [(Total Score)/(Total questions)]

And the formula to figure out the percentage of each station is using by multiplying the average score with

100% and divided by ideal score (10). The formula is:

Station percentage=[(Total Score x 100)/(ideal score=10)]

The determining of each station category is detemined by the station percentage based on the scale. By doing the research, some components or factors should be get. The factors are external factors, such as lower monitoring to the raw material quality and the product quality from the nearest health center, the lower awareness of the owner about the hygiene, the lower maintenance of the water treatment installations, the lower knowledge of the owner/operator about the treatment installations, the lower of standard operational procedure and rules [5,6], which all of these factors can become the lack of treatment installation performance.

Based on those problems, the failure factors and problems can give some damages to the quality of the water. The effects and causes can be identified using fishbone methods.

There are some main failure factors. Those factors are:

1) Raw water. This factor has some sub factors, they are the material of the reservoir tank, the intensity of cleaning the reservoir tank, and the monitoring of the raw water quality
2) Internal factors of the station. This factor has some sub factors, they are: the procedure of refill, the human resources of the drinking water refill station, the monitoring of the product, the sanitary and hygiene of the station.
3) External factor. This factor has some sub factors, they are: the monitoring of the government (PUSKESMAS or health ministry) and the hygiene of the customers galloons.
4) Water treatment installation performance. It has some sub factors, they are: the standard operational procedure and the implementation of the treatment
5) Water treatment installation maintenance. It has some sub factors, they are the maintenance of pump and unit of the installation and the maintenance of every unit.

V. CONCLUSION

1) From four parameters, the most potential parameter which can give big damage is Total Coliform.
2) By using fishbone diagram, there are five factors of the failure. The factors are raw water, internal factors, external factors, water treatment installations performance, and water treatment installations maintenance.

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