

IOP MSE 1125_ Identification and Factors of Failure Risk in Refill Drinking Water Quality by Using Ishikawa Diagram

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Identification and Factors of Failure Risk in Refill Drinking Water Quality by Using Ishikawa Diagram

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Abstract. The owner of refill drinking water stores (RDWS) have a big opportunities to expand their business since most of people need drinking water with the cheaper price than bottled drinking water. However, some issues regarding the quality of refill drinking water (RDW) have been arised recently, such as issue of pathogen existence in the treated water of RDW. This study aims are to measure the RDW quality and to identify the factors of failure risk of RDWS in treating RDW by using Ishikawa diagram. Study was carried out in 23 RDWS in Gunung Anyar District of Surabaya City. Sample was taken and measured for pH, turbidity, total dissolved solid (TDS), total coliform and Eschericia coli concentration. Ishikawa diagram was applied to reveal risk failure factors of RDW treatment processes. The results show that microbiology parameters was not fulfilled the drinking water quality standard. Ishikawa diagram found that man, material, method, machine, monitoring and evaluation for environment were the factors of failure risk. Therefore it is necessary to provide recommendations to reduce the failure risk of microbiology parameters through UV or Ozone contact time of at least 4 minutes, routine monitoring of treatment units, preparing procedure operational standard.

1. Introduction

People have consumed drinking water, which is produced by drinking water waterworks company (PDAM). Population growth has linier correlation with drinking water consumption, therefore increasing population indicates increasing drinking water production [1]. Nowadays, an advanced technology for producing drinking water has been applied for commercial purposes. It is known as refill drinking water (RDW), which is managed by refill drinking water stores (RDWS). People tends to choose RDW over bottled drinking water for daily consumption, due to RDW has lower price than the later [2]. Gunung Anyar District has the potential in marketing refill drinking water in the city of Surabaya because it has a population in 2013 of 53,476 with an area of around 962 Ha with economic growth of 5.60% in 2010 [3], this condition is an opportunity for many entrepreneur to sell RDW. The fact is some of the RDWS provides safely RDW, as proved in the previous studies [4, 5]. RDW must meet the drinking water quality standards, which referred to Permenkes No.492/Menke Per/IV/2010 about Drinking Water Quality Standard and Permening No.65/MPP/Kep/10/2004 about Technical Requirements for the Water and Trade Store. The low quality assurance of drinking water produced by RDWS has been the main issues, particularly increasing the number of microbiology parameters such as total coliform, Eschericia coli. It indicates the possibility of pathogenic bacteria that existed in contaminated water [4]. Thus the quality of RDW



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should be continually reviewed in the context of safeguarding quality that greatly affects the degree of public health. According to that issues, it was necessary to observe the factors of failure risk of unfulfilled drinking water quality by RDWS. Fishbone Diagram or known as Ishikawa Diagram is one of the method for analyzing the failure risk of a process. Ishikawa diagram is an structured approach for quality control analyzing in order to identify some issues, inappropriate, failure in the systems. Using Ishikawa diagram could solve the problems by finding the failure factors easily. Ishikawa diagram was created to assess failure risk problems through questionnaire data and brainstorming method to the RDWS owners [6, 7]. The aims of this study are to measure the RDW quality and to identify the factors of failure risk of RDWS in treating RDW by using Ishikawa diagram. The output of this study will give some recommendation to the owner of RDWS for managing RDWS, to the government for monitoring and evaluation RDWS, and for the society for controlling the RDW quality.

2. Materials and Methods

Samples was collected from thirteen Refill Drinking Water Store (RDWS) at Gunung Anyar District, Surabaya City. Water samples was analyzed for pH by using pH-meter, turbidity by using turbidimeter, total dissolved solid (TDS) by using gravimetry, total coliform and Eschericia coli by using most probable number test (MPN). Interview was conducted to collect information regarding source water and failure risk analysis. All data was analyzed by using Ishikawa Diagram to know the failure risk factors.

3. Results and Discussions

3.1. Identification of Failed Risk

Most of drinking water refill storage have been using two main process for drinking water refill treatment technology, filtration and disinfection. Firstly, in the filtration, source water was discharged into silica sand filter in order to filtering fine particles and to reduce turbidity as well. The following process is activated carbon filtration for removing micro pollutant, such as organic matter, smell, detergent, phenol, and heavy metal. Further, the treated water was discharged into cartridge filter with membrane pore size 1-1 micron in order to remove remaining fine particles and obtain the clear water eventually. Secondly is disinfection by using ultraviolet ((UV), ozonation (Ozone), reserve osmosis (RO), and combination between those methods. Disinfection is used to kill pathogen, which is the main issue for drinking water [8].

Table 1. Disinfection technology and raw water sources of refill drinking water store (RDWS)

No	Name of DWRS	Disinfection Technology	Raw Water Sources (Location)	No	Name of DWRS	Disinfection Technology	Raw Water Sources (Location)
1	A	UV	Pacet	7	I	UV-Ozone	Prigen
2	B	UV	Trawas	8	J	UV-Ozone	Prigen
3	C	UV	Trawas	9	K	UV-Ozone	Prigen
4	D	UV	Trawas	10	L	UV-Ozone	Trawas
5	E	UV	Prigen	11	M	UV-Ozone	Trawas
6	F	UV	Prigen	12	N	RO	Trawas
7	G	UV	Prigen	13	O	Tidak ada	Prigen
8	H	UV	Prigen				

Final stage is packing the treated water into sterilized bottle and closed tightly. According to the observation data, UV technology was implemented by eight RDWS, combination of UV-Ozone was applied by five RDWS, and only one RDWS used RO technology, as shown in Table 1. In addition,

source water for RDW was taken from 3 mountain water, including Prigen, Trawas and Pacet. Source water and treated water quality of RDW is shown in Figure 1, Figure 2, Figure 3, Figure 4, and Figure 5, which presented pH, turbidity, TDS, total coliform, and Eschericia coli, respectively. pH value of source water and treated water of RDW is in the range of drinking water quality standard, that is 6.5-8.5, as shown in Figure 1. It indicates that treated water of RDW is safe regarding the pH value. Figure 2 shows the turbidity number, it indicates a low number, which is less than 5 NTU, over the standard one, as shown in Figure 3. Those figure conjectures that physical parameters of RDW describe a safety drinking water consumption for daily life. However, the biological parameters indicate a contradictive situation. It shows that both of total coliform and Eschericia coli in particular RDWS did not obtain the standard drinking water quality. as seen on Figure 4 and Figure 5.

pH

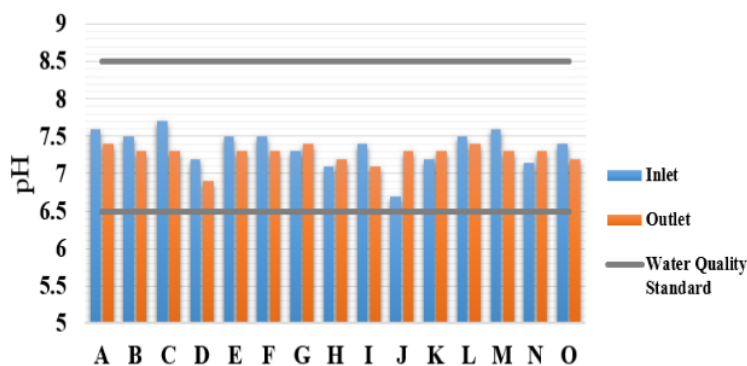


Figure 1. pH concentration of raw water and refill drinking water

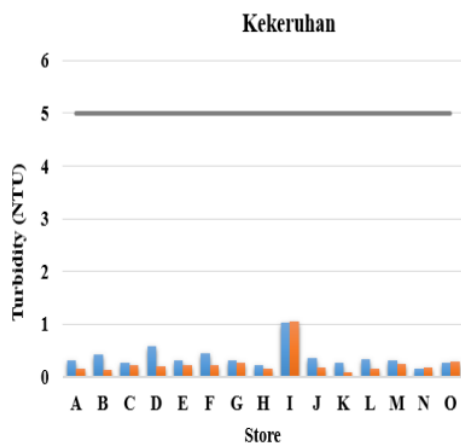


Figure 2. Turbidity concentration of raw water and refill drinking water

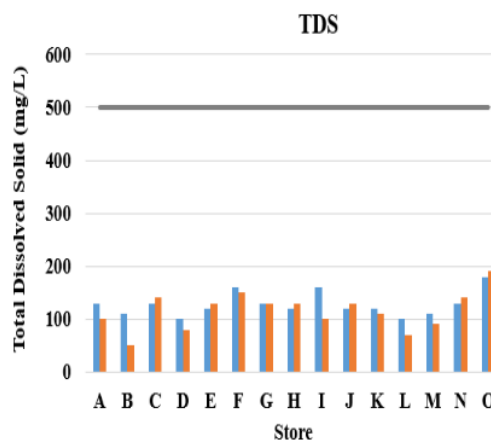


Figure 3. Total Dissolved Solid (TDS) concentration of raw water and refill drinking water

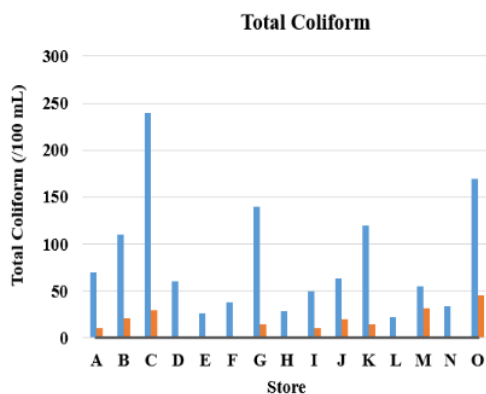


Figure 4. Total Coliform concentration of raw water and refill drinking water

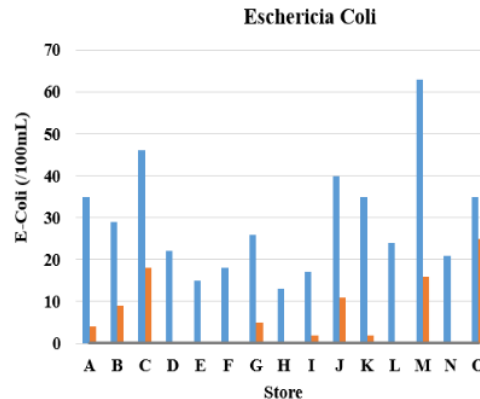


Figure 5. Eschericia coli concentration of raw water and refill drinking water

3.2. Factors of failure risk in refill drinking water quality

According to fishbone diagram [6], there are identified five points of risk failure for RDW quality, as describes in the following paragraphs.

1. Man

Man, who serves the customers in refilling water, is lack of information regarding standard for bottle handling, including washing bottle, sterilized bottle, washing hand before serving the refill, unhygienic behavior, inappropriate working costumes, even some of them were smoking during working. Shortly, man have not follow the procedure for refilling bottle as regulated in the Permenindag No.651/MPP/Kep/10/2004.

2. Material

According to Permenkes RI No. 32/2017, source water quality has fulfill the requirements of water sanitation with physical, chemical, microbiology, and radioactive parameters. The observation data have shown that two DWRS has taken source water failed to meet the water quality standard. Therefore, DWRS has to monitor source water quality analysis from distributor, at least once per-three months for microbiology parameters and once per-six months for physical and chemical analysis [8]. According to survey information, all of DWRS has been analyzing source water once, in the early time, during their start to run the store.

3. Method

All of DWRS does not have procedure operational standard (POS) for drinking water refill treatment processes. According to Permenindag No. 651/MPP/Kep/10/2004 about Technical Requirements for Drinking Water Refill Store, it is necessary to provide POS, to analyze physical parameters once per-month, once per-three months for chemical analysis, and once per-six month for microbiology parameters for confirming treated water quality [9].

4. Machine

According to Permenindag No.651/MPP/Kep/10/2004 about RDW treatment should be involved source water tank, pre-filtration, carbon filter, cartridge filter, disinfection unit, and storage tank. Unit production is the main equipment for RDW production. This study observed that each RDWS has applied different filter, because the government has not regulated the specification standard for microfilter for RDW treatment. The treated RDW will gain the water quality standard if a detail specification filter was installed completely. The surface of all equipment should me sanitized, free

from residual, every day maintenance. However, in fact the existing filter in all RDWS have not been maintained well. For disinfection unit, most of RDWS does not provide it properly. It is probably the main problem related to the higher microbiology parameters than the water quality standard. In the storage tank, the funnel has been oxidized, quite dirty, and there is no disinfection unit. It is probably another issue for total coliform existence in the treated refill drinking water.

5. Monitoring and Evaluation of Environment

Monitoring and evaluation should be conducted by Department of Health, Government of Surabaya as govern in the Permenkes No.43/2014. In addition, according to Permenkes No.907/2002 about monitoring for water quality standard, it has been governed that chemical and microbiology monitoring should be conducted once per-every 3 months for raw water and once per-month for refill drinking water. Lack of monitoring and evaluation will cause to low quality control for refill drinking water [4]. According to the observation in the RDWS, it was found that only two RDWS got training and supervising from the government. In addition, the government visited the RDWS only once per-six to twelve months, which is not enough monitoring.

Some recommendation have been assessed according to the fishbone diagram information, as described in the following paragraph:

1. The minimum contact time for UV disinfection is 4 second, for Ozone technology is 4 minutes, and changing the UV disinfection after expired date [10]. It is suggested to apply reserve osmosis for microbial removal, even though the price is quite expensive.
2. Monitoring and evaluation for machine should be conducted strictly according to the regulation, including checking the cleaning period, expired date, changing the broken spare part regularly.
3. Monitoring and evaluation for the material (raw water and refill water) should be conducted strictly and claimed for inappropriate raw water quality.
4. Provide procedure operational standard (SOP) for the officer of RDWS, therefore it will support for internal monitoring and evaluation [11], and the SOP should be re-evaluate within 3 months.

Government should provide some preventive action in order to support the improvement for refill drinking water quality, such as making the policy regarding punishment for RDWS that is break the regulation for RDW production, training and certification for the officer of RDWS which is certified by Department of Health, Government of Surabaya City. Training was carried out in order to increase the skill in maintenance RDW equipment. Improvement for cooperation among the owner of RDWS in term of association of RDWS. In addition, society as user of RDW have to involved as social control for monitoring refill drinking water quality. User of RDW should boiled the water before drinking and for using any purposes, this is to prevent pathogen contaminant which could be existed in the RDW.

4. Conclusion

This study identifies that mostly RDWS uses two main process for drinking water refill treatment technology, namely filtration and disinfection. Raw water for RDW was taken from three different mountain water, which is located in Prigen, Trawas and Pacet. The quality of RDW for physical parameters, such as pH, turbidity, and TDS meet the drinking water quality standard, however for microbiology parameters, such as total coliform and *Eschericia coli* do not. According to fishbone diagram, microbiology pathogen existed in the RDW due to five factors as assess by Ishikawa Diagram, a failure risk analysis. Those five failure is are man, material, method, machine, and monitoring-evaluation. This study suggests that government, society, and the owner and theirs staff of RDW should works and cooperate to monitor and evaluate the RDW quality in order to obtain safety water consumption.

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