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DRINKING WATER PROTECTION QUALITY CONTROL TO MINIMIZE RISK OF CONSUMER HEALTH

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ABSTRACT

Drinking water in Indonesia is produced by IPAM (Instalasi Pengolahan Air Minum/ a Water Treatment Plant), AMDK Company (Air Minum Dalam Kemasan/Bottled Water) and AMIU Depot (Air Minum Isi Ulang/refilled drinking water). The drinking water producers must pay attention to water quality. The water produced by people is used for daily needs. The quality of drinking water products is regulated in Minister of Health Regulation No. 492 of 2010. Drinking water production processes are often encountered problems such as the quality of raw water, treatment units, and other risk factors for the production process. This research was conducted to minimize the risks that occur by identifying critical points that need to be corrected. In this research, the Hazard Analysis Critical Control Point (HACCP) method is used. This method is needed to identify the dangers and risks in the production chain and then control can be determined by focusing on prevention to minimize the risks that may arise. The HACCP principle is hazard analysis based on physical, chemical and biological hazards, determining critical points, setting limits for each critical point, establishing monitoring systems, establishing corrective actions for each critical point, recording and verification. Furthermore, an alternative control is determined in accordance with the regulations in the HACCP procedure to optimize the quality of its products. The results of the analysis and evaluation of the condition of the existing IPAM X found 15 critical points. The biggest source of risk that affects the quality of production is found in the operations of each processing unit and fluctuations of its discharge. In AMDK X Company, 17 critical points were found with the biggest source of risk coming from incomplete Standard Operational Procedure and a late maintenance period. Whereas AMIU Depot found 25 critical points with the biggest source of risk came from media replacement and UV unit replacement.

KEYWORDS : Drinking water, Quality control, HACCP, IPAM, AMDK, AMIU Depot

INTRODUCTION

The quality of river water or surface water which is generally used as raw water in the drinking water treatment process at IPAM is greatly affected by the surrounding human activities. Activities that can have an impact include changes in land use patterns to become agricultural land, fields and settlements, and increased industrial and human activities (Agustiningsih *et al*., 2012). At present the burden of surface water pollutants has exceeded many of the grade water quality standards and is classified as polluted so that it does not support it as a source of raw water for IPAM.

Springs or ground water are widely used by AMDK companies and AMIU depots as raw water for their production. The utilization of ground water or springs increases with the increase in city population. Karnaningroem *et al*. (2017) and Entjang, (2003) stated that many AMIUs did not meet the quality standards with high coliform parameter values. During the transfer of AMIU from the water source to the depot, the water quality changes due to transportation and the storage system.

Another cause of the increased need for water is the source of drinking water from the Regional Drinking Water Company (PDAM) which cannot be consumed directly by consumers because it is contaminated by microorganisms in the distribution process. This is a problem because the tap water can not be drunk straight from the tap and had to boil the water first before drinking. Therefore, as an effort to overcome this problem is to use the latest technologies that produce drinking water without boiling it first. The raw water used comes from springs and is processed through several stages and then packaged and produced as bottled drinking water. To achieve the best quality bottled drinking water, each company must meet the AMDK quality standards that refer to the Minister of Health Regulation No. 492 of 2010.

Changes in the quality of raw water can affect the quality of drinking water that's processed and distributed to the community (Sasongko *et al.*, 2014). This is adjusted to the provisions in the Minister of Health Regulation No. 492 of 2010 concerning Requirements for Drinking Water Quality that every drinking water provider is obliged to guarantee that the drinking water it produces is safe for health if it meets the physical, biological and chemical requirements contained in mandatory parameters and additional parameters. In addition, based on ISO 3551: 2015, the standardization of the quality of Bottled Water is also made with the aim of adjusting the standards with the development of technology, the standard adjustment with the new regulations in force, protecting the health and interests of consumers, ensure fair trade, support the development, and diversification of bottled water industry products. Efforts to achieve these standards both IPAM, AMDK and AMIU required overall control and supervision of drinking water production by implementing a HACCP management system.

MATERIALS AND METHODS

The material used in the form of primary data and secondary data. Primary data was obtained by sampling to test water quality from IPAM, AMDK Company and AMIU Depot. It also conducted interviews and questionnaires against the leaders of the production IPAM, bottled water company, and AMIU Depots as Expert Judgment. Expert judgment is a person who understands the related drinking water treatment process that will provide an assessment of the questionnaire given. Secondary data is data about the performance of the production process of each processing unit obtained from relevant sources and the results can be accounted for, such as raw water descriptions, drinking water treatment flow diagrams, organizational structure data, SNI (Indonesia's National Standard) 01-4852-1998, Regulation of the Minister of Health Number 492 of 2010 concerning Requirements for Drinking Water Quality, and Regulation of the Minister of Health Number 736 of 2010 concerning Procedures for Supervision of Drinking Water Quality.

Hazard Analysis Critical Control Point (HACCP) method can be carried out by following the SNI 01-4852-1998 guidelines regarding the HACCP system. HACCP plan is based on the existing condition that occurs in the production system IPAM X, AMDK X Company and AMIU depots. HACCP plans can be made if they follow 5 important principles, the following is an explanation of each of the 5 HACCP principles:

Hazard Analysis

Hazard risk analysis can be carried out on the drinking water production system of IPAM X, AMDK X Company and AMIU Depot through the document processing flow diagram, Standard Operational Procedures (SOP), water quality data, and other secondary or primary data for initial definition of the problem. In this section are identified and defined product characteristics, types of contaminants, chemicals, or foreign objects that may arise related to the production process so that the water quality is affected. The scope of hazard analysis is the influence that can harm the health of consumers and the environment, as well as a qualitative or quantitative evaluation of the presence of hazards. According to Sudarmaji (2015), important things to consider include:

- Formulation is the condition of raw materials that can affect product safety and stability.
- Process is a treatment process that can pose a risk of danger.
- The treatment of human resources that carry out or oversee the course of the production process.

Identification of Critical Control Point

After the hazard risk has been obtained, it can be determined a critical control point in the production system that has the highest potential risk of drinking water. Determination of critical control points can be helped by fishbone diagrams and FMEA. The CCP is determined at each stage of the process for biological, chemical, physical and technical hazards.

Establish Critical Limits for Critical Control Point

Critical limits are safety limits that must be fulfilled for each control measure carried out in the CCP step. Critical limits are the criteria that distinguish between safety and the possibility of being unsafe. Determination of critical limits based on legislation, safety standards, and values that have been scientifically tested.

Establish a Monitoring System

Monitoring is the action needed to ensure that the process is controlled and runs within the specified critical limits. Monitoring is carried out through observation. All parties that have responsibility for monitoring must be trained and have a clear understanding.

Establish Corrective Action

Corrective actions must be properly defined to ensure the CCP that are out of control can be controlled and further deviations can be prevented.

RESULTS AND DISCUSSION

Risk and Hazard Identification Causes of Failure

The first principle in the HACCP method is the analysis of hazards that may arise in the production process. The danger comes from technical aspects as well as human resources that can cause process failures and affect the quality of production results. To identify hazards, it is necessary to know the existing conditions and analyzed using fishbone diagrams, then prioritization is carried out using the FMEA method. The following is a fishbone diagram of drinking water treatment:

Figure 1 has shown the fishbone diagram of IPAM X production system. The head of fishbone skeletons is the main issue happened in IPAM X which is the water treatment plant units do not work properly. Then the fins are the 9 factors which predicted as the root causes, from every fin there are several thorns which are the root aspects of every root causes.

The following are the types of failures and their identified hazards:

1. The lack of training regarding drinking water quality management system in accordance with SNI 01-4852-1998 which can cause system failure due to human resources as the processing executor does not understand well the management of drinking water quality.
2. There is no strainer in the water withdrawal pipe from the intake to the raw water pump, so the macrodebric waste particles that pass through coarse filtration or the barscreen can enter until the processing unit.
3. Gradient Speed in the flocculation process exceeds the design criteria so that it poses a danger that floc is not formed optimally and precipitation cannot occur.
4. The filter media has never been replaced so that it can cause danger, such as turbidity and organic matter will not drop.
5. The gas transfer speed at the existing condition of the aerator unit is insufficient and does not comply with the design criteria. Hazards that can arise from such failures are organic

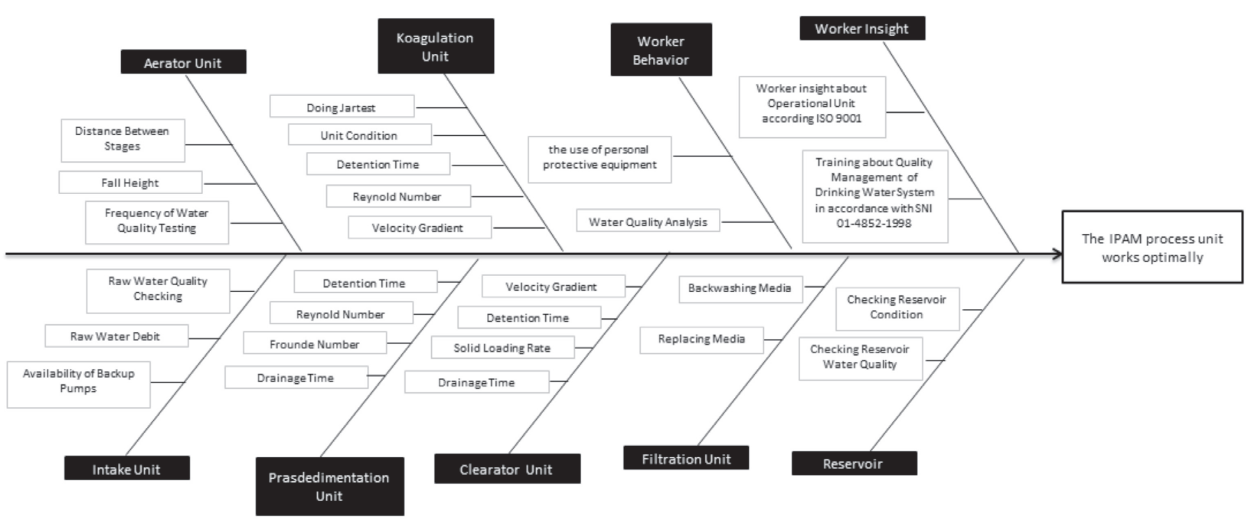

Fig. 1. Fishbone Diagram of IPAM X

substances in the water can not be decomposed completely and can trigger Trihalometan in the disinfection process.

6. Reynold numbers and froude numbers of prasedimentationunits of existing conditions do not match the existing design criteria. So that the flow in the prasedimentationunit is turbulent and danger can arise, which the efficiency of removal of turbidity won't be optimal.
7. The absence of a backup pump in the IPAM X will affect the quality, quantity and continuity of water in the event of damage or maintenance.
8. Not implementing the jar test routinely so that the hazards that can arise is chemicals dosage are not optimum so that floc will not be formed optimally, and turbidity also organic substances can not be dropped.
9. The workers incomprehension regarding the operational unit according to ISO9001 derivative will have a major impact on treatment processes that affect water quality. The quality of product can be decreased if there is a procedure or process that is not implemented properly by the workers.
10. Drainage of prasedimentation which is not in accordance with the type of unit. Drainage of prasedimentation which should use a scrapper, but using manual methods due to damaged scrapper conditions will cause the mud to not be wasted optimally.
11. Raw water discharge in IPAM's has fluctuations which are largely influenced by the season. As a result of the fluctuating raw water discharge can affect the optimal stay time of a unit. If the detention time is not optimal, it will affect the effectiveness of processing and the quality of water produced.
12. The detention time of prasedimentation which is not in accordance with the conditions of the discharge that enters the treatment will result in not optimal deposition in the pre-sedimentation unit so as not to reduce turbidity.

Figure 2 has shown the fishbone diagram of company X production system. The head of fishbone skeletons is the main issue happened in company which is the water treatment plant units do not work properly. Then the fins are the 8 factors which predicted as the root causes, from every fin there are several thorns which are the root aspects of every root causes.

The following are the types of failures and their identified hazards:

1. Lack of water quality management training (based on SNI 01-4852-1998)
2. Overdue ozone generator period usage
3. Lack of sampling points in every water treatment unit influent and effluent channel
4. Violate the Standard Operating Procedure of Water Treatment Plant Sanitation
5. Overdue silica sand as filtration unit media period usage
6. Overdue manganese sand as filtration unit media period usage
7. Overdue active carbon as filtration unit media period usage

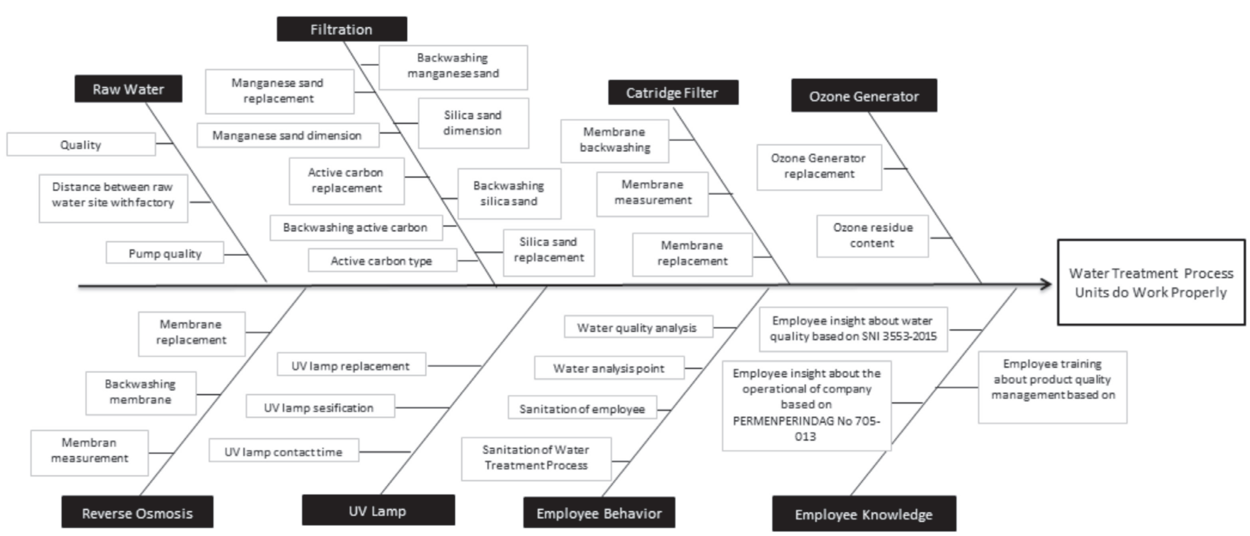

Fig. 2 Fishbone Diagram of AMDK X Company

8. Lack of water quality knowledge based on SNI 3553:2015 for the employee
9. Lack of company operational knowledge based on PERMENPERINDAG Number 75 Year 2003 for the employee
10. Violate the Standard Operating Procedure of employee Sanitation
11. Overdue silica sand backwashing period
12. Overdue manganese sand backwashing period
13. Overdue active carbon backwashing period
14. Overdue reverse osmosis membrane backwashing period
15. Overdue cartridge filter membrane backwashing period
16. Overuse reverse osmosis membrane
17. Overuse cartridge filter membrane

Figure 3 has shown the fishbone diagram of AMIU Depot production system. The head of fishbone skeletons is the main issue happened in AMIU Depots which is the water treatment plant units do not work properly. Then the fins are the 5 factors which predicted as the root causes, from every fin there are several thorns which are the root aspects of every root causes.

The following are the types of failures and their identified hazards:

1. There is no improvement in the quality of refill drinking water production
2. The quality of raw water is far from the quality standard set by the Ministry of Health
3. Contamination of organic matter in raw water
4. Reduced ability to filter impurities, reduce turbidity, filter odors, colors and organic matter
5. Reduced ability to filter particles of smaller sizes
6. Processed water products contain pathogenic bacteria that can be harmful to consumers
7. The processed products still contain organic compounds, bacteria, viruses or fungi
8. The processed water results are contaminated with the surrounding air
9. Managers and practitioners have never carried out control of the processed water produced

After forming fishbone diagram, the next step of identifying the risks is using FMEA. In FMEA method, we need to determine the severity, occurrence, and detection score of every entity or root causes. Every entity will have the three scores of severity, occurrence, and detection value and they would be multiplied into Risk Priority Number (RPN) with 100 as the maximum score. The highest RPN score would be the number one priority of the risk assessment and it is automatically be the first critical control point which should be focused on in order to avoid any disruption in the production system.

Determination of Critical Control Points and Critical Limits

After identifying the risks, then the critical control points can be determine from the RPN score. Critical control points are identified after process

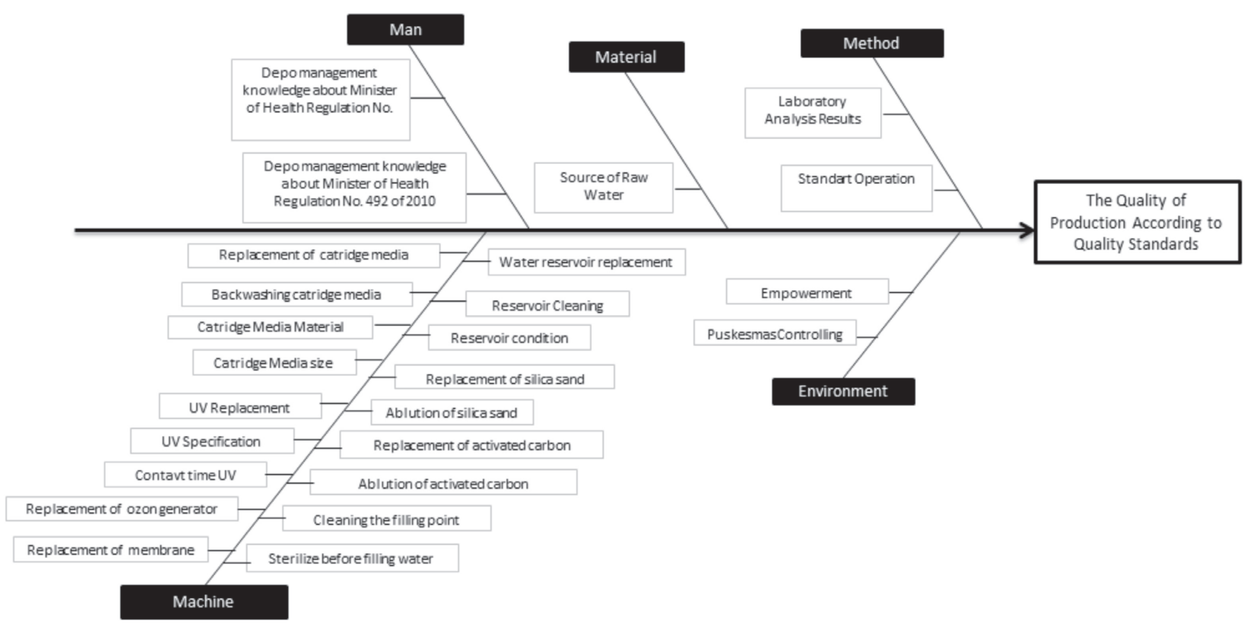

Fig. 3 Fishbone Diagram AMIU Depot

Table 1. Critical Control Points and Critical Limits IPAM X

Type of Potential Failure	Risk Analysis from Potential Failure	Critical Control Points	Critical Limits	Reference
Training about Quality Management of Drinking Water System in accordance with SNI 01-4852-1998	Failure in the production system	Number of quality management training	Training at least once a year	ISO 22000 and SNI 01-4852-1998 about Hazard Analysis Systems and Critical Point Control (HACCP) and guidelines for its application
Strainers availability in Water Retrieval Pipes	Macrodebric particles pass to the processing stage	Macrodebric particles	Screen cleaning and strainer installation	Minister of Public Works Regulation No. 26 of 2014 about Standard Operating Procedures for the Management of Drinking Water Supply Systems
Gradien Speed in Floculation	Floc is not formed optimally and precipitation cannot occur.	Turbidity in Clearator's Efluen	7 NTU	WTP Regulation (IK-5.4.1-2)
Replacement of Filter Media	Cannot reduce turbidity and organic matter	Turbidity	≤ 5 NTU	Minister of Health Regulation No. 492 of 2010
		Organic matter	≤ 10 mg/L	Minister of Health Regulation No. 492 of 2010
		Period of the media usage	3 years	EPA Water Treatment Manual for Filtration
Transfer Gas of Unit Aerator	Decomposition of organic substances not optimal	Organic matter	Removal of organic matter on cascade aerators 20-45%	Qasim *et al.*, 2000. Water Works Engineering: Planning, Design and Operation
Reynold (Nre) and Froude (Nfr) Number of Pre-sedimentation Units	Efficiency removal of turbidity is not optimal due to turbulent conditions	Efficiency removal of turbidity	65-70%	Metcalff and Eddie
Availability of Backup Pumps	Disturbances in the quality, quantity and continuity of the raw water and water production	Processing discharge	2200 L/sec and installation of a backup pump	WTP Capacity and Minister of Public Works Regulation No. 26 of 2014 about Standard Operating Procedures for the Management of Drinking Water Supply Systems
Effluent quality testing of aerator unit	Can not know the efficiency of removal of organic substances andwater quality is disrupted due to no routine testing	Efficiency removal of Organic matter	Removal of organic matter on cascade aerators 20-45%	Qasim *et al.*, 2000. Water Works Engineering: Planning, Design and Operation
		Quality testing	Tested every two hours	SNI 6775: 2008 about Procedures for Operation and Maintenance of WTP Units

Table 1. *Continued ...*

Type of Potential Failure	Risk Analysis from Potential Failure	Critical Control Points	Critical Limits	Reference
Implementation of Jar Test	The chemical dosage is not optimum (not suitable)	Implementation of Jar Test	Best floc formation within 30 minutes, the implementation of the jar test every two hours	SNI 6775: 2008 about Procedures for Operation and Maintenance of WTP Units, EPA Water Treatment Manuals for Coagulation, Flocculation, and Clarification
Worker Knowledge related to Unit Operations in accordance with ISO 9001 Rules	Quality of production decreases	Number of training related to operations	Once in three-month training for operators	ISO 9001
Depletion of Pre-sedimentation	The surface area is reduced due to the remaining sludge in the pre-sedimentation unit	Drain with a scraper on schedule	12-24 hours	SNI 6774: 2008 about Procedures for Planning the WTP Unit
Raw Water Discharge	The detention time is not optimal	Detention time	According to design criteria of each units	The DED that in accordance with SNI 6774: 2008 concerning Procedures for Planning WTP Units and laboratory data
Detention time of Pre-sedimentation	Cannot reduce turbidity due to the deposition is not optimal	Efficiency removal of turbidity	65-70%	Metcalff and Eddie

Table 2. Critical Control Points and Critical Limits AMDK X

Type of Potential Failure	Risk Analysis from Potential Failure	Critical Control Points	Critical Limits	Reference
Lack of water quality management training (based on SNI 01-4852-1998)	Unable to identify the risks and issues in production system which can affect the mineral water production	The amount of employee training about water . quality management	1 time	ISO 22000
Overdue ozone generator period usage	Decreasing of ozone generator effectiveness in removing pathogens in water	Ozone generator usage period	5 years	EPA 2011 Water Treatment Manual (Disinfection)
Lack of sampling points in every WTP influent and effluent channel	Unable to understand the disinfection process in the water	Water quality analysis points outlet	In every WTP units inlet and	PERMENPERINDAG Number 705 Year 2003
Violate the Standard Operating Procedure of Water Treatment Plant Sanitation	Mineral water production are contaminated by pathogens	WTP Sanitation schedule	Everyday	PERMENPERINDAG Number 705 Year 2003
		Mandatory facility in production room	Full function drainage, hand washing facility, special storage room	PERMENPERINDAG Number 705 Year 2003
Overdue silica sand as filtration unit media period usage	The silica sand is unable to filter particles in the water	Silica sand usage period effectively	3 years	EPA 1995 Water Treatment Manuals (Filtration)
Overdue manganese sand as filtration unit media period usage	The manganese sand is unable to filter particles in the water effectively	Manganese sand usage period	3 years	EPA 1995 Water Treatment Manuals (Filtration)
Overdue active carbon as filtration unit media period usage	The active carbon is unable to remove odor, color pigment, and taste in the water effectively	Active carbon usage period	2-3 years	EPA 1995 Water Treatment Manuals (Filtration)
Lack of water quality knowledge based on SNI 3553:2015 for the employee	Unable to detect the issues in water quality laboratory analysis with the quality standard	The amount of employee training about water quality knowledge	1 time	ISO 9001
Lack of company operational knowledge based on PERMENPERINDAG Number 75 Year 2003 for the employee	Unable to conduct the proper operational of the factory based on PERMENPERINDAG Number 705 Year 2003	The amount of employee training about the operational of the company	1 time	PERMENPERINDAG Number 705 Year 2003

Table 2. *Continued ...*

Type of Potential Failure	Risk Analysis from Potential Failure	Critical Control Points	Critical Limits	Reference
Violate the Standard Operating Procedure of employee Sanitation	Mineral water production are contaminated by pathogens	Sanitation procedure and the mandatory personal protection equipment	Employee special uniform, mandatory hand washing habit, mouth and hair cover	PERMENPERINDAG Number 705 Year 2003
Overdue silica sand backwashing period	The attached contaminants in the silica sand are dissolved in the water	Filtration unit backwash schedule	24 hours	SNI 6774:2008
Overdue manganese sand backwashing period	The attached contaminants in the manganese sand are dissolved in the water	Filtration unit backwash schedule	24 hours	SNI 6774:2008
Overdue active carbon backwashing period	The attached contaminants in the active carbon are dissolved in the water	Filtration unit backwash schedule	24 hours	SNI 6774:2008
Overdue reverse osmosis membrane backwashing period	The attached contaminants in the reverse osmosis membrane are dissolved in the water	Reverse Osmosis unit backwash schedule	24 hours	EPA 2005 Membrane Filtration Guidance Manual
Overdue cartridge filter membrane backwashing period	The attached contaminants in the cartridge filter membrane are dissolved in the water	Cartridge Filter unit backwash schedule	24 hours	
Overuse reverse osmosis membrane	Reverse osmosis membranes are unable to filter fine particles, sodium, ions, and pathogens in the water	Reverse Osmosis membrane usage period	3 years	
Overuse cartridge filter membrane	Cartridge Filter membranes are unable to filter fine particles in the water	Cartridge Filter membrane usage period	1 month	

flow diagram and production system risk assessment are done (Daulay, 2014).

However, not every potential failure can be chosen as a critical control point. Critical control point is a step, point, or procedure which greatly affected the safety and quality of drinking water and has high risk if it is not controlled (Hassan, 2016). Every failure which has significant impact and high risk would be automatically classify as critical control point. The highest RPN score (100)

Table 3. Critical Control Points and Critical Limits AMIU Depots

Type of Potential Failure	Risk Analysis from Potential Failure	Critical Control Points	Critical Limits	Reference
Understanding of the Depot Manager	There is no improvement in the quality of refill drinking water production	Depo management knowledge about Minister of Health Regulation No. 492 of 2010	Empowerment at least once a year	Minister of Health Regulation No.43 of 2014
		Depo management knowledge about Minister of Health Regulation No. 43 of 2014	Empowerment at least once a year	Minister of Health Regulation No.43 of 2014
Raw Water Condition	The quality of raw water is far from the quality standard set by the Ministry of Health	pH TDS Turbidity *Escheria coli*	6.5 - 8.5 ≤ 500 mg/L ≤ 5 NTU 0/100 ml sample	Minister of Health Regulation No. 492/ MENKES/ PER/ IV /2010
Raw Water Reservoir	Contamination of organic matter in raw water	Water reservoir replacement Reservoir Cleaning	3 years 2 weeks	Industry and Trade Regulation No. 651 / MPP/Kep/10/2004
Preliminary Filter	Reduced ability to filter impurities, reduce turbidity, filter odors, colors and organic matter	Replacement of silica sand Ablution of silica sand Replacement of activated carbon Ablution of activated carbon	3 years 2 weeks 2-3 years 2 weeks	EPA 1995 Water Treatment Manuals (Filtration) EPA 1995 Water Treatment Manuals (Filtration
Cartridge Filter	Reduced ability to filter particles of smaller sizes	Replacement of media Backwashing media Media Material string Media size	1 month 24 hours Ceramics, sponge, 1 μ, 3 μ, 5 μ, and 10 μ	EPA 2005 Membrane Filtration Guidance Manual
Ultraviolet System	Processed water products contain pathogenic bacteria that can be harmful to consumers	Duration of Operation UV Specification Replacement UV	During operation 8 gpm power 1 year	Decree of the Minister of Industry and Trade Republic of Indonesia regarding Technical
Ozon System	Processed water products contain pathogenic bacteria that can be harmful to consumers	Replacement of ozon generator Contact time	3 years 30 minute	Requirements for Refill Drinking Water Depot No. 651/MPP / Kep / 10/2004
Reverse Osmosis System	The processed products still contain organic compounds, bacteria, viruses or fungi	Replacement of membrane	6 month	
Water Fill Processed	The processed water results are contaminated with the surrounding air	Cleaning the filling point Sterilize before filling water	Finish filling Finish filling	
External Controlling	Managers and practitioners have never carried out control of the processed water produced	Puskesmas Controlling Empowerement from Puskesmas/ DINKES Kota Surabaya	1 moth 1 year	Minister of Health Regulation No.907 of 2002 Minister of Health Regulation No. 43 of 2014

Table 4. Monitoring System and Corrective Action of IPAM X

Sl. No	Critical Control Points	Critical Limits	Monitoring				Corrective Action
			Monitoring Point	Procedure	Frequency	Person in Charge	
1	Number of quality management training	Training at least once a year	Production Section of WTP "X"	Monitoring / evaluation of workers and production based on field conditions, quality management report documents and quality achievement	Every month	Unit manager of company X	A training on drinking water quality management system that is in accordance with SNI 01-4852-1998 is held once a year and is attended by all staff of IPAM X
2	Macrodebric particles	Screen cleaning and strainer installation	Water Retrieval Pipesand balancing wells	Observation of water, screen and balancing well conditions	Every hour	Intake Operator and supervisor of WTP	Strainer installation in the water intake pipe so that waste does not enter the processing unit. Cleaning the screen and the ballancing well every 2 hours
3	Turbidity in Clearator's Efluent	7 NTU	Clearator's Effluent	Turbidity check use turbidimeters, Checking the flocculant pipe and maintain the flocculant dose using jar test.	Every hour	Clearator Operator	Reducing the speed of the water by multiplying holes, setting the flocculant pipe and dosing must be optimum through jartest
4	Turbidity	≤ 5 NTU	Filtration Unit	Turbiditycheck use turbidimeters in effluents	Every hour	Filter Operator	Replacement of filter media once every 3 years or when the media is saturated, which is marked by water quality exceeds quality standards
5	Organic matter	≤ 10 mg/L		Organic matter check use permanganate titration methods in effluents	Every two hours	Laboratory personnel	
6	Period of the media usage	3 years		• Visual observation of media color, volume and thickness. • Backwash of media	Every day	Supervisor of IPAM X	

Table 4. *Continued ...*

Sl. No	Critical Control Points	Critical Limits	Monitoring				Corrective Action
			Monitoring Point	Procedure	Frequency	Person in Charge	
7	Organic matter	Removal of organic matter on cascade aerators 20-45%	Influent and effluent of the Aerator Unit	Organic matter check use per-manganate titration methods	Every two hours	Laboratory personnel	Addition of diffusion aerators
8	Efficiency removal of turbidity	65-70%	Influent and effluent of Pre-sedimentation	Turbidity check use turbidimeters in effluents	Every hour	Control operator	The detention time must be according to the discharge entry and design criteria. Drain the prasedimentation routinely and optimally
9	Processing discharge	2200 L/sec and installation of a backup pump	After the intake unit head to the processing unit	• Water level monitoring. • Monitoring the pressure, ampere, voltage, power etc. of the pump.	Every hour	Pump operator	add a backup pump
10	Efficiency removal of Organic matter	Removal of organic matter on cascade aerators 20-45%	Influent and effluent of the Aerator Unit	Organic matter check useper manganate titration methods	Every two hours	Laboratory personnel	Addition of diffusion aerators
11	Quality testing	Tested every two hours					
12	Implementation of Jar Test	Best floc formation within 30 minutes, the implementation of the jar test every two hours	Coagulation Unit	Visual observation of floc formation	Every hour	Clearator Operator	The implementation of the jartest is held every 2 hours
13	Number of training related to operations	Once in three-month training for operators	Drinking water production unit	Monitoring field operational conditions and its documents	Each month	Production Manager	Add training for staff along with competency tests regarding unit operations and water quality
14	Drain with a scraper on schedule	12-24 hours	Pre-sedimentation Unit	Visually monitor of the surface area	Every twelve hours	Control operator	Repair the scraper so that the prasedimentation drain is optimal
15	Detention time	According to design criteria of each units	Effluent of all units	Pump checking and water quality from the effluent of each unit	Every hour	Control operator, Laboratory personnel	Pump and valve settings

Table 5. Monitoring System and Corrective Action of AMDK X

No	Critical Control Points	Critical Limits	Monitoring				Corrective Action
			Monitoring Point	Procedure	Frequency	Person in Charge	
1	The amount of employee training about water quality management	1 time	Company X factory	Monitor the documents of quality management report, customer satisfaction report, and monthly report	Every month	Unit manager of company X	Arrange an employee training about the better product management quality every year
2	Ozone generator usage period	5 years	Ozone generator	Check the report of water quality analysis in *Escherichia coli* content at ozone generator outlet	Every start of the year	Quality Control Staff	Ozone generator replacement
3	Water quality analysis points	In every WTP units inlet and outlet	WTP units inlet and outlet points	Monitor the sampling procedure along with choosing the sampling points	Every day	The head of company X laboratory analysis	Do proper sampling in raw water site, WTP inlet and outlet units
4	WTP Sanitation schedule Mandatory facility in production room	Everyday Full function drainage, hand washing facility, special storage room	Company X production room	Monitor the sanitation process entirely	Every start of the shift	Quality Control Staff	Do proper sanitation in production room
5	Silica sand usage period	3 years	Filtration Unit	Monitor the silica sand condition (color, height, and volume of sand)			Replace the silica sand
6	Manganese sand usage period	3 years		Monitor the manganese sand condition (color, height, and volume of sand)	Every start of the year	Quality Control Staff	Replace the manganese sand
7	Active carbon usage period	2-3 years		Monitor the active carbon condition (color, shape, and amount of carbon)			Replace the active carbon
8	The amount of employee training	1 time	Company X	Analyze all the laboratory report	Every year	Unit manager	Arrange an employee

Table 5. *Continued ...*

No	Critical Control Points	Critical Limits	Monitoring				Corrective Action
			Monitoring Point	Procedure	Frequency	Person in Charge	
	about water quality knowledge		factory	from physics, chemical, and microbiological parameters		of company X	training about the health water quality knowledge every year
9	The amount of employee training about the operational of the company	1 time	Company X factory	Analyze all the production and operational aspect report	Every year	Unit manager of company X	Arrange an employee training about the operational of the company every year
10	Sanitation procedure and the mandatory personal protection equipment	Employee special uniform, mandatory hand washing habit, mouth and hair cover	Company X production room	Monitor the sanitation process entirely	Every start of the shift	Quality Control Staff	Do proper sanitation check of every employee
11	Filtration unit backwash schedule	24 hours	Filtration unit	Check the tank headloss and the laboratory report physical parameter data of filtration unit outlet	Every shift	Filtration Unit operator	Do backwash to filtration unit every day for 10 minutes
12	Filtration unit backwash schedule	24 hours					
13	Filtration unit backwash schedule	24 hours					
14	Reverse Osmosis unit backwash schedule	24 hours	Reverse Osmosis unit	Analyze the laboratory report physical parameter data of RO unit outlet	Every shift	Reverse Osmosis Unit operator	Do backwash to reverse osmosis unit every day for 10 minutes
15	Cartridge Filter unit backwash schedule	24 hours	Cartridge Filter unit	Analyze the laboratory report physical parameter data of CF unit outlet	Every shift	Cartridge Filter Unit operator	Do backwash to cartridge filter unit every day for 10 minutes
16	Reverse Osmosis membrane usage period	3 years	Reverse Osmosis unit	Monitor the RO membrane condition (color, porosity, and appearance)	Every start of the year	Quality Control Staff	Replace the reverse osmosis membrane
17	Cartridge Filter membrane usage period	1 month	Cartridge Filter unit	Monitor the CF membrane condition (color, porosity, and appearance)	Every start of the week	Quality Control Staff	Replace the cartridge filter membrane

Table 6. Monitoring System and Corrective Action of Depo AMIU X

No	Critical Control Points	Critical Limits	Monitoring				Corrective Action
			Monitoring Point	Procedure	Frequency	Person in Charge	
1	Depots management knowledge about Minister of Health Regulation No. 492 of 2010	Empowerment at least once a year	owner of drinking water depots	Socialization and monitoring from Surabaya City Health Office	every 3 months	Surabaya City Health Office	Participating in the socialization of refill drinking water depot management
2	Depots management knowledge about Minister of Health Regulation No. 43 of 2014	Empowerment at least once a year	Owner of drinking water depots				
3	pH	6.5 - 8.5	Effluent	Checking the pH of raw water and effluents	Every 3 months	Puskesmas controlling officer	Conduct periodic water quality testing in accordance with the Ministry of Health Regulation
4	TDS	≤ 500 mg/L	Filter Unit	Clean the filter units	Every month		
5	Turbidity	≤ 5 NTU	Filter Unit		Every month		
6	*Escherichia coli*	0 /100 ml sample	UV Unit	Doing UV replacement	Every year		
7	Water reservoir replacement	3 years	Water Reservoir	Doing replacement water reservoir which has passed its useful life	Every 3 years	Depot Owner	Replacement of the raw water reservoir material into a safe food ingredient
8	Reservoir Cleaning	2 weeks		Clean the water reservoir	Every 2 weeks	Depot Owner	Clean the reservoir every 2 weeks
9	Replacement of silica sand	3 years	Filter Unit	Monitor the silica sand condition (color, height, and volume of sand)	24 hours	Depot Owner	Perform regular replacement ≤ 2 years
10	Ablution of silica sand	2 weeks					Clean the media regularly ≤ 1 weeks
11	Replacement of activated carbon	2-3 years					Perform regular replacement ≤ 2 years
12	Ablution of activated carbon	2 weeks					Clean the media regularly ≤ 1 weeks
13	Replacement of media	1 month					Perform regular replacement ≤ 4 weeks
			Catridge Filter Unit	Analyze the laboratory report physical parameter	24 hours	Depot	Clean the media

Table 6. *Continued...*

No	Critical Control Points	Critical Limits	Monitoring				Corrective Action
			Monitoring Point	Procedure	Frequency	Person in Charge	
14	Backwashing media	24 hours		data of CF unit outlet		Owner	regularly every day
15	Media Material	Ceramics, sponge, string		.			Use the most effective media in the filtering material, which is ceramic material
16	Media size	1 µ, 3 µ, 5 µ, and 10 µ					Use media with a smaller density, that is, a combination of using the overall size of 1 µ or 1µ, 3µ, 10µ or 1µ, 5µ, 10µ
17	Duration of Operation	During operation	UV Unit	Monitoring of UV conditions by checking the *Escherichia coli* test	24 hours	Depot Owner	The UV system works during working hours
18	UV Specification	8 gpm power					Choose specifications according to production capacity, choose specifications > 1gpm UV per 1 gpm of production water
19	Replacement UV	1 year					UV replacement ≤ once a year
20	Replacement of ozon generator	3 years	Ozone Unit	Check the report of water quality analysis in *Escherichia coli* content at ozone generator outlet	24 hours	Depot Owner	Make a replacement ≤ 3 year
21	Contact time	30 minute					Ozone system functioned> 1 hour
22	Replacement of membrane	6 month	Reverse Osmosis Unit	Check the report of water quality analysis in *Escherichia coli* content at reverse osmosis outlet	24 hours	Depot Owner	Carry out membrane replacement ≤ 6 month
23	Cleaning the filling point	Finish filling	Water Filling Unit	Monitoring the condition of the water filling	During filling water processed	Depot Owner	Clean the water filling place every completed filling of water to consumers
24	Puskesmas Controlling	1 moth	Depots		Every month		Perform regular control in accordance with the regulations of the minister of health
25	Empowerement from Puskesm as/ DINKES Surabaya City	1 year	Depots	Scheduled Puskesmas control of depot owners	Once a year	Puskesmas control officer	Hold socialization regarding the management of drinking water refill depots regularly

would be the first critical control point and the potential failure that has score below 20 will not be classify as a critical control point. Determination of critical control points and critical limit each water treatment production can be seen in Tables 1 to 3.

a. IPAM X

b. AMDK X Company

c. AMIU Depots

Monitoring System and Corrective Actions

Monitoring system is a necessary to control critical control points before it surpassed critical limits. It should be organized and evident in order to avoid misunderstanding of the procedures, therefore the person in charge can do their task easily and correctly. Monitoring system can be an early warning for the company to fix the problems occur in the production system, therefore further problem can be avoided and the product quality can be ensured.

Monitoring system and corrective actions each water treatment production can be seen in Tables 4 to 6.

a. IPAM X

b. AMDK X

c. Depo AMIU

CONCLUSION

From the results of the research and analysis carried out, it can be concluded as follows:

a. The water quality management plan using the HACCP method that can be applied to the production system and human resources IPAM X is focused on improving the performance of water treatment units, regulating the discharge that enters processing must be in accordance with the capacity of the unit, there must be a plan for adding more units before the uprating so that the processing can run optimally, and increase the insight of workers on water quality with training in accordance with SNI 01-4852-1998.
b. Evaluation of the existing condition of the company AMDK X produces information that can be further studied with HACCP management plan is incomplete SOP, maintenance of each processing unit such as media and membrane is always late so it is not in accordance with applicable regulations, sanitation of workers and factories are not follow the applicable SOP
c. The failure of the refill drinking water production process based on HACCP analysis is influenced by the understanding of the depot manager or practitioner, the source of raw water used, the time of media replacement, the time of UV replacement and the controlling of related parties from the refill drinking water depot.

REFERENCES

Agustiningsih, D., Setia, B.S. and Sudarno, 2012. Analisis Kualitas Air dan Strategi Pengendalian Pencemaran Air Sungai Blukar Kabupaten Kendal. *Jurnal Presipitasi.* 9 (2) : 64-71.

Daulay, S.S. 2014. Hazard Analysis Critical Control Point (HACCP) and Implementasinya dalam Industri Pangan. Widyaiswara Maadya Pusdiklat Industri.

Entjang, I. 2003. Mikrobiologi Dan Parasitology Untuk Akademi Keperawatan Dan Sekolah Tinggi Kesehatan Yang Sederajat. Citra Aditya Bakti. Bandung.

Hassan, F. 2016. Kajian Penerapan Sistem Hazard Analysis Critical Control Point (HACCP) di IPAM Porong PDAM Deltra Tirta Sidoarjo. Surabaya: Institut Teknologi Sepuluh Nopember.

Karnaningroem, N., Bramanti, G. W. and Muzakky, A. 2017. Manjemen Risiko Dengan Metode Fish Bone Dan Failure Mode Effect Analysis (FMEA) Pada Air Bersih. Surabaya: Teknik Lingkungan ITS.

Sasongko, Budi E., Widyastuti, E. and Priyono, R.E. 2014. Kajian Kualitas Air dan Pengunaan Sumur Gali oleh Masyarakat di Sekitar Sungai Kaliyasa Kabupaten Cilacap. *Jurnal Ilmu Lingkungan.* 12 (2) : 72-82.

Sudarmaji, 2015. Analisis Bahaya dan Pengendalian Titik Kritis (Hazard Analysis Critical Control Point). *Jurnal Kesehatan Lingkungan.* 1 (2) : 183-190.