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Hazard analysis in drinking water plant

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ABSTRACT

Source, sedimentation, coagulation, flocculation, filter, and tank are parts of a water treatment plant. As a result, some issues threaten the process and affect the drinking water quality, which is required to provide clean drinking water according to special standards and international and local specifications, determined by laboratory results from physical, chemical, and biological tests. In order to keep the water safe for drinking, it is necessary to analyze the risks and assess the pollution that occurs in every part of the plant. The method is carried out in a common way, which is monitoring through laboratory tests, and it is among the standards of the global and local health regulators.

Keywords: Hazard, analysis, water plant, Risk, HIRA.

تحليل المخاطر في محطات شرب الماء

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الخلاصة

المصدر ، والترسيب ، والتخثر ، والتلبد ، والفلتر ، والخزان كلها أجزاء من محطة معالجة المياه. ونتيجة لذلك ، هناك قضايا تهدد العملية وتؤثر على جودة مياه الشرب ، والتي تتطلب توفير مياه شرب نظيفة وفق معايير خاصة ومواصفات عالمية ومحلية ، والتي تحددها النتائج المخبرية من المادية ، الاختبارات الكيميائية والبيولوجية. من أجل الحفاظ على المياه آمنة للشرب ، من الضروري تحليل المخاطر وتقييم التلوث الذي يحدث في كل جزء من أجزاء المصنع. يتم تنفيذ الطريقة بطريقة مشتركة ، وهي المراقبة من خلال الاختبارات المعملية ، وهي من بين معايير الهيئات الصحية العالمية والمحلية.

الكلمات الرئيسية : المخاطر ، التحليل ، محطة المياه ، المخاطر ، HIRA

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1. INTRODUCTION

Water treatment plants include inlet, sedimentation, coagulation, filter, filter, and tank. Therefore, some problems threaten the process and affect the quality of drinking water, which is obligated to provide clean drinking water within particular standards and within the international and local specifications that we conclude by laboratory results from physical, chemical, and biological tests **(Dewi et al., 2019).** In order to avoid risks, an evaluation must be made for each unit in the treatment plant, from the raw water to the filter at the end of the plant (**Mohammed and Abdulrazzaq, 2021**). The results of unit examinations are analyzed statistically to find the correct conclusions, know the expected problems, and work to find a solution (**Al-Musawi, 2016**).

Risk analysis is an analytical method for alerting the presence of risks because the presence of risks leads to losses in terms of the economy and the production process and disrupts water quality results **(Dewi et al., 2019).**

HACCP (Hazard Analysis and Critical Control Points) can be defined as a system that helps water reach consumers that is suitable for drinking and domestic use. It is considered a preventive system because it leads to detecting and controlling risks. Hazard analysis was applied in Iran to the drinking water treatment plant. It included the identification of points that include a raw water source, pre-chlorine, coagulation, flocculation, sedimentation, filtration, and post-chlorine. After applying this system, it is determined that the water can be reduced to the minimum values in drinking water to be safer and healthier **(Khaniki et al., 2009).**

There are many systems used to identify risks, for example, ISO 9001. The World Health Organization suggested using preventative risk management approaches to manage water quality issues in 2004 for drinking water quality **(Jayaratne, 2006).**

Each type of water has different types of pollution, and the treatment must be related to the quality of the water. For example, a conventional plant consists of the following steps: sifting, coagulation, flocculation, sedimentation, filtration, and disinfection. It is expected that there will be an analysis that raises the risks from the source to the end of the treatment and reduces the causes of its occurrence **(Hassan and Masduqi, 2016).**

2. HAZARD in WATER TREATMENT PLANT

A water treatment plant is a critical piece of infrastructure., so safety and health are important aspects and a source of concern in its development. A study was conducted in Indonesia to determine the risks in the water treatment plant, and the results obtained from different categories of them are chlorine leakage and industrial fires. The highest value is given to chlorine leakage and fire because their impact threatens various things, including industrial accidents that may damage human life and the environment **(Falakh and Setiani, 2018).**

The first to apply risk analysis and control points were Havelaar in 1994, which expressed that the risks in drinking water are mainly caused by contamination of raw water, and it is a

pathogen. Therefore, the World Health Organization has developed principles of risk assessment in drinking water guidelines **(Dewettinck et al., 2019).** Raw resource water, sedimentation, filtration, and chlorine disinfection are the Hazard Analysis Critical Points. The risks of the water treatment plant were evaluated to reach the study's goal, which is to determine the effectiveness of each treatment point to remove indicators from the water and apply the limits of water quality guidelines related to health for the expected effects **(Jagals, 2004).** The risk clearance plans involved many years in controlling the pollution risks **(Hellier, 2000).** In the United States, the city of Toledo issued a warning that the water was not suitable for drinking. The reason is the presence of large quantities of toxic micro cysteine in the final treated water, which is a dangerous toxic substance produced by cyanobacteria algae, so water safety planning is important to obtain healthy water **(Jetoo et al., 2015).**
Identifying the Risk Hazard Identification and Risk Assessment (HIRA) is a method of detecting and supplying hazards based on their likelihood, frequency, and severity and assessing negative consequences such as potential loss and injury. The work process in the sector must pay attention to environmental health and safety issues to promote the industry's effectiveness. Risk evaluations were carried out using risk guidelines and criteria. Hazards must be identified, risks must be assessed, and sustained levels must be tolerated **(Falakh and Setiani, 2018**). It includes analyzing risks and critical control points by following a control method as soon as possible and at formal costs, as shown in **Table (1) (Hassan and Masduqi, 2016).**

Table 1 Hazard Analysis and Critical Control Points for Water Treatment Plant **(Hassan and Masduqi, 2016)**

Process step	Hazards identified	Critical components	Critical Limits	method	Check period	Corrective measures
Klorinasi	Chemicals Overdose	Chlorine	2-3 ppm	Chlorine Comparator	every hour	Chlorine dosing pump stroke settings
	Disinfection by-products (THMs)			Chlorine Comparator	every hour	Chlorine dosing pump stroke settings
Coagulation, Flocculation Sedimentation	Overdose of coagulant	The coagulant dose	Best floc formation in 30 minutes	jar Test	Every one day	Coagulant dosing pump stroke settings
	Total dissolved solids (TDS) (lack of formation of floc)	formation of floc	Observation		Every hour	Coagulant dosing pump stroke settings
		PH	Visual observations		Every hour	Addition of soda ash
Filtration	Total dissolved solids (TDS) (lack of formation of floc)	decrease in discharge	filter water level	Visual observations	Every hour	Backwash
Re-chlorination	Organic	Organic matter (KMnO4)	10mg/l	permanganate titration		Addition disinfectant
	Microbe or pathogen-resistant	residual chlorine	5 ppm	Chlorine Comparator		Chlorine dosing pump stroke settings
reservoir	recontamination	Turbidity	5 NTU	Nefelometer	Every hour	Affixing PAC
		residual chlorine	<2ppm	Chlorine Comparator	Every hour	Affixing disinfectant

		pH	<6,5/>8,5	pH meter	Every hour	Affixing netralisator form of soda ash or calcium
Distribution	recontamination	residual chlorine	<2 ppm	Chlorine Comparator		Chlorination (distribution system)
		chemical parameters	mandatory parameter	Health Minister Regulation No. 492 of 2010	Every week randomized	

3. Water Hazard Classification and Treatment

Drinking water is important to be provided with a safe and sustainable supply, and it must be used for drinking and household purposes. Therefore, it must be free of diseases and harmful chemicals. Water treatment may be unsafe, exposing human health to severe risks. Bacterial hepatitis, cholera, dysentery, dengue, paratyphoid, salmonella, colossi, filariasis, parasitic infections, and amebiasis are the most frequent diseases spread by consuming contaminated water. Polluted water can also lead to various bacterial, viral, and parasite infections. Drinking water should be free of disease-causing microorganisms such as bacteria, viruses that cause (hepatitis and enteroviruses), algae, fungi, protozoa, and worms **(Pal et al., 2018).**

In a risk assessment study, the results showed that aflatoxin is removed. Only cleaning and a reverse osmosis unit can remove ricin, while sand filtration has little effect. It is less efficient in removing toxins. In a study, the microbial analysis showed an increase in colon bacteria, and their number decreased by increasing the residual free chlorine **(Bahramian, 2020).**

Arsenic in surface waters is considered a catastrophic problem. In a study, arsenic was identified in low concentrations in drinking water, and it was reported because of the dangerous health effects, and arsenic removal techniques became abundant. There are methods for treating arsenic, including coagulation, anion exchange, disposable iron media, etc**. (Choonga et al., 2007).**

In Semarang, Indonesia, a water treatment plant was audited, and the types of hazards in the plant, their possibility, and the degree of their presence. **Table (2)** shows the most prominent hazards and their degree of danger **(Falakh and Setiani, 2018).**

Table 2 Water Treatment Plant Hazard Identification and Risk Assessment **(Falakh and Setiani, 2018)**

No.	Treatment unit	Hazard Situation	Risk Factors	Impacts	Matrix for Risk Analysis		
					L	S	Risk Value
1	Chamber for Flow Meters	Entrance and exit from the flow meter chamber are both .possibilities	Inhalation of chlorine by a worker within the chamber	Chlorine inhalation causes a lost-time accident that can lead to death.	3	2	6 (medium Risk)
2	Chemical Building Demolition	Working at the height of 8 meters to destroy walls and floors	Falling from an approximate height of 8 meters to the ground	Injury that lasts a lifetime up to death	2	4	8 (High Risk)
3	Room of Command	Hazardous Electricity	A short circuit in the electrical system	Fractures, Death, and Misfortune	3	5	15 (Extreme Risk)
4	Treatment Process	Once a month, clean the buildup sludge in the raw water inlet channel of the accretor	hazardous environment, poor entrance accessibility	More than one person died in a fatal accident	2	5	10 (High Risk)
5	Treatment Process	Once a month, clean up removing sludge	All risks associated with restricted spaces, such as falls and electrical shock	Accident that results in death	2	4	8 (High Risk)
6	Treatment Process	Increases main drain valve work, odor and noise	Sliding, falling	Accident that results in death	1	4	4 (Medium Risk)
7	Treatment Process	Cleaning in the compartment	Drowning and falling	Accident that results in death	1	4	4 (Medium Risk)

8	Water treatment line	height of a sand filter	Drowning and falling	Concussion, fracture	3	2	6 (Medium Risk)
9	Pump room for backwash	At the backwash pump, there is a rotating element that makes noise .and is slick	Damage to the arm and hand caused by a loose bolt, loudness, or a tumble.	Amputation of an arm, dislocation, hearing loss, and concussions	3	3	9 (High Risk)
10	The turbine's gearbox	rotatable parts exposed	Projection of a loose bolt causes injury to the arm or .hand	Amputation of an arm, machine shutdown, and a fracture	2	3	6 (Medium Risk)
11	Facilities with Chlorine	Crash inside the site	Personnel crashed by chlorine vehicle	Fatality accident	3	4	12 (High Risk)
12	Chlorine Facilities	Chlorine Leakage	Inhalation of chlorine	Accidental death, disaster	3	5	12 (Extreme Risk)
13	Chlorine Facilities	Falling container when loading/unloading	Falling heavy objects (weight: +1.8-ton, height: 1.5 m) had an .impact	Irreversible harm/fracture	2	2	4 (Medium Risk)
14	Purchasing	purchasing gadgets, equipment, tools, materials, and services, specifications are incorrect or .missing	Inappropriate devices, equipment, tools, and materials	Production must be halted or fatalities will occur.	5	1	5 (Medium Risk)
15	Gallery of filters	work in increase	Falling from a great height (6 M)	Accident results death	2	4	8 (High Risk)
16	Laboratory	UV radiation (The device has a UV germicidal lamp with a	Erythema is a skin condition that causes	For a lengthy period, skin problems or	4	2	8 (High Risk)

		wavelength of 257.7 nm, including UV-C type)	damage to the center of .the eye	cataracts in the eyes			
17	Reservoir	hazard in a confined space	insufficient O2 content, increased toxic gas content, and electric leakage	Death, poisoning, and fainting	2	4	8 (High Risk)
18	Acid substance	presence of strong acid in the laboratory	Skin contact, inhalation	Skin sores, Respiratory problems	3	1	3 (Low Risk)
19	H2SO4 storage and dosage	H2SO4 inhalation	fog of strong acid H2SO4 that caused from dosing pump for water	Irritation, blindness, and burns	2	4	8 (High Risk)
20	Pump Submersible	Electrical	Fire, Electric Caution	Accident, Misfortune	1	5	5 (Medium Risk)
21	Hazardous chemical waste storage	Spills of waste	Dangerous substances waste spills during the pouring process, as well as waste leaks	Pollution, poisoning, and fainting are all problems caused by the .environment	3	2	6 (Medium Risk)
22	Poly Aluminum Chloride Storage	Aluminum Chloride Polymer	Leaks on pipe and valves ball	Irritation, blurred vision, and indigestion are all symptoms of irritable bowel .syndrome	3	2	6 (Medium Risk)

4. SUMMARY

To deliver healthy water within international and local standards, risks must be analyzed, and the units' work evaluated from the source of raw water and units of treatment plants down to the consumer.

There are several methods of risk assessment, the commonly used method is to monitor and conduct laboratory tests, and the results must be within the specification that the water is not usable

Each type of pollution has a way to treat and get rid of it, so it is necessary to detect the types of pollutants from raw water if it is surface water or groundwater.

5. REFERENCES

Al-Musawi, N. O. A., 2016. Application of Artificial Neural Network for Predicting Iron Concentration in the Location of Al-Wahda Water Treatment Plant in Baghdad City, *Journal of Engineering*, 22(9), 72-82.

Bahramian, A., 2020. Hazards identification and the units assessment of a the water treatment plant against pathogenic and biotoxin threats affecting by physicochemical parameters, *Iranian Journal of Chemical Engineering (IJChE)*, 17(4), 33-48.

Choong, T. S., Chuah, T. G., Robiah, Y., Koay, F. G., and Azni, I., 2007. Arsenic toxicity, health hazards and removal techniques from water: an overview, *Desalination*, 217(1-3), 139-166.

Dewettinck, T., Van Houtte, E., Geenens, D., Van Hege, K., and Verstraete, W., 2001. HACCP (Hazard Analysis and Critical Control Points) to guarantee safe water reuse and drinking water production-a case study, *Water Science and Technology*, 43(12), 31-38.

Dewi, M. R., Karnaningroem, N., and Mardyanto, M. A., 2019. Study of Drinking Water Production in Water Treatment Plant "X" using Hazard Analysis Critical Control Point Method, *IPTEK Journal of Proceedings Series*, (5), 232-239.

Falakh, F., and Setiani, O., 2018. Hazard identification and risk assessment in water treatment plant considering environmental health and safety practice, *In E3S Web of Conferences* (Vol. 31, p. 06011), EDP Sciences.

Hassan, F., and Masduqi, A., 2016. Application of Hazard Analysis Critical Control Point (HACCP) in The Drinking Water Company. In The 1st International Seminar on Management Technology.

Hellier K., 2000. Hazard analysis and critical control points for water supplies., P102, South Africa

Jagals, C., and Jagals, P., 2004. Application of HACCP principles as a management tool for monitoring and controlling microbiological hazards in water treatment facilities, *Water Science and Technology*, 50(1), 69-76.

Jayaratne, A., 2008. Application of a risk management system to improve drinking water safety, *Journal of Water and Health*, 6(4), 547-557.

Jetoo, S., Grover, V. I., and Krantzberg, G., 2015. The Toledo drinking water advisory: suggested application of the water safety planning approach, *Sustainability*, 7(8), 9787-9808.

Khaniki, G. R. J., Mahdavi, M., and Mohebbi, M. R., 2009. HACCP application for treatment of drinking water for Germi in Iran, *J Food Agric Environ*, 7(2), 709-12.

Mohammed, N. Y., and Abdulrazzaq, K. A., 2021. Evaluation of Drinking Water Quality in Al Wahda Treatment Plant in Baghdad City-Iraq, *Journal of Engineering*, 27(9), 38-50.

Pal, M., Ayele, Y., Hadush, M., Panigrahi, S., and Jadhav, V. J., 2018. Public health hazards due to unsafe drinking water, Air Water Borne Dis, 7(1000138), 2.