Jurnal Pijar MIPA
https://jurnalfkip.unram.ac.id/index.php/JPM

ISSN 1907-1744 (Print)
ISSN 2460-1500 (Online)

Analysis of Residual Free Chlorine Content in Rinjani Waterpark Swimming Pool Water, East Lombok District

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Received: December 10, 2024. Accepted: January 15, 2025. Published: January 29, 2025

Abstract: Water is the most essential component in daily life. One of its uses is as water in swimming pools. A swimming pool is a public place and facility in the form of a pool building used for swimming. The water used in swimming pools must have a quality that complies with the quality standards determined for the water. One of the parameters required in PERMENKES Nomor 2 Tahun 2023 is the remaining free chlorine. This research aims to analyze the residual free chlorine content in Rinjani Waterpark swimming pool water, where it is known from the results of preliminary studies that Rinjani Waterpark uses chlorine as a disinfectant to kill bacteria in the water and purify the pool water. There were several complaints from swimming pool visitors, such as eye irritation and itchy skin after swimming in that swimming pool, so further analysis was needed. The type of research used in this research is descriptive qualitative. The samples used in this research were 4 samples. The sampling technique uses total sampling. Testing was carried out at the STTL Mataram laboratory to see the free chlorine content in water samples using Mohr's Argentometry method. After conducting the research, the results were obtained that the samples that did not meet the requirements were samples with codes P1 M=2.3 mg/L, P3 M=1.77 mg/L, P4 M=2.3 mg/L, and P3 A = 0 mg/L. Visitors who want to visit the Rinjani Waterpark swimming pool are expected to use personal protective equipment (PPE) such as swimming goggles to avoid the impact of chlorine levels that are too high in the water. Swimming pool managers should pay attention to the chlorine dosage in the water so that it does not cause side effects to visitors.

Keywords: Argentometry Method; Free Residual Chlorine; Swimming Pool Water.

Introduction

Water is a component needed in all aspects of life. The need for water is not only used to fulfill primary needs but is also used for tertiary needs, like exercising, where water can be used for swimming activities in swimming pools. Swimming pools are public places and facilities in the form of pool buildings, filled with treated water, equipped with good comfort and safety facilities, located inside and outside the building, and used for swimming, recreation, or other water sports [1]. One way to attract visitors to swim in a pool is to provide clean pool water facilities, but clean pool water alone is not enough to guarantee quality. Apart from cleanliness, the health of pool water must also be maintained to avoid water-borne diseases. Swimming pool water must always be kept clear and healthy so that it is free from water pollution, which can cause harm to visitors. Even though the filling and circulation of pool water are controlled, this does not mean the pool water is free from pollution; pool water pollution can occur due to chemical and microbiological pollution [2]. One of the chemical parameters required by swimming pool quality standards is the residual free chlorine in swimming pool water. According to PERMENKES Nomor 2 Tahun 2023, the standard quality for residual free chlorine in swimming pool water is 1 - 1.5 mg/L.

There are 2 residual forms of chlorine in water: free chlorine and bound chlorine. The remaining bound chlorine is naturally bound to water, but if added sufficiently, free chlorine can produce free chlorine [3].

Chlorine is a disinfectant commonly added to swimming pool water. Residual chlorine levels that are too high or too low in swimming pools can harm the health of swimming pool users. Too high levels can cause irritation and respiratory problems, while too low levels can cause bacteria to grow freely in the water [4]. Chlorination is the process of adding chlorine to water that has undergone filtration. It is a step forward in the water purification process[5]. This chlorination aims to kill microorganisms in the water [6]. High residual chlorine levels in swimming pool water can cause health problems for swimming pool users. If the chlorine addition is insufficient, microorganisms in the water cannot be reduced optimally, and if the addition is excessive or too much, it can cause allergies, skin itching, and an unpleasant odor [7].

Currently, swimming pool tourism is the destination most frequently visited by residents, one of which is managed by the East Lombok Regency Government, namely the Rinjani Waterpark swimming pool. The Rinjani Waterpark swimming pool is one of the largest pools in East Lombok Regency. Rinjani Waterpark Swimming Pool has 4 swimming pools, each intended for different needs. The results of initial observations show that the Rinjani Waterpark pool managers use chlorine in their swimming pools. According to information from pool visitors, some feel itchy skin and have eye irritation after swimming. This

How to Cite:
W. Wahyudin, E. Fatmalia, and D. Yuliansari, "Analysis of Residual Free Chlorine Content in Rinjani Waterpark Swimming Pool Water, East Lombok District", *J. Pijar.MIPA*, vol. 20, no. 1, pp. 65–69, Jan. 2025. https://doi.org/10.29303/jpm.v20i1.8182

underlies the need for further analysis of the remaining free chlorine content in the Rinjani Waterpark pool water.

Research Methods

The type of research used is descriptive qualitative using Mohr Argentometry (direct titration) SNI 6989.19.2009 and will be presented with research data. This type of qualitative research was carried out by observing the final results of the titration, which was characterized by the appearance of a brownish-red precipitate if the sample was positive for containing chlorine. Then, calculate the residual free chlorine levels in the swimming pool water samples.

This research was carried out in May 2024. The sampling location was the Rinjani Waterpark swimming pool in East Lombok district, and the samples were then analyzed at the STTL Mataram Environmental Laboratory. The sampling points in this study consisted of four swimming pools where chlorine was added. Sampling was done twice, before and after being given chlorine, to determine the residual levels of free chlorine before and after direct contact with humans.

The tools, materials, and research procedures used in this research are presented as follows.

Sampling

The tools used in sampling and testing samples are sample bottles, measuring cups, measuring flasks, Erlenmeyer flasks, burettes, statives, clamps, funnels, beaker glasses, volume pipettes, analytical scales, spatulas, watch glasses and ovens. The materials used in this research were swimming pool water samples, 0.01 N NaCl solution, 5% K_2CrO_4 indicator, 0.01 N $AgNO_3$, and Aquades. Chemical sampling is done by collecting water directly at the pool's edge using a sample bottle and giving it a name label. It is then taken directly to the STTL Laboratory for testing.

Testing of Residual Free Chlorine Levels

The work procedure for testing residual free chlorine levels in swimming pool water uses Mohr's Argentometry method in SNI 6989.19.2009 [8]. The advantage of chlorine analysis using the Argentometry method is that it is easy and fast to carry out, has sufficient precision and accuracy, and can be used to determine the chloride content with different properties [9].

The initial step is to make a reagent solution; the first is a 0.01N NaCl solution namely the NaCl powder is dried in an oven at a temperature of 140°C and then cooled in a desiccator. Weigh 0.824 g, put it in a 1000ml measuring flask, and dissolve using distilled water until the mark. The second solution is a 5% K_2CrO_4 solution, where 5 grams of K_2CrO4 is added with $AgNO_3$ until a brownish-red precipitate forms. Leave it for 12 hours, then filter, and the filtrate is diluted with distilled water to a volume of 100ml. The third solution is the $AgNO_3$ solution, 2.395 g of $AgNO_3$, which is weighed and dissolved in distilled water to 1000 ml and then stored in a dark (brown) bottle.

Next, the $AgNO_3$ solution was standardized with 0.01 N NaCl by adding 25 ml of 0.01 N NaCl solution to the Erlenmeyer flask, then adding 1 ml of 5% K_2CrO_4 indicator solution and homogenizing. After that, it is titrated with the $AgNO_3$ solution until the color changes to red-brown. Then, the volume of $AgNO_3$ used is recorded, and the normality of the $AgNO_3$ standard solution is calculated.
The normality calculation is as follows:

$$N\ AgNO_3 = \frac{V\ NaCl \times N\ NaCl}{V\ AgNO3}$$

Description:

N $AgNO_3$ = Normality $AgNO_3$
V $AgNO_3$ = Volume $AgNO_3$
N NaCl = Normality NaCl
V NaCl = Volume NaCl

Next, the residual free chlorine content in the sample is determined; the residual chlorine content in the pool water is determined as follows: first, put 100 ml of the sample into a 250 ml Erlenmeyer flask, then add 1 ml of 5% K_2CrO_4 indicator solution. Titration was carried out with a standard solution of AgNO3 until the end point of the titration was marked by the formation of a brownish-red precipitate from Ag_2CrO_4. Then, the volume of $AgNO_3$ used was calculated. Carry out a blank titration against 100 ml of distilled water as in the previous step [10].

The calculation of free chlorine residual content is as follows:

$$\text{Free Chlorine Residual Content} = \frac{(A-B) \times N \times 35.5 \times 100}{\text{Volume Sampel}}$$

Description:

A	:	Volume of AgNO3 standard solution for sample titration (ml)
B	:	Volume of AgNO3 standard solution for blank titration (ml)
N	:	Normality of AgNO3 standard solution (N)
35.5	:	Relative atomic Cl

In this study, pool water samples will be analyzed descriptively, qualitatively, and quantitatively and presented in a table based on laboratory research results. Qualitative analysis is done by observing the titration results, namely the appearance of reddish-brown sediment. Quantitative analysis is carried out to calculate the chlorine content obtained based on the titration results computed using the SNI 6989.19.2009 formula.

Results and Discussion

The Rinjani Waterpark swimming pool is one of the largest pools in the East Lombok District. Swimming Pools Rinjani Waterpark has 4 swimming pools, each intended for different needs.

The samples are then tested at the STTL Mataram Environmental laboratory using Mohr's Argentometric Titration method. Titration was carried out in duplicate for each sample and blank. Research was obtained based on research carried out by SNI 6989.19.2009.

Standardization of Normality of $AgNO_3$ Solutions

Silver nitrate is first standardized before titration to ensure the titrant solution is standardized according to the desired normality. The normality of the silver nitrate

produced is 0.01 N. Standardization is carried out using 0.01 N NaCl solution. The reaction that occurs during standardization is as follows:

$2NaCl + K_2Cr_2O_4 \rightarrow Na_2CrO_4 + 2\ KCl$
$Na_2CrO_4 + 2\ AgNO_3 \rightarrow AgCrO_4 + NaNO_3$ [11]

The calculation for standardizing the $AgNO_3$ solution based on the test results is as follows.

Known:
V NaCl : 25 ml
N NaCl : 0.01 N
V $AgNO_3$: 25 ml
Asked N $AgNO_3$: ...?
Calculation

$$N\ AgNO_3 = \frac{V\ NaCl \times N\ NaCl}{V\ AgNO3} = \frac{25\ ml \times 0.01\ N}{0.01\ ml} = 0.01\ N$$

Standardization of the $AgNO_3$ solution with NaCl solution aims to determine the concentration of the $AgNO_3$ titrant solution, making it easier to calculate the residual free chlorine level you want.

Residual Free Chlorine Levels in Pool Water

The results of the examination of residual free chlorine levels carried out on samples that had been titrated show that the appearance of a brownish-red precipitate marked the end point of the titration.

Information: Brownish Red Precipitate

Figure 1. Titration Results

Based on the test and titration results on all samples, test results and calculations of free chlorine levels in swimming pool water were obtained. These results are presented in the table below.

Table 1. Results of Examination of Residual Free Chlorine Levels in Rinjani Waterpark Swimming Pool Water Samples

Sampel Code	Repetition 1 (R1) (mg/L)	Repetition 2 (R2) (mg/L)	PERMENKES Nomor 2 Th. 2023	Info for R1	Info for R2
P1 M	2.3	1.2		NQ	Q
P2 M	1.42	0.35		Q	NQ
P3 M	1.77	1.77		NQ	NQ
P4 M	2.3	1.2	1 – 1.5	NQ	Q
P1 A	1	1	mg/L	Q	Q
P2 A	1	1		Q	Q
P3 A	1	0		Q	NQ
P4 A	1.2	1.2		Q	Q

Information Code:

P1 : Pool 1	M : Morning
P2 : Pool 2	A : Afternoon
P3 : Pool 3	Q : Qualify
P4 : Pool 4	NQ: Not Qualify

In titration using the Argentometry-Mohr method, appropriate indicators are needed, especially K_2CrO_4, as a marker for the endpoint of the titration. The indicator must reach the endpoint of the titration, which then produces a reddish-brown silver chromate precipitate as the final result [12]. In the Mohr's Argentometry method, the reactions that occur is:

$$2Ag^+ + CrO_4 \rightarrow A_gCrO_4$$ [11]

When taking samples from 4 pools, observations were made on the water system in the swimming pools. The irrigation system used is a fill and draw system, namely a water filling system in the swimming pool that is completely replaced so that a large amount of chlorine is used. Chlorine is given to each pool except Pool 2 (children's pool) in the same dose. The dosage used in administering chlorine is ± 200 grams.

Sampling was carried out twice, namely in the morning and afternoon, to determine the difference in free chlorine levels in the swimming pool before and after visitors' use.

Examining residual free chlorine levels in the morning and evening collections showed a significant decrease. They met the quality standards regarding swimming pool water media by PERMENKES Nomor 2 Tahun 2023, namely 1-1.5 mg/L.

An error caused the difference in levels in repetition samples 1 and 2 during the titration, namely a lack of titration volume, which caused the residual chlorine level in repetition 2 samples to be lower.

Residual chlorine in swimming pool water is essential because chlorine is a disinfectant. The use of disinfectants must be adjusted to obtain residual chlorine values that comply with applicable standards.

The use of chlorine must also be considered carefully, and applicable safety limits must be observed. Using a disinfectant with a low concentration can result in the germs in the swimming pool water not being disinfected optimally. In contrast, using the disinfectant excessively can leave residual chlorine, impacting health [13].

Chlorine levels that are lower than requirements can also reduce the pool's disinfection ability, allowing microorganisms such as bacteria and viruses to develop. This can be detrimental to the health of swimming pool visitors [14]. It can cause health problems such as diarrhea, red diarrhea, eye irritation, itching, and other skin diseases [15]. Meanwhile, chlorine levels in water can cause health problems such as eye irritation and complaints that a water pH that is too high or low will prevent chlorine from working optimally and can result in lime deposition [16]. High levels of residual free chlorine in water and low pH in swimming pools are two factors that cause eye irritation. This condition can cause health problems such as a stinging sensation in the eyes, red eyes, a burning sensation, and itching in the eyes [17].

Pool water residual chlorine levels swimming are also influenced by the many pool users swimming. Residual chlorine levels will decrease as the user more and more. More and more pool users will be carried by dirt or microorganisms attached to pool users' bodies in the swimming pool, resulting in residual chlorine reacting as a disinfectant [18]. To minimize the impact of excess chlorine that visitors can feel, swimming pool managers should provide Personal Protective Equipment (PPE) such as swimming goggles, head coverings, and sunblock before swimming. Swimming goggles can reduce eye irritation, and sunblock can prevent skin irritation after swimming [17].

However, suppose swimming pool water containing excess chlorine is accidentally swallowed. In that case, visitors are expected to get out of the swimming pool, drink lots of water, and spit out some water again. Drinking lots of water is expected to neutralize the chlorine that enters the body so that it can be excreted through urine. The chlorine from urine will also reduce the risk of poisoning and digestive disorders [19].

Moreover, if chlorine enters the body through inhalation, consumption, or skin contact, this compound reacts with water to produce acid. Chlorine is corrosive and can damage cells in the body [20].

Therefore, managers must ensure that the chlorine levels given to each swimming pool are by the recommended levels. The advantages and disadvantages of providing chlorine levels in swimming pools can affect the health and comfort of swimming pool visitors. The right amount of chlorine, called Break Point Chlorination (BPC), can completely kill pathogenic bacteria and prevent moss growth in the water [21].

Conclusion

Based on the results of research regarding the analysis of residual free chlorine in the Rinjani Waterpark swimming pool water, East Lombok Regency, it can be concluded that there is residual free chlorine content in the Rinjani Waterpark swimming pool with levels ranging from 0 - 2.3 mg/L, some levels from this test still not qualify the quality standard threshold set by PERMENKES Nomor 2 Tahun 2023 for swimming pool media, namely 1 - 1.5 mg/L. Some samples do not qualify for the requirements based on quality standards in PERMENKES Nomor 2 Tahun 2023 for swimming pool media, namely in repetition 1 with sample codes P1 M, P3 M, and P4 M, and in repetition 2 with sample codes P2 M, P3 M, and P3 A. An error in the titration caused the difference in results in repetitions 1 and 2 carried out during the test, so it is recommended that future research be more careful in the titration process to get good results.

Author's Contribution

Wahyudin: Compiling and Designing Analysis; Enida Fatmalia: Conducting Analysis and Writing Articles; Dini Yuliansari: Collect Data

Aknowledgement

We would like to express our thanks to Sekolah Tinggi Teknik Lingkungan Mataram for the funds provided so that this research can run well. Apart from that, we would also like to thank the STTL Mataram Chemistry and Biology Laboratory for giving us the opportunity to carry out research on testing chlorine levels in the samples we examined.

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