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Well Water Quality of Residents in The Tofu Industry, Pakintelan Village, Gunungpati District

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ABSTRACT

Small and medium-sized industries, particularly the tofu industry, are often characterized by low energy efficiency and high pollution due to a lack of industrial wastewater treatment, leading to direct discharge that degrades water bodies and the surrounding well water quality. This study aims to analyze the quality of well water near the tofu industry in Pakintelan Village, Gunungpati District, Semarang City, to assess its suitability as drinking water. A quantitative descriptive research approach was used with purposive sampling. Data were collected through observation, interviews, and laboratory tests focusing on physical (Odor, Taste, TDS), chemical (pH, Nitrate, Nitrite), and biological (Coliform) parameters from residents' wells. The quality status was determined using the STORET Index method and an ANOVA test, in accordance with the Minister of Health Regulation No. 02 of 2023. The results confirmed that tofu liquid wastewater negatively affects well water quality, and that the distance between the well and the tofu industry significantly influences this water quality. This research contributes to environmental science by providing empirical evidence of the direct contamination pathway from untreated tofu effluent to domestic water sources and highlighting well distance as a critical factor in managing water resources in industrial areas.

ARTICLE INFORMATION

Keywords:
tofu industry waste; water quality, well water

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INTRODUCTION

Tofu and tempeh consumption in Indonesia will increase in 2024, reaching an average of 0.201 units per capita per week, up 0.104% from the previous year. This increase in consumption is in line with the increasing number of tofu industries, which are widespread household businesses. The tofu production process requires a large amount of water (28.8 liters per kg of soybeans). Liquid waste from small food industries, such as tofu production, contains carbohydrates, proteins, fats, minerals, and chemicals, which can cause handling problems. Small- and medium-sized industries are classified as having low energy efficiency and high pollution levels due to the lack of waste treatment facilities. Discharging tofu liquid waste directly into water bodies without treatment will pollute the aquatic environment. Small and medium-sized enterprises are categorized as industries with low energy efficiency and high pollution levels because of the lack of industrial wastewater treatment.

Wastewater from the tofu industry, when directly discharged into water bodies without prior treatment, can pollute aquatic environments (Viky & Nurudin, 2024). Tofu liquid waste, which contains various organic substances, can accelerate microbial growth in water. The characteristics of liquid waste from tofu processing include: 1) Containing organic matter that can decompose if left stagnant in the open for several days; 2) The temperature of the liquid waste ranges from 40-60

degrees which is higher than the surrounding ambient temperature; and 3) It is acidic due to the acidic agglutination process of soybean extract, which can kill microbes and reduce the dissolved oxygen level in the waters (Farhana & Yayi, 2021).

Water quality indicates the suitability of water for specific uses, including drinking, bathing, and washing; irrigation and agriculture; livestock; recreation; and biology (Pratiwi et al., 2021). Clean water quality must meet the requirements outlined in Minister of Health Regulation No. 02 of 2023 regarding drinking water, covering physical, chemical, and biological aspects (Ministry of Health of the Republic of Indonesia, 2023). In Indonesia, many water bodies have been polluted by waste from factories and households, including soap and detergent. Therefore, water quality must be maintained so that water can be utilized as intended (Jannah et al., 2021). However, the current problem is the year-over-year decline in water quality. This is caused by the amount of industrial waste, including waste from the tofu industry. Thus, it is a logical consequence that water quality in a given environment decreases.

Pakintelan Village is one of the villages located in the Gunungpati District of Semarang City. In Pakintelan Village, specifically in RW 02 Dusun Kepil, there are two household tofu industries managed by the community. This tofu industry has been in operation for 20 years, with an average daily production capacity of 70-100 kg of soybeans, yielding 70 blocks of tofu. The large amount of tofu produced has a significant impact on environmental pollution, as most tofu producers do not properly process tofu production waste. In a very short time, the tofu industry in Pakintelan Village is capable of producing a considerable amount of liquid waste. The waste from tofu production is discharged into a river near the tofu factory, which flows past the residents' houses. The liquid waste from the tofu, dumped into the river, turns black and emits a foul odor. This can affect water quality, especially in wells near the tofu industry. Based on the above phenomenon, research was conducted on the effects of the liquid waste disposal from the tofu industry on the quality of well water in Pakintelan Village, Gunungpati District.

METHOD

This research was conducted in Pakintelan Village, Gunungpati District, Semarang City, Central Java, Indonesia. The tofu industry in Pakintelan Village has been established for 15–20 years, with a daily production capacity of 70–100 kg of soybeans. Tofu production takes place every day from 05:00 AM to 04:00 PM. Given the long history of the tofu industry, the volume of raw materials used, and the daily production schedule, this situation raises concerns about the potential for changes in the quality of the well water surrounding the industry. The pollution is primarily caused by tofu producers discharging their wastewater directly into the river without any prior treatment.

The research location, Pakintelan Village, is a rural area where studies on the effects of liquid tofu waste have not yet been conducted. Therefore, the author believes there is a lack of understanding of the impact of tofu liquid waste on well water quality and a noticeable absence of prior research analyzing well water quality at this location. Furthermore, few studies have been found that specifically address the influence of tofu liquid waste on well water quality, as previous research has predominantly focused on its impact on river water.

The approach employed in this study is a quantitative descriptive approach. Descriptive analysis is used to examine a single variable, in the form of frequency distribution tables and percentage analyses, specifically the laboratory results for the physical, chemical, and biological parameters of well water and tofu liquid waste. The results were compared with the quality standards stipulated in Minister of Health Regulation Number 02 of 2023. Subsequently, an ANOVA will be performed to identify significant differences in well water quality by distance from the pollution

source, namely the tofu industry. To analyze the effect of distance from the tofu industry on well water quality, an ANOVA will be conducted on pH, TDS, Nitrate, Nitrite, and Coliform.

RESULTS AND DISCUSSION

Based on observations of the wells' physical condition, it was found that all three wells do not meet the requirements for dug wells established by the Ministry of Public Works and Public Housing (PUPR) in 2017. Table 1 presents observations on the physical condition of the wells.

Table 1. Observations of the Physical Condition of Wells

Condition	Well			Requirements PUPR 2017	Notes
	1	2	3		
Shape	Round	Round	Round	Round or Square	M
Depth	5 m	15 m	10 m	2 m	M
Distance from River	3 m	≤ 5m	≤ 5m	10 m	NM
Well Wall (Top)	30 cm Concrete pipe	42 cm Concrete pipe	63 cm Concrete pipe	≥300 cm Concrete pipe	NM
Well Wall (Bottom)	100 cm Concrete pipe	Soil	Soil	80 cm	NM
Well Floor	5 cm Cement plaster	Soil	Soil	100 cm Concrete pipe	NM

**M/NM: Meets/Does Not Meet*

Based on Table 1, the physical condition of the wells does not meet the requirements set by the Ministry of Public Works and Public Housing (PUPR), specifically regarding the distance of the well from the river, the upper well wall, the lower well wall, and the well floor. These factors can affect the quality of well water, as microorganisms and contaminants can more easily enter the groundwater. Microbiological water quality pollution can pose health risks. According to Yoga (2020), the quality of well water is significantly influenced by the well's physical condition, position, walls, rim, and floor. Improvements and maintenance of the well conditions are necessary, such as upgrading the well floor to a waterproof surface to prevent or reduce seepage into the well.

The purpose of testing the biological parameters (Total Coliform), physical parameters (Taste and Odor), and chemical parameters (pH, Nitrate, and Nitrite) in this study is to assess the quality of well water located around the tofu industry in Pakintelan Village, Gunungpati District, Semarang City, in accordance with the water quality standards set by Minister of Health Regulation No. 02 of 2023. Below is Table 2, which presents the results of the parameter examination.

Table 2. Testing of Mandatory Drinking Water Parameters

Well	Test Result	Maximum Allowable Level	Unit	Notes
Mikrobiological				
Total Coliform				
1	300-600	0	CFU/100ml	NM
2	100-800			NM
3	200-3400			NM
Physical				
TDS (Total Dissolved Solids)				
1	135-138	<300	mg/L	M
2	113-117			M
3	113-122			M
Taste				
1	Not Tasting	Not Tasting	-	M
2	Not Tasting			M
3	Slightly Bitter			NM
Odor				
1	Odorless	Odorless	-	M
2	Odorless			M
3	Odorless			M
Chemical				
pH				
1	8,4-9,4	6,5-8,5	-	NM
2	7,6-8,5			M
3	8,0-8,7			NM
Nitrate				
1	1,185-1,210	20	mg/L	M
2	0,898-1,074			M
3	4,022-4,134			M
Nitrite				
1	0,003-0,004	3	mg/L	M
2	0,031-0,035			M
3	0,009-0,011			M

(Source: Data Analysis)

**M/NM: Meets/Does Not Meet*

Based on Table 4.2, testing of mandatory drinking water parameters according to the quality standards set by the Ministry of Health Regulation No. 02 of 2023 indicates that the parameters that do not meet the requirements are Coliform, Taste in Well 3, and pH in Wells 1 and 3. The parameters that meet the requirements include TDS (Total Dissolved Solids), Taste in Wells 1 and 2, Odor, pH in Well 2, Nitrate, and Nitrite

The examination results show that the three wells do not meet the quality standards set by Ministry of Health Regulation No. 02 of 2023, which requires 0 CFU/100 ml for Coliform bacteria. The highest number of Coliform bacteria was found in Well 3, which is suspected to be influenced by the direction of subsurface water flow. According to Kodoatie (2021), groundwater flowing through rivers contaminated with Coliform bacteria can seep into nearby wells. Water from rivers contaminated by industrial waste can infiltrate the groundwater source of wells.

The high levels of Coliform bacteria are also influenced by the well's proximity—only 3 meters—to a former chicken coop, which does not comply with the Ministry of Public Works and Public Housing (PUPR) recommendation that the distance between a dug well and a pollution source should be at least 10 meters. Waste produced by poultry farms can affect the quality of well water. Based on information from the well owner, they were not aware of the safe distance between the chicken coop and the well. A well too close to livestock pens increases the risk of bacteria entering the groundwater and contaminating the well water with microbes. The closer the well is to the livestock pen, the poorer the microbiological quality of the well water.

This aligns with research by Sari and Situmorang (2020), which found that a livestock pen distance of ≤ 10 meters significantly influences the presence of total Coliform in dug well water. Livestock waste can contaminate wells through soil seepage and poor waste management. A study by Rahmawati et al. (2024) analyzed various factors affecting the presence of bacteria in dug well water. Among 40 samples examined, the most influential factors were the distance between livestock pens and wells, as well as the behavior of water users. Another contributing factor to the high levels of Coliform bacteria is inadequate or non-compliant well construction, such as a well edge less than 80 cm high, a well located outside the house, and the use of wooden boards as a cover. These conditions increase the risk of Coliform contamination. According to Syafarida et al. (2022), there is a correlation between well construction (walls, rims, and floors) and environmental sanitation conditions (e.g., septic tanks and waste disposal sites) and the contamination of well water with Coliform bacteria, thereby increasing the risk of well water pollution.

Overall, across the three wells, a fairly uniform level of standard quality was achieved due to the limited scope of the research area. This study's limited scope resulted in a uniform soil structure and texture across the research area, leading to no variation in permeability values. Nevertheless, all three wells were declared not to meet the potable water quality standards stipulated by the Minister of Health Regulation No. 02 of 2023. Coliform bacteria in well water can cause serious health problems, including digestive disorders such as diarrhea, urinary tract infections, and diseases caused by waterborne pathogens (Supenah et al., 2023). The physical condition of the wells may be the cause of the deteriorating microbiological quality of well water in Pakintelan Village. The community needs to understand the construction and maintenance of wells in accordance with established standards. Therefore, there is a need for outreach and education on proper well maintenance and the surrounding environment.

The results of TDS (Total Dissolved Solids) testing varied. 9 well water samples met the quality standards established by the Ministry of Health Regulation No. 02 of 2023. The highest TDS level was found in Well 1, which may be due to its proximity—less than 10 meters—to a pollution source: a tofu factory. This is likely caused by limited land space, making it difficult to maintain a safe distance from the pollution source. The presence of a tofu industry near the well area may contaminate Well 1, as tofu wastewater can seep into the groundwater through the soil. Additionally, the high TDS could result from a combination of dissolved organic and inorganic substances present in the water. The main sources of elevated TDS levels include runoff from industrial or domestic wastewater discharge. As tofu production is conducted daily, the factory environment remains moist, increasing the risk of liquid waste contaminating nearby wells.

A study by Aneta et al. (2021) stated that TDS levels in water can be influenced by runoff from residential areas, mountain water, soil sediments, and industrial wastewater. Another contributing factor to the high TDS level is the well's location, which is close to residential areas, situated behind. High nitrate levels can affect the taste of water. Nitrate testing showed that Well 3 had the highest nitrate concentrations, ranging from 4.022 to 4.134 mg/L. Although these levels are still within the regulatory limits, nitrate may still contribute to an unpleasant taste.

Organic contamination is another reason why Well 3 water has an unpleasant taste. Observations revealed that the well is located relatively close to a river and a garden, potentially affecting soil conditions around the well. Soil containing certain minerals can impart taste to water. The surrounding garden contains various plants, and organic decomposition from leaves, roots, and decaying vegetation can release organic compounds into the soil and water. This decomposition process can produce taste in the water. This supports the findings of Rohmawati and Kustomo (2020), who stated that changes in water taste may result from decaying organic matter, chemical compounds, algae, and aquatic plants and animals that contaminate the water. Putri et al. (2021) also noted that vegetation density can influence the physical and chemical properties of water.

Foul odors in water indicate the decomposition of organic matter by microorganisms. Odors can also be caused by algae, fungi, and other substances present in the water (Nanda et al., 2023). The purpose of taste testing in well water is to analyze taste differences against standard quality benchmarks. Physically, water can be evaluated by taste. Water that tastes bitter, salty, sweet, sour, or abnormal indicates poor water quality and possible contamination by pollutants (Nurhajawarsi, 2023). Analyzing the taste of well water is important for detecting potential contaminants or substances that may affect its suitability for consumption. Several factors, including chemical composition, microorganisms, and water conditions, can influence water taste.

Based on all samples, the three wells were odorless, indicating that the well waters 1, 2, and 3 comply with the quality standards set by Minister of Health Regulation No. 02 of 2023. Water with an unpleasant odor indicates contamination by bacteria, and the change in odor is usually caused by protein content from industrial waste (Al Idrus, 2018). Odor in a well is a critical indicator of pollution or contamination; the smell in the water is typically associated with dissolved chemical compounds, microorganisms, or organic materials (Nanda et al., 2023). Odor, taste, and color can all indicate that a water body has poor quality or is contaminated.

Based on the pH testing conducted, the highest pH values were observed in wells 1 and 3. This is because wells 1 and 3 are relatively close to the river, at ≤10 meters, which makes the water in wells 1 and 3 alkaline. In well 3, it was also found that the well is located near a former chicken coop, less than 10 meters away, which contributes to the water's alkalinity. According to the Ministry of Public Works and Housing (Ministry of Public Works and Public Housing of the Republic of Indonesia, 2022), the minimum distance between wells and sources of pollution should be 10 meters. The depth of a well can also affect the pH value of the water. Well 1 has a depth of 5 meters, which is shallower than wells 2 and 3. According to Sanjaya and Pingki (2022), the deeper the well, the higher the pH level, as determined by both simultaneous and partial testing. However, in this study, well depth did not affect pH levels. This may be influenced by tofu production processes, in which shallower water is more susceptible to the effects of tofu wastewater and decomposed organic matter.

Another cause of high pH levels could be the disruption of tofu waste decomposition. Tofu wastewater contains organic matter that can degrade over time. However, if waste treatment is inadequate or improperly conducted, the decomposition process that typically produces acids may be hindered. As a result, the pH remains high, potentially contaminating the soil and, in turn, affecting the quality of well water. The third sampling of well 3 had a lower pH than the first and second samplings, which may be due to differences in temperature at the time of sampling. Temperature affects the equilibrium of a system and influences the pH of a solution. This aligns with Pratami (2019), who found that sample temperature significantly influences pH readings, with higher temperatures increasing pH values, though not significantly. A pH below six or above nine can make some chemical compounds in the human body toxic. Well water with high pH levels can cause health issues, though not necessarily immediately. This is supported by Suni et al. (2024), who stated that the lower the pH, the more acidic the water; conversely, the higher the pH, the more alkaline the water. Such conditions

can lead to health problems like nausea, headaches, and respiratory issues. Low-pH water can dissolve metals, such as iron. An increase in water temperature can increase the corrosiveness and the levels of dissolved gases, including O_2, CO_2, and H_2S. Biologically, high iron content is influenced by iron bacteria, which rely on oxidizing iron for their sustenance (Wijayanti & Amyati, 2022). Well water that is too acidic also poses health risks, as low pH increases the toxicity and solubility of metals, making water more likely to contain heavy metals. However, the acidic nature of well water can also result from high CO_2 levels, which may not pose significant health risks (Singkam et al., 2021).

In general, the acceptable pH range for drinking water is 6-7. However, some drinking water has higher pH levels (8–9), commonly referred to as alkaline water. It is important to adjust water consumption to individual body needs and ensure water quality is considered. Low-pH water can cause metal pipe corrosion, releasing elements like lead, copper, and cadmium into the water, and can even damage clothes when used for washing.

The nitrate test results from the three wells indicate that all wells meet the quality standards set by the Ministry of Health Regulation No. 02 of 2023. Nitrate is a nitrogen compound found in natural waters that can disrupt ecosystems if present in excess. Nitrate is a key water-quality parameter (Arafha, 2020). High nitrate levels in water sources can be hazardous to human health and other living beings. Familiar sources of nitrate pollution include industrial waste, septic tanks, and livestock waste. Nitrate testing in well water aims to provide information on compound concentrations and indicate whether the water meets established standards.

Based on the test results, well 2 had the lowest nitrate level, while well 3 had the highest. Observations showed that Well 3 is located close to a former chicken coop (< 10 m). According to the well owner, the coop had been in existence for about 3 years. This is supported by Marlinda (2019), who identified sources of contamination, including latrines, septic tanks, animal pens, garbage disposal sites, and wastewater channels. Wells located close to pollution sources are at higher risk of nitrate contamination. The closer a well is to a livestock area, the poorer its water quality.

Wells around the tofu industry in Pakintelan Village, Gunungpati Subdistrict, have varying nitrate levels. Other influencing factors include differences in distance, well construction, groundwater movement, geographical conditions, soil types, and seasonal changes. These factors can cause nitrate levels to vary between wells. This aligns with Lathifah (2019), who stated that nitrate levels in well water are influenced by the condition of the well floor, the surrounding environment, well construction, and topography.

Seasonal changes also affect nitrate concentrations. Sampling was conducted during the rainy season, when lower nitrate concentrations were observed in groundwater. Rainy seasons increase water volume in wells and affect soil nutrient concentrations. According to Ardhaneswari and Wispriyono (2022), high rainfall increases plant nitrogen uptake and reduces nitrate concentration. Widigdo et al. (2020) also found that nitrate, nitrite, and orthophosphate levels are generally lower in the rainy season than in the dry season. Nitrite is an oxide compound known as nitrogen monoxide and is typically found in stale or aged wastewater. Nitrite does not persist for long due to oxidation processes and is commonly found in corrosive industrial materials. Nitrite is unstable and tends to oxidize into nitrate (Emilia, 2019).

Nitrite tests on the three wells showed that all met the quality standards set by the Ministry of Health Regulation No. 02 of 2023. This indicates that all three wells near the tofu industry are still within safe limits and the water can still be consumed, although it should be boiled first. The public must remain vigilant about nitrite formation in their well water, as nitrite compounds can be very harmful to human health. Nitrite levels varied, with the highest found in well 2. This is likely because Well 2 is relatively close to the riverbank and easily contaminated by seepage from the river, which is used as a wastewater disposal site by the tofu industry. Well 2 is an old structure—built around 25

years ago—which increases the risk of long-term contamination from surface pollutants like domestic waste, fertilizers, and organic matter. These pollutants may contain nitrogen that can be converted into nitrite through nitrification. The lowest nitrite level was found in well 1, possibly due to the oxidation of nitrite into nitrate, which can influence nutrient levels that correlate with dissolved oxygen. According to Meirinawati and Fitriya (2018), nitrate and nitrite levels are influenced by biological activity and plant growth near water bodies, which can reduce water acidity (pH).

High nitrite concentrations can harm human health, potentially causing methemoglobinemia and toxic effects if levels exceed 0 mg/L. Methemoglobinemia is caused by the oxidation of hemoglobin, turning Fe^{2+} into Fe^{3+} (methemoglobin), which cannot carry oxygen. When the amount of methemoglobin exceeds the body's ability to convert it back to hemoglobin, it can result in cyanosis, tissue hypoxemia, and even death (Ardhaneswari & Wispriyono, 2022). High environmental nitrite levels pose serious health risks. According to Ardhaneswari and Wispriyono (2022), high nitrite levels are hazardous for infants under 3 months old, as they can lead to Blue Baby Syndrome or methemoglobinemia.

The community widely uses dug wells, but the public still does not fully understand well construction or site location; therefore, there is a need to improve well location and construction to prevent contamination. This factor causes the nitrite levels to vary between wells. According to Sholehah et al. (2020), dug wells are easily contaminated by seepage, which generally originates from waste disposal, because their water tables are relatively close to the surface. The condition of the well construction can also be a source of contamination; for example, wells with open construction or those where water is retrieved using a bucket. The relationship between pH values and the distance of the wells is presented in Figure 1.

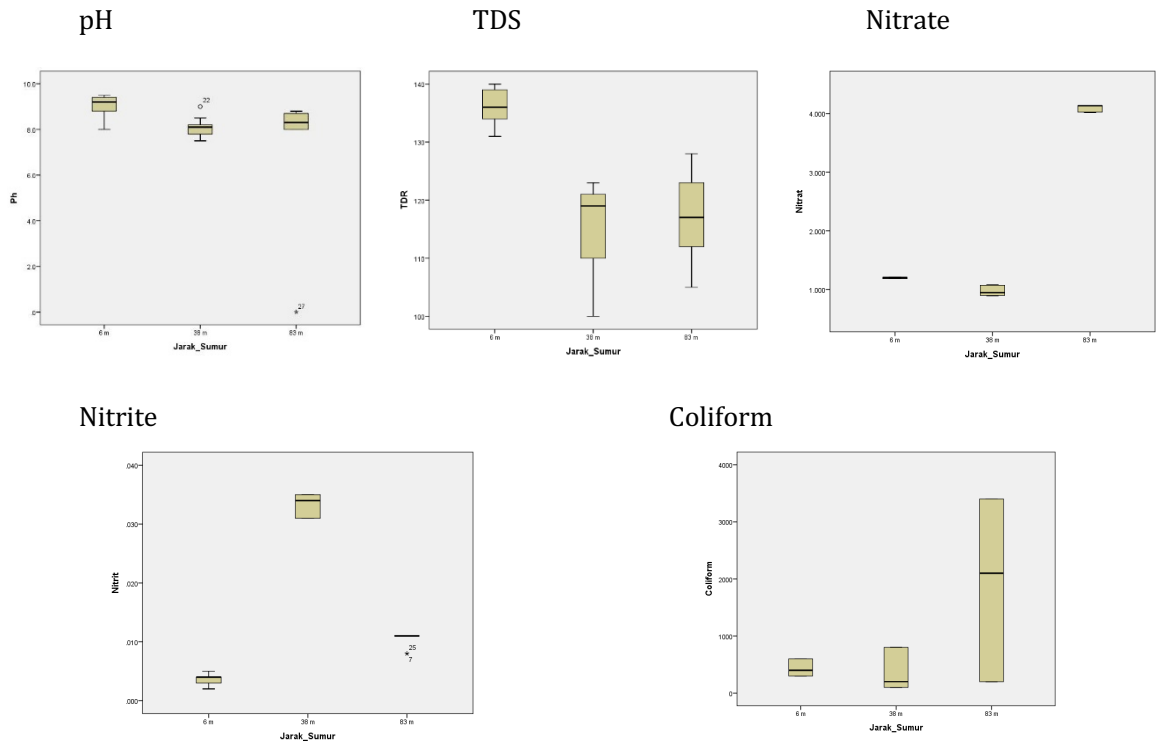

Figure 1. Box Plot of Testing

The results of the parametric One-Way ANOVA test on pH by well distance indicate that the wells near the tofu industry have the highest pH, at 6 m, with a value of 9.056. The distance of 38 m ranks second, with an average pH of 8.111. The average value at a distance of 83 m ranks second-

lowest, with a pH of 7.478. The average pH test values imply that higher average values indicate higher pH levels, suggesting that water quality is deteriorating. Overall, the results show that there is no significant relationship between well depth and pH. This has important implications for water resource management, as it suggests that other factors may have a greater influence on well water quality.

The calculated F value is 2.015 with df1 = 2 and df2 = 24, yielding a p-value of 0.155, which is greater than 0.05. Therefore, the null hypothesis (H0) is rejected, indicating that there is no difference in well distance with respect to pH content. The calculated F value of 2.015 indicates the ratio of variance between the groups, based on well distance, to the variance within the groups. A higher F value typically indicates a greater difference between groups. The significance value obtained is 0.155. This indicates that the probability of obtaining results at least as extreme as those observed if the null hypothesis (H0) is true is 15.5%. Since the p-value (0.155) is greater than 0.05, there is not enough evidence to reject the null hypothesis (H0). In other words, we accept the null hypothesis and reject the alternative hypothesis (Ha). This means there is no significant difference between well distance and pH content.

The results of the prerequisite test indicate that the TDS values follow a normal distribution and that the TDS data variance is consistent. Therefore, a parametric One-Way ANOVA was conducted to test the research hypothesis, yielding an F value of 2.015 with df1 = 2 and df2 = 24. The significance value is 0.000, which is less than 0.05, indicating that the alternative hypothesis (Ha) is accepted and that there is a significant difference between well distance and TDS content. The calculated F value of 2.015 indicates a significant difference between the groups, namely the well distance and the distance variation. The higher the F value, the greater the likelihood that the observed differences are due to the distance of the well from the tofu industry.

The significance value obtained is 0.000. This indicates that the probability of obtaining the same result if the null hypothesis (H0) is true is very small. In this context, H0 typically states that there is no difference between well distance and TDS content. Since the p-value (0.000) is less than 0.05, we reject the null hypothesis (H0) and accept the alternative hypothesis (Ha). This indicates a significant difference between well distance and TDS content. The acceptance of Ha shows that there is a significant relationship between well distance and TDS content, which has important implications for water resource management and public health.

The results of the prerequisite test indicate that the calculated F value is 2.015 with df1 = 2 and df2 = 24, resulting in a significance value of 0.000, which is less than 0.05. This means that the alternative hypothesis (Ha) is accepted, indicating a significant difference between well distance and nitrate content. The significance value obtained is 0.000. This shows that the probability of obtaining results as extreme or more extreme if the null hypothesis (H0) is true is very small. In this context, H0 typically states that there is no difference between the groups being compared. Since the p-value (0.000) is less than 0.05, we reject the null hypothesis (H0) and accept the alternative hypothesis (Ha), indicating a significant difference between well distance and nitrate content. In other words, well distance affects the nitrate content in water. Overall, Ha's acceptance indicates a significant relationship between well distance and nitrate content.

The results of the parametric One-Way ANOVA test on nitrate levels by well distance indicate that wells near the tofu industry have the highest nitrate levels, at 83 m with a value of 4.09678. The distance of 6 m ranks second, with an average nitrate value of 1.19944. The average value at a distance of 38 m ranks second-lowest, with a value of 0.97244. Overall, Ha's acceptance indicates a significant relationship between well distance and nitrate content.

The results of the prerequisite test indicate that the calculated F value is 2.015 with df1 = 2 and df2 = 24, resulting in a significance value of 0.000, which is less than 0.05. This means that the

alternative hypothesis (Ha) is accepted, indicating a significant difference between well distance and nitrite content. The significance value obtained is 0.000. This means that the probability of obtaining results as extreme or more extreme if the null hypothesis (H0) is true is very small. In this context, H0 typically states that there is no difference between well distance and nitrite content. Since the p-value (0.000) is less than 0.05, we reject the null hypothesis (H0) and accept the alternative hypothesis (Ha), indicating that there is a significant difference between well distance and nitrite content.

The results of the parametric One-Way ANOVA test on nitrite levels by well distance indicate that wells near the tofu industry have the highest nitrite levels, with a distance of 83 m and a value of 4.09678. The distance of 6 m ranks second, with an average nitrite value of 1.19944. The average value at 38 m is the second-lowest nitrite value, at 0.97244. Overall, Ha's acceptance indicates a significant relationship between well distance and nitrite content.

The results of the prerequisite test indicate that the calculated F value is 2.015 with df1 = 2 and df2 = 24, resulting in a significance value of 0.001, which is less than 0.05. This means that the alternative hypothesis (Ha) is accepted, indicating a significant difference between well distance and coliform content. Since the p-value (0.001) is less than 0.05, we reject the null hypothesis (H0) and accept the alternative hypothesis (Ha). This indicates a significant difference between well distance and coliform content. The acceptance of the alternative hypothesis (Ha) shows that variations in well distance can lead to significant differences in the levels of Coliform detected in well water. This suggests that the distance of the well from potential pollution sources (such as domestic waste, animal waste, or agricultural runoff) affects the level of coliform contamination present in the well water. The significant differences in coliform content can be explained by environmental factors related to the proximity of the well to pollution sources, such as domestic waste, agricultural runoff, or animal waste that can leach into the soil and contaminate water sources. Wells closer to these pollution sources tend to have higher coliform levels, while those farther away may be less susceptible to direct contamination (Saalidong et al., 2022).

The results of the parametric One-Way ANOVA test on Coliform by well distance indicate that wells near the tofu industry have the highest coliform levels, with a distance of 83 m and a value of 1900.00. The 6 m distance ranks second, with an average coliform value of 433.33. The average value at 38 m is the second-lowest coliform value, at 366.67.

CONCLUSION

Analysis of the problem formulation in Pakintelan Village, Gunungpati District, Semarang City reveals several critical issues: the physical condition of residents' wells fails to meet the 2017 construction guidelines set by the Ministry of Public Works and Public Housing (PUPR), the quality of well water used by the local tofu industry does not comply with the quality standards outlined in Minister of Health Regulation No. 02 of 2023, and notably, the distance of the well is a significant factor directly affecting the quality of well water in the tofu industry.

DECLARATION OF GENERATIVE AI

The authors declare that no generative AI or AI-assisted technologies were used in the writing process of this manuscript.

CONFLICTING INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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REFERENCES

Al Idrus, S. W. (2018). Analisis Pencemaran Air Menggunakan Metode Sederhana pada Sungai Jangkuk, Kekalik, dan Sekarbela Kota Mataram. *Paedagoria: Jurnal Kajian, Penelitian dan Pengembangan Kependidikan, 5*(2), 8-14.

Aneta, R., Umboh, J. M., & Sondakh, R. C. (2021). Analisis Tingkat Kekeruhan, Total Dissolved Solids (TDS), dan Kandungan Escherichia coli pada Air Sumur di Desa Arakan Kecamatan Tatapaan. *Kesmas: Jurnal Kesehatan Masyarakat Universitas Sam Ratulangi, 10*(4).

Arafha, B. R. A. (2020). *Optimalisasi Efektivitas Kolom Reduksi Kadmium pada Pengujian Nitrat (NO3) dengan Spektrofotometer UV Vis* [Final Project].

Ardhaneswari, M., & Wispriyono, B. (2022). Analisis Risiko Kesehatan Akibat Pajanan Senyawa Nitrat dan Nitrit pada Air Tanah di Desa Cihambulu Subang. *Jurnal Kesehatan Lingkungan Indonesia, 21*(1), 65-72.

Farhana, D., & Wijaya, Y. R. P. (2021). Pemanfaatan Limbah Cair Tahu sebagai Pupuk Organik Cair untuk Berbagai Tanaman di Kampung Lengkong, Kota Langsa. *Seminar Nasional Peningkatan Mutu Pendidikan*, 2(1), 83-87.

Jannah, F. Z., Zuhri, M. S., & Mulyadi, E. (2021). Optimasi Kadar Ozon dalam Proses Disinfeksi Bakteri Coliform pada Pengolahan Air Minum. *Jurnal Teknik Kimia, 15*(2), 59-65.

Kodoatie, R. J. (2021). *Tata Ruang Air Tanah*. Penerbit Andi.

Korniasih, N. W., & Sumarya, I. M. (2021). Total Coliform dan Escherichia coli Air Sumur Bor dan Sumur Gali di Kabupaten Gianyar. *Jurnal Widya Biologi, 12*(02), 90-97.

Lathifah, Q. A. Y. (2019). Studi Kandungan Nitrat dan Kesadahan dalam Air Sumur di Kecamatan Kalidawir Kabupaten Tulungagung. *Warta Bhakti Husada Mulia: Jurnal Kesehatan, 6*(1).

Marlinda, M., Moelyaningrum, A. D., & Ellyke, E. (2019). Keberadaan Bakteri Escherichia coli dan Coliform pada Sumur Gali dan Bor Rumah Pemotongan Hewan. *Jurnal Kesehatan Lingkungan Jurnal dan Aplikasi Teknik Kesehatan Lingkungan, 16*(1), 679-688.

Meirinawati, H., & Fitriya, N. (2018). Pengaruh Konsentrasi Nutrien terhadap Kelimpahan Fitoplankton di Perairan Halmahera-Maluku. *Oseanologi dan Limnologi di Indonesia, 3*(3), 183-195.

Ministry of Health of the Republic of Indonesia, 2023. (2023). *Peraturan Menteri Kesehatan Nomor 2 Tahun 2023 tentang Peraturan Pelaksanaan Peraturan Pemerintah Nomor 66 Tahun 2014 tentang Kesehatan Lingkungan*.

Ministry of Public Works and Public Housing of the Republic of Indonesia. (2017). *Guidelines for Housing and Rural Settlement Development*. Jakarta.

Nanda, M., Purba, A. F. H., Gultom, K., Sari, K. S., Muthmainah, N., & Ramadhan, F. (2023). Analisis Parameter Fisik (Kekeruhan, Bau, Rasa) dan Uji Kandungan Besi (Fe) pada Sumur Gali dan Sumur Bor di Kelurahan Bantan, Kecamatan Medan Tembung. *Jurnal Kesehatan Tambusai, 4*.

Nurhajawarsi, N., & Haryanti, T. (2023). Analisis Kualitas Air Sumur Sekitar Kawasan Industri Bantaeng (KIBA). *Sebatik, 27*(1), 43-51.

Pratami, L. W. D. (2019). *Pengaruh Suhu terhadap Pengukuran pH Meter Berbasis Arduino Uno Dilengkapi Kalibrasi Internal* [Doctoral dissertation, Poltekkes Kemenkes Surabaya].

Pratiwi, S. S. D., Yushardi., & Sudarti. (2021). Analysis of Well Water Quality in Manduro Village, Kabuh District, Jombang Regency. *Journal of Research and Education Chemistry (JREC)*.

Putri, I., Shafira, K., Andrea, S., & Fitri, M. (2021). Pengaruh Vegetasi terhadap Kualitas Genangan pada Ruang Terbuka di Permukiman Tepian Sungai Musi, Palembang. *Seminar Nasional Hari Air Sedunia*, 3(1), 117-123.

Rahmawati, A. N., Utami, D. W., Saryanti, D., & Kurniaaji, B. (2024). Analisis Most Probable Number (MPN) Coliform dan Escherichia coli pada Air Sumur Bor di Pemukiman Warga Kelurahan Pucangsawit Surakarta. *Jurnal Kesehatan Lingkungan Indonesia, 23*(2), 146-152.

Rohmawati, Y., & Kustomo, K. (2020). Analisis Kualitas Air pada Reservoir PDAM Kota Semarang Menggunakan Uji Parameter Fisika, Kimia, dan Mikrobiologi, serta Dikombinasikan dengan Analisis Kemometri. *Walisongo Journal of Chemistry, 3*(2), 100-107.

Saalidong, B. M., Aram, S. A., Otu, S., & Lartey, P. O. (2022). Examining the Dynamics of the Relationship Between Water pH and Other Water Quality Parameters in Ground and Surface Water Systems. *PLoS ONE, 17*(1), e0262117.

Sanjaya, M. S. T., & Pingki, T. (2022). Analisis Pengaruh Ketinggian Tanah dan Kedalaman Sumur terhadap Suhu dan pH Air Sumur di Kabupaten Blitar. *Jurnal Teori dan Aplikasi Fisika*, 231-242.

Sari, Y., & Situmorang, N. (2020). Pengaruh Jarak Kandang Ternak terhadap Total Coliform pada Air Sumur Gali di Desa Klambir. *BIOLINK (Jurnal Biologi Lingkungan Industri Kesehatan), 6*(2), 186-195.

Sholehah, H., Susane, H., & Khalidi, F. (2020). Pemeriksaan Kadar Nitrit (NO2-) pada Air Sumur Gali di Desa Jempong Kota Mataram dengan Metode Spektrofotometri UV-Vis. *Jurnal Sanitasi dan Lingkungan, 1*(2), 58-64.

Singkam, A. R., Lestari, I. L., Agustin, F., Miftahussalimah, P. L., Maharani, A. Y., & Lingga, R. (2021). Perbandingan Kualitas Air Sumur Galian dan Bor Berdasarkan Parameter Kimia dan Parameter Fisika. *Jurnal Pendidikan Biologi dan Sains, 4*(2), 155-165.

Suni, Y., Fallo, G., & Blegur, W. A. (2024). Analisis Kualitas Air Sumur Gali di Kelurahan Maubeli Kota Kefamenanu Kabupaten Timor Tengah Utara. *Journal of Science Diversity, 5*(1).

Supenah, P., Setiwan, F., & Supriyatin, S. (2023). Pemeriksaan Coliform pada Air Sumur di Sekitar Tempat Pemrosesan Akhir Sampah (TPA) Walahar Jumbleng dengan Metode Most Probable Number (MPN). *Jurnal Multidisiplin Indonesia, 2*(1), 73-80.

Syafarida, U. Y., Jati, D. R., & Sulastri, A. (2022). Analisis Hubungan Konstruksi Sumur Gali dan Sanitasi Lingkungan terhadap Jumlah Bakteri Coliform dalam Air Sumur Gali (Studi Kasus: Desa PAL IX, Kecamatan Sungai Kakap). *Jurnal Ilmu Lingkungan, 20*(3), 437-444.

Viky, V., & Nurudin, A. (n.d.). Pengendalian Pencemaran Air Akibat Kegiatan Industri Tahu. *Notarius, 17*(2), 656-670.

Widigdo, B., Hariyadi, S., Iswantari, A., & Pangaribuan, A. (2020). Evaluation of Water Quality of Crown Golf Ornamental Lake, North Jakarta Based on N and P Content. *Habitus Aquatica, 1*(2), 28-37.

Wijayanti, N., & Amyati, A. (2022). Kualitas Fisik dan Kimia Air Bersih di Pasar Beringharjo Yogyakarta. *Jurnal Ilmu Kesehatan Masyarakat, 11*(03), 270-278.

Yoga, I. G. A. P. R., Astuti, N. P. W., & Sanjaya, N. N. A. (2020). Analisis Hubungan Kondisi Fisik dengan Kualitas Air pada Sumur Gali Plus di Wilayah Kerja Puskesmas II Denpasar Selatan. *HIGIENE: Jurnal Kesehatan Lingkungan, 6*(2), 52-63.