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Analysis of Ammonia (NH_3) Levels in Dug Well Water in Apit Aiq Hamlet, Batulayar Village, Batulayar Subdistrict, West Lombok Regency

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Abstract: Dug well water is a common source of water used by rural communities. However, water pollution can pose risks to both health and the environment, such as contamination by ammonia. The sources of ammonia pollution generally originate from agricultural waste, livestock waste, and domestic household waste. The purpose of this study was to analyze the ammonia concentration and assess the feasibility of dug well water using the UV-Vis spectrophotometry method. The results of this study showed that Well 1 had an ammonia concentration of 0.045 mg/L in the first trial and 0.047 mg/L in the second trial; Well 2 had a consistent ammonia concentration of 0.224 mg/L in both trials; and Well 3 had an ammonia concentration of 0.192 mg/L in the first trial and 0.191 mg/L in the second trial. The findings indicate that Well 1 meets the Class I water quality standard of 0.01 mg/L, whereas Wells 2 and 3 do not meet this standard. However, Well 2 still meets the Class III water quality standard of 0.3 mg/L, and Well 3 meets the Class II standard of 0.2 mg/L, based on Government Regulation No. 22 of 2021. Therefore, only Well 1 is suitable for consumption, while Wells 2 and 3 are not suitable for drinking but may still be used for daily household needs. This condition is likely caused by livestock pens located approximately 11–23 meters from the wells, as well as the disposal of household and domestic waste near the dug wells, which may have seeped into the groundwater and contributed to elevated ammonia levels.

Keywords: Ammonia; Dug Well; Pollution.

Introduction

Rural communities typically utilise multiple sources of water to meet their daily needs, one of which is well water. Since water is a vital natural resource that is vulnerable to contamination, it must meet certain requirements to be considered safe for consumption. According to the Regulation of the Minister of Health of the Republic of Indonesia No. 492/Menkes/IV/2010, safe water must meet physical, chemical and microbiological standards [1]. The quality of well water must be carefully monitored to prevent adverse effects on human health and the environment, as it serves as one of the primary sources of clean water used in daily activities such as drinking, cooking, bathing, washing, sanitation, agriculture, and other purposes. Among these various uses, the most important is its use for drinking.

In general, clean water is defined as water that is suitable for use as raw water for drinking purposes. This suitability also implies that the water is appropriate for bathing, washing, and sanitation. However, being classified as clean water does not necessarily mean it can be consumed directly; it must still be boiled before drinking. The Ministry of Health provides a more detailed definition of clean water, stating that clean water is water used for daily needs that becomes drinking water after being properly treated and boiled. The standard for clean water refers to water that meets the requirements for a drinking water supply system. These requirements encompass water quality parameters that cover physical, chemical, biological, and radiological aspects, ensuring that consumption does not pose any adverse health effects [2].

A dug well is one of the most common and widely used types of wells for extracting groundwater, particularly by small communities and individual households as a source of drinking water. Approximately 45% of the Indonesian population uses wells as a source of clean water, and of that percentage, around 75% are estimated to use dug wells [3]. In West Lombok, one of the hamlets that relies on well water as its primary source of drinking water is Apit Aiq Hamlet, situated in the hilly area of Batulayar Village. The well serves as the main water source for daily needs, making it important to assess its quality. One of the factors that can decrease the quality of well water is the presence of chemical parameters, such as ammonia. Ammonia in water originates from organic nitrogen derived from proteins and urea, as well as inorganic nitrogen resulting from waste, domestic household wastewater, livestock waste, and agricultural runoff [3]. Therefore, it is suspected that the well water in Apit Aiq Hamlet is contaminated with ammonia, as it is located close to livestock pens (approximately 11–23 meters away) and domestic wastewater disposal sources, such as greywater and blackwater from septic tanks. Based on initial observations, the distance between the septic tanks and the wells ranges from 5 to 14 meters. Additionally, the wells are situated near residents' gardens, where organic debris may enter the wells due to open or uncovered well mouths. This litter may decompose and mineralize into nitrogen, which, during the rainy season, can infiltrate into the wells and become a source of ammonia contamination.

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Ammonia at high concentrations can be harmful to both human health and the environment. Ammonia can cause both short-term and long-term health effects, such as skin irritation, eye irritation, throat irritation, respiratory problems, kidney damage, and lung damage [4]. In terms of environmental impact, ammonia can alter the taste and odor of water [5] and serve as a nitrogen source for algae and bacteria, accelerating the growth of microorganisms that make the water appear turbid. Furthermore, ammonia can reduce the concentration of dissolved oxygen in water. It is also highly soluble and can increase the water's pH level, making it more alkaline, which leads to water pollution [6].

Ammonia gas is corrosive and can rapidly affect the eyes, causing severe injury and even blindness. When it comes into contact with the skin, ammonia can cause irritation and chemical burns, depending on the level of exposure. Ingesting ammonia solution can lead to symptoms such as pain in the mouth, throat, and chest, excessive salivation, and burns along the aerodigestive tract. Exposure to ammonia gas is characterized by symptoms including irritation of the nose, throat, and respiratory tract [7].

According to Government Regulation No. 22 of 2021, Water Quality Standards refer to the threshold values or concentrations of living organisms, substances, energy, or components that are present or should be present in water, as well as pollutants whose presence is tolerated within certain limits, in this case, the parameter being ammonia. Water is classified into several classes based on its intended use: Class I: 0.1 mg/L-water used for drinking purposes that meets drinking water quality standards. Class II: 0.2 mg/L, water used for water recreation facilities, freshwater aquaculture, livestock, and irrigation. Class III: 0.5 mg/L, water used for freshwater aquaculture, livestock, irrigation, or other purposes requiring similar water quality standards [8].

Therefore, it is necessary to conduct an analysis of ammonia levels in well water to determine its quality. The results of the ammonia concentration test in well water are then compared with the Class I water quality standards, as outlined in Government Regulation No. 22 of 2021, which concerns the implementation of environmental protection and management.

Research Methods

This type of research is descriptive quantitative research, which is an empirical study in which the data are presented in numerical form. Descriptive quantitative research aims to describe, examine, and explain a phenomenon based on numerical data as it is, without the intention of testing any specific hypothesis [9]. The measuring instrument used in this study was a UV-Vis spectrophotometer. The sample was collected in Apit Aiq Hamlet, Batulayar Village, Batulayar District, West Lombok Regency, West Nusa Tenggara Province, and the testing was carried out at the Environmental Laboratory Unit (UPTD) of the Environmental and Forestry Service of West Nusa Tenggara Province.

The ammonia testing method was based on SNI 06-6989.30-2005. The equipment used included a 500 mL sample bottle, dropper pipette, volumetric pipette, pH meter, stationery (ATK), 50 mL Erlenmeyer flask, micropipette, measuring cylinder, and UV-Vis spectrophotometer. The materials used were an alkaline citrate solution, a 5% sodium hypochlorite solution, a phenol solution, sodium nitroprusside, a 2 mL water sample, ammonium chloride, a mask, and gloves.

Results and Discussion

Calibration Curve

The ammonia concentration test first requires the preparation of a standard solution series using a diluted ammonia stock solution within a concentration range of 0.000 mg/L to 0.500 mg/L. The absorbance of these solutions is then measured using a UV-Vis spectrophotometer at a wavelength of 640 nm. The test results are subsequently presented in the form of a calibration curve, as shown in the figure below.

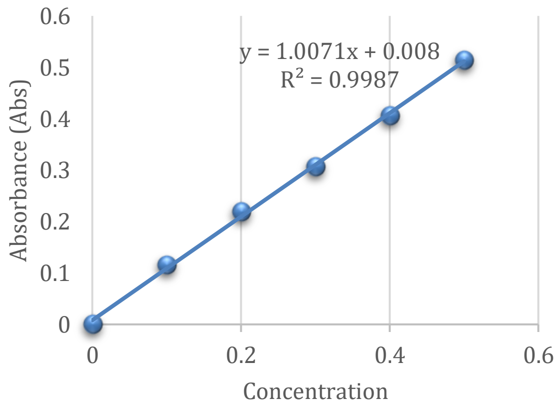

Figure 1. Calibration Curve

From the graph above, it can be seen that the lowest value of the standard solution test is 0 at a concentration range of 0.000 mg/L, while the highest value is 0.513 at a concentration range of 0.500 mg/L. A good calibration curve is indicated when the measured values consistently increase with concentration. Additionally, an R^2 value of greater than 0.995 indicates a strong correlation between concentration and absorbance. Equipment calibration is the process of measuring instruments to ensure they produce accurate and reliable data in accordance with established standards. Calibration is beneficial for measuring materials and instruments, ensuring they remain in accordance with the sensor specifications of the measuring instrument [10].

Results of Ammonia Concentration Testing in Well Water

Table 1. Results of Ammonia Concentration Testing in Well Water

Sample ID	NH_3 (mg/L)	Quality Standard	Remarks
LCS NH_3 as N 0.3 mg/L	0.298	%R LCS = 98.67%	Accurate
CRM	0.295	%R = 108%	Accurate
ASM-K001A	0.045	0.1 mg/L	Within standard
ASM-K001B	0.047		Within standard
ASM-K002A	0.224		Exceeds standard
ASM-K002B	0.224		Exceeds standard
ASM-K003A	0.192		Exceeds standard
ASM-K003B	0.191		Exceeds standard

Notes / Explanations:

a) LCS (Liquid Calibration Standard): A reference solution used to verify the accuracy of analytical measurements.
b) CRM (Certified Reference Material): A standardized material with known concentration values used to ensure the reliability and accuracy of test results.
c) %R (Percentage Reflectance): The percentage value indicating the accuracy or recovery rate of the measurement results.
d) ASM-K001A: Well water sample 1 / replication 1.
e) ASM-K001B: Well water sample 1 / replication 2.
f) ASM-K002A: Well water sample 2 / replication 1.
g) ASM-K002B: Well water sample 2 / replication 2.
h) ASM-K003A: Well water sample 3 / replication 1.
i) ASM-K003B: Well water sample 3 / replication 2.

After obtaining the results from the calibration curve above, the ammonia concentration was then tested using a UV-Vis spectrophotometer. The data from the ammonia concentration test were then compiled and presented in Table 1.

Based on the results obtained, the ammonia concentration at point 1 meets the quality standard, which is less than 0.1 mg/L, as indicated in both the first test (0.045 mg/L) and the second test (0.047 mg/L). This condition occurs because the distance between the well and the septic tank is approximately 13 to 14 meters. However, the distance between the water source and the septic tank does not always have a strong influence on groundwater quality. There are cases where the distance meets the required standards but still exhibits high concentrations due to other factors, in accordance with Regulation No. 3 of 2014 of the Ministry of Health [11] and consistent with the findings [12], as shown in Table 1. In addition, the cemented area around the wellhead of well 1 is wider compared to wells 2 and 3, which is likely to reduce the infiltration of organic materials from nearby gardens.

Meanwhile, at points 2 and 3, the ammonia levels did not meet the quality standards, ranging from 0.191 to 0.224 mg/L. This is due to the poor construction of the wells; for example, the well floors are partially damaged, with a thickness of only 5 cm; the wells are uncovered; and nearby gardens are located approximately 6 and 4 meters from the well sites. These conditions allow pollutants to infiltrate the wells more easily. This finding is consistent with [13], who stated that the potential source of ammonia is nitrogen, a compound that is difficult to oxidise into nitrite and nitrate, resulting from the decomposition of waste by bacteria. As a result, ammonia compounds are carried down by rainfall and seep into shallow groundwater.

Additionally, the distance from pollution sources, such as septic tanks, is approximately 5 meters, and cattle barns owned by residents are located at distances of around 23 and 11 meters. Cattle waste, which is solid, often mixes with urine and gases such as methane and ammonia during disposal [14]. Therefore, the closer the dug wells are to livestock barns, the more likely it is that waste seeps into the soil, leading to a decline in groundwater quality. This result aligns with the findings of [15], who reported that high ammonia concentrations were caused by the proximity of the wells to local livestock farms.

Results of Ammonia (NH_3) Concentration Test Compared to Government Regulation No. 22 of 2021

Based on the obtained ammonia concentration test results, the values were then compared with the water quality standards established in Government Regulation No. 22 of 2021.

Table 2. Comparison of Test Results with Water Quality Standards Based on Water Classes in Government Regulation No. 22 of 2021

Sample ID	NH_3 (mg/L)	Class I 0.1 mg/L	Class II 0.2 mg/L	Class III 0.3 mg/L	Class IV (-)
ASM-K001A	0.045	√			
ASM-K001B	0.047	√			
ASM-K002A	0.224			√	
ASM-K002B	0.224			√	
ASM-K003A	0.192		√		
ASM-K003B	0.191		√		

Explanation of Water Classifications (Based on Government Regulation No. 22 of 2021):

a) Class I: Water used for drinking purposes, meeting the drinking water quality standards.
b) Class II: Water used for water recreation facilities, freshwater aquaculture, livestock, and irrigation.
c) Class III: Water used for freshwater aquaculture, livestock, irrigation, or other uses requiring similar water quality standards.
d) Class IV: Water used primarily for irrigation or other purposes with similar water quality requirements.

Results of Physical Indicator Measurements of Dug Wells in the Field

Table 3. Measurement of Physical Indicators of Dug Wells in the Field at Apit Aiq Hamlet, Batulayar Village

Indicator	Well I	Well II	Well III
Well depth	12 meters	7 meters	10 meters
Well floor			
a. Type of floor	Cement	Cement + soil	Cement
b. Length	146 cm	64.5 cm	122 cm
c. Thickness	17 cm	5 cm	7.5 cm
Height of the well edge	65 cm	75 cm	80 cm
Well cover	None	None	None
Well width/area	145 cm/9,425 cm²	106 cm / 7,950 cm²	151 cm / 12,080 cm²
Distance from potential contamination sources			
a. Septic tank	13 meters	10 meters	4 meters
b. Garden	14 meters	6 meters	11 meters
c. Livestock pen	1.5 meters	23 meters	6 meters
d. Residential house	17 meters	5 meters	6 meters
pH	7	7	4
Temperature	25°C	26°C	27°C

Physical indicators are an important aspect to consider in analysing ammonia levels in dug wells. The results of the physical indicator measurements of the dug wells are presented in Table 3.

The close proximity between dug wells and sources of contamination can lead to water pollution. Distance is one of the key requirements that must be considered in the construction of dug wells, as it can significantly impact the distribution, growth, and breeding patterns of microorganisms. The distance between a dug well and sources of contamination, such as septic tanks, animal pens, waste disposal sites, and others, should be at least 15 meters and at a higher elevation than the source of contamination [16].

The depth of a well is one of the most common and widely used constructions for extracting groundwater by small communities and individual households for drinking and daily needs, with dug wells typically having a depth of around 7–10 meters below the ground surface [17].

Feasibility of Dug Well Water in Apit Aiq Hamlet, Batulayar Village, Batulayar District

Based on the results of the ammonia level analysis obtained, the feasibility of using well water for daily activities can be determined, as shown in Table 4.

Table 4. Feasibility of Dug Well Water Samples in Apit Aiq Hamlet, Batulayar Village

Sample ID	NH_3 (mg/L)	Quality Standard	Description
ASM-K001A	0.045	0.1 mg/L	Suitable
ASM-K001B	0.047		Suitable
ASM-K002A	0.224		Not Suitable
ASM-K002B	0.224		Not Suitable
ASM-K003A	0.192		Not Suitable
ASM-K003B	0.191		Not Suitable

The residents of Apit Aiq Hamlet, Batulayar Village, rely on dug well water to meet their daily needs, including bathing, washing, cooking, drinking, and livestock farming. However, based on the test results and the ammonia concentrations obtained from each sample, it can be concluded that among the three dug wells in Apit Aiq Hamlet, Batulayar Village, Batu Layar District, West Lombok Regency, which were sampled and tested for ammonia levels, only one well is suitable for use and consumption. The other two wells are deemed unsuitable for use and consumption based on Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management, specifically under the category of Class I water, which is defined as water used for drinking purposes in accordance with drinking water quality standards.

Based on the results, which indicate that only one of the three wells is suitable for use, it is highly likely that consuming or using water with high ammonia content may pose health risks, both in the short and long term. Ammonia concentrations of 400–700 mg/L in water can cause short-term or acute effects such as irritation of the respiratory tract, nose, throat, and eyes [18]

Meanwhile, water containing ammonia can still be used and consumed by boiling it first to reduce health risks. Ammonia has a boiling point between 33 °C and 50°C, meaning it evaporates and escapes from water when heated [19]. Ammonia levels in water can be reduced or treated through the application of well water treatment systems, such as filtration processes. These systems aim to remove impurities from the water and improve its quality, ensuring it is free from bacteria and safe in terms of odor and taste [20]. Filtration methods often use sand filters with materials such as silica sand/quartz and zeolite. Additionally, ammonia contamination can also be mitigated using phytobiofilm technology, which employs water hyacinth as a phytotreatment agent [21].

Conclusion

The conclusions from the study on Ammonia Levels in Dug Well Water in Dusun Apit Aiq, Batulayar Village, Batulayar District, West Lombok Regency, West Nusa Tenggara Province are as follows: ammonia concentration in each sample: Sample 1 (Well 1): Ammonia concentration of 0.045 mg/L in the first trial and 0.047 mg/L in the second trial. Sample 2 (Well 2): Ammonia concentration of 0.224 mg/L in both the first and second trials. Sample 3 (Well 3): Ammonia concentration of 0.192 mg/L in the first trial and 0.191 mg/L in the second trial. Based on the test results, Well 1 is suitable for use and consumption, while Wells 2 and 3 are not suitable for consumption but may still be used for daily activities. This conclusion refers to the water quality standards of Class I, II, III, and IV as stated in Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management.

Author's Contribution

U. Hasanah: Contributed to the conceptualization and design of the study, sample collection, sample testing, data analysis, and manuscript writing. D. Yuliansari and Nurhidayatullah: Supervised the entire research process, provided theoretical insights, and reviewed the final draft. All authors have read and approved the final manuscript.

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