



Relationship Between Dug Well Construction and Physical Quality of Clean Water in Kayangan, North Lombok

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Abstract

Dug wells serve as the main household water source for communities in the Kayangan Health Center area of North Lombok, making their structural integrity essential for ensuring safe water access. This study aimed to examine the relationship between dug well construction and the physical quality of clean water. An observational analytic study with a cross-sectional design was conducted from April to June 2024. From a total population of 82 dug wells, 45 wells were selected as study samples using the Slovin formula with a 10% margin of error and simple random sampling to ensure equal selection probability. Well construction characteristics were assessed through direct field observation using a structured checklist based on Indonesian Ministry of Health standards. Physical water quality was evaluated through organoleptic testing of color, odor, and taste in accordance with national clean water regulations. The results showed that 88.9% of dug wells did not meet recommended construction requirements, particularly regarding parapet height, well lining, and watertight flooring. Physical testing indicated that 80% of water samples met quality standards, while 20% failed to meet one or more indicators. Statistical analysis using the Chi-Square test revealed no significant association between well construction and physical water quality ($p = 0.258$). These findings suggest that physical indicators alone may not adequately reflect contamination risks, highlighting the need for comprehensive water quality monitoring that includes microbiological and chemical assessments to ensure groundwater safety.

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INTRODUCTION

Access to clean water remains a fundamental public health requirement, particularly in rural regions that rely heavily on shallow groundwater sources. In many Indonesian communities, dug wells are widely used as household water supply systems due to their affordability and accessibility. However, the safety of dug well water is strongly influenced by construction quality, which determines its vulnerability to contamination from surface runoff, nearby pollution sources, and inadequate environmental sanitation (WHO, 2017).

Previous studies have demonstrated that improper well construction significantly increases the risk of water contamination. Inadequate parapet height, non-watertight well floors, and poorly lined walls have been shown to facilitate the entry of contaminants into shallow groundwater systems (Jagaba et al., 2020; Gnimadi et al., 2024). Furthermore, shallow groundwater aquifers at depths of 5–15 m are particularly susceptible to infiltration from domestic waste, especially

in high-rainfall regions, thereby increasing the likelihood of deterioration in water quality (Chandra, 2022; Ogoko, 2019).

Despite the availability of national regulations and international guidelines emphasizing structural integrity of dug wells, non-compliant well construction remains prevalent in many rural settings. Most existing research has predominantly focused on microbial contamination, waterborne diseases, or general sanitation practices. In contrast, empirical studies that specifically examine the association between structural compliance of dug wells and physical water quality parameters such as color, odor, and taste remain limited, particularly at the district and community health center levels. This gap restricts the availability of practical evidence needed by local authorities to prioritize structural improvements in water supply systems.

Regional environmental indicators further highlight the urgency of this issue. The Water Quality Index (WQI) for West Nusa Tenggara Province consistently classifies North Lombok Regency as having moderate water quality, with a score of 49.44 reported in both 2023 and 2024, indicating the need for immediate intervention. In the working area of the Kayangan Community Health Center, dug wells serve as the primary source of household water, making construction-related risks a critical public health concern.

This study addresses the identified research gap by focusing explicitly on the relationship between dug well construction characteristics and physical water quality parameters, as defined by Indonesian national standards. By emphasizing physical indicators that are directly perceived by users and routinely assessed in field inspections, this study provides context-specific evidence that complements existing microbiological research. Therefore, the present study aims to analyze the relationship between dug well construction and the physical quality of clean water in the working area of the Kayangan Community Health Center, North Lombok Regency. The findings are expected to offer practical guidance for local health offices, environmental health officers, and policy makers in prioritizing well rehabilitation, strengthening community-based water safety management, and improving enforcement of construction standards for rural water supplies.

METHOD

This study employed an observational analytic design with a cross-sectional approach to examine the relationship between dug well construction and the physical quality of clean water in the working area of the Kayangan Community Health Center, North Lombok Regency. The research was conducted from April to June 2024.

The study population consisted of 82 dug wells identified within the study area. The sample size was determined using the Slovin formula with a 10% margin of error, resulting in a total of 45 dug wells selected for analysis. A simple random sampling technique was applied to ensure that each well had an equal probability of being selected. A complete list of dug wells was obtained from local environmental health records, and random selection was conducted using a random number generator to minimize selection bias.

Primary data were collected through direct field observations using a structured checklist adapted from the Indonesian Ministry of Health well construction standards (1998). The checklist assessed key construction components, including well depth, wall lining condition, parapet height, wellhead protection, floor impermeability, and distance from potential sources of contamination such as septic tanks, waste disposal sites, and drainage channels. To ensure content validity, the checklist items were derived directly from nationally recognized technical guidelines and reviewed by environmental health practitioners prior to data collection.

Physical water quality parameters color, odor, and taste were assessed using organoleptic testing methods in accordance with the Indonesian Ministry of Health Regulation No. 32 of 2017. To enhance data reliability, observations and organoleptic assessments were conducted consistently by the same trained field observer using standardized procedures. Repeated observations were performed on a subset of wells to confirm consistency of the assessment results.

Secondary data, including regional water quality reports, sanitation profiles, rainfall information, and environmental health documentation, were obtained from local health offices and relevant literature. These data were used to contextualize the findings and to identify environmental factors that could potentially influence physical water quality.

To control for potential confounding variables, observations were conducted during similar daytime conditions, and wells were assessed under normal usage circumstances. Environmental characteristics such as surrounding land use, proximity to pollution sources, and visible sanitation conditions were recorded descriptively to support interpretation of the results. Data analysis included univariate analysis to describe the distribution of dug well construction characteristics and physical water quality status. Bivariate analysis was performed using the Chi-Square test to examine the association between well construction variables and physical water quality outcomes. A significance level of $p < 0.05$ was applied to determine statistical significance. The overall research procedure is illustrated in Figure 1.

Conceptual Framework

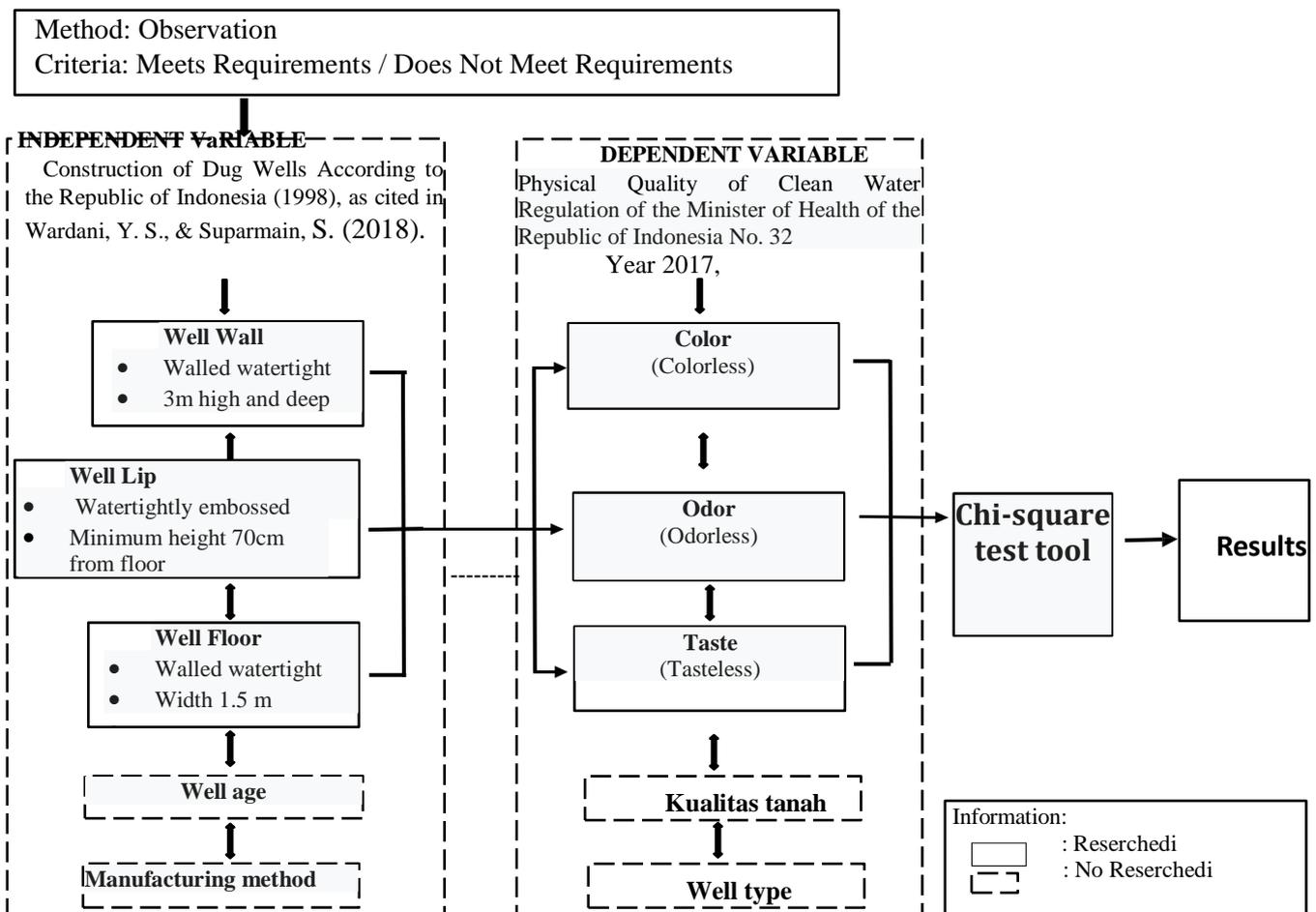


Figure 1. Research Flow of the Study

RESULTS AND DISCUSSION

Dug Well Construction Characteristics

The assessment of 45 dug wells showed that the majority did not comply with recommended construction standards. A total of 40 wells (88.9%) were categorized as non-compliant, while only 5 wells (11.1%) met the required criteria. The most frequently observed deficiencies included insufficient parapet height, non-watertight well flooring, shallow well depth, and inadequate wall lining.

Table 1. Compliance of Dug Well Construction

| Construction Category | Frequency (n) | Percentage (%) |
|-----------------------|---------------|----------------|
| Compliant | 5 | 11.1 |
| Non-compliant | 40 | 88.9 |
| Total | 45 | 100 |

These structural shortcomings have important long-term implications for water safety. Inadequate parapet height reduces protection against surface runoff, allowing rainwater mixed with domestic waste to enter the well. Similarly, non-impermeable flooring facilitates vertical infiltration of contaminants from surrounding soil layers, particularly during the rainy season. Previous studies have demonstrated that such construction defects significantly increase the vulnerability of shallow wells to physical, chemical, and microbiological contamination over time (Jagaba et al., 2020; Gnimadi et al., 2024). The WHO (2017) further emphasizes that the absence of effective structural barriers compromises groundwater protection, even when water appears physically acceptable at the time of sampling.

Physical Water Quality of Dug Wells

The organoleptic assessment indicated that 36 water samples (80.0%) met the physical quality standards, while 9 samples (20.0%) did not meet the requirements. Non-compliant samples exhibited changes in color, odor, or taste, suggesting the presence of suspended solids, organic matter, or dissolved substances originating from surrounding environmental sources.

Table 2. Physical Water Quality of Dug Wells

| Physical Quality Category | Frequency (n) | Percentage (%) |
|---------------------------|---------------|----------------|
| Meets standard | 36 | 80.0 |
| Does not meet standard | 9 | 20.0 |
| Total | 45 | 100 |

Although the majority of samples met physical standards, these results should be interpreted cautiously. Physical parameters are known to be influenced by **external environmental factors**, including land-use patterns, sanitation practices, rainfall intensity, and soil permeability. In areas with similar geological conditions, such as the study location, groundwater may exhibit relatively uniform physical characteristics across wells despite differences in construction quality (Ogoko, 2019). Moreover, agricultural activities, domestic wastewater disposal, and surface drainage systems around wells can introduce organic and inorganic materials that alter water appearance, odor, or taste independently of structural well conditions (Chandra, 2022).

Relationship Between Well Construction and Physical Water Quality

The Chi-Square analysis showed no statistically significant association between dug well construction and physical water quality ($p = 0.258$). Although non-compliant wells were far

more prevalent, their physical water quality did not differ significantly from that of compliant wells.

Several explanations may account for this finding. First, physical water quality indicators (color, odor, taste) have limited sensitivity and may not detect early or low-level contamination, particularly from microbial or chemical sources. Water may appear clear, odorless, and tasteless while still posing health risks, as documented in numerous groundwater studies (WHO, 2017; Jagaba et al., 2020).

Second, external environmental factors may exert a stronger influence on physical water quality than construction characteristics alone. Seasonal rainfall, surface runoff patterns, and homogeneous soil composition across the study area may lead to similar physical water characteristics among wells, regardless of structural condition. High groundwater recharge during the rainy season may also dilute suspended materials, masking the effects of poor construction.

Third, frequent water extraction by households may contribute to continuous groundwater turnover, preventing stagnation and reducing visible changes in physical parameters. This phenomenon can result in acceptable organoleptic characteristics even in wells with substandard construction, as observed in rural groundwater systems with high daily usage rates (Rahmawati et al., 2021).

Table 3. Relationship Between Well Construction and Physical Water Quality

| Construction Category | Meets Standard | Does Not Meet Standard | Total | p-value |
|-----------------------|----------------|------------------------|-----------|---------|
| Compliant | 3 | 2 | 5 | |
| Non-compliant | 33 | 7 | 40 | 0.258 |
| Total | 36 | 9 | 45 | |

This finding echoes the conclusions of Rahmawati et al. (2021), who observed that physical water quality did not always correlate with structural well conditions, particularly in rural areas where similar soil compositions and environmental exposures exist across households.

Scientific Interpretation of Findings

The absence of a statistically significant relationship suggests that well construction alone is not a reliable predictor of physical water quality. This highlights several important implications:

1. Physical parameters alone are insufficient to assess water safety in shallow dug wells.
2. Structural deficiencies may pose latent long-term risks, particularly for microbial and chemical contamination that are not detectable through organoleptic testing.
3. Comprehensive water quality monitoring should integrate microbiological and chemical analyses alongside physical assessments to better capture construction-related contamination pathways.

These findings underscore the importance of strengthening preventive interventions focused on well construction improvement while simultaneously expanding routine water quality surveillance beyond physical indicators.

CONCLUSION

This study found that the majority of dug wells in the working area of the Kayangan Community Health Center did not meet recommended construction standards. Despite this, 80% of water samples still fulfilled the physical quality requirements based on color, odor, and

taste. The statistical analysis revealed no significant relationship between well construction and physical water quality ($p = 0.258$). These findings indicate that physical water parameters are not sensitive enough to reflect the structural condition of wells and may fail to detect early signs of contamination.

RECOMMENDATIONS

- **Strengthening community education on well construction standards.** Community-based education programs should emphasize technical aspects of safe dug well construction, including minimum parapet height (≥ 70 cm), impermeable flooring with proper slope, watertight wall lining, and adequate distance from contamination sources. Practical demonstrations and illustrated technical guidelines can improve compliance and reduce long-term contamination risks.
- **Implementation of comprehensive and sensitive water quality testing.** Periodic water monitoring should not be limited to physical parameters but expanded to include microbiological testing, such as *Escherichia coli* and total coliform analysis using membrane filtration or Most Probable Number (MPN) methods, as well as chemical testing for parameters commonly associated with shallow groundwater contamination, including nitrate, nitrite, iron (Fe), manganese (Mn), and ammonia. These parameters are more sensitive indicators of contamination pathways related to poor well construction and environmental sanitation.
- **Integration of environmental risk assessment methods.** Local health authorities are encouraged to incorporate sanitary risk inspection (SRI) tools and environmental mapping techniques—such as assessment of land use, drainage patterns, and proximity to latrines or agricultural activities—to identify external factors influencing water quality that were not captured through physical assessment alone.
- **Strengthening regulatory enforcement and technical assistance.** Enforcement of national construction standards for newly built wells should be accompanied by technical guidance and rehabilitation support for existing non-compliant wells. Simple corrective measures—such as sealing well floors, increasing parapet height, and improving surface drainage—can substantially reduce contamination risks when properly implemented.
- **Directions for future research.** Future studies should adopt multidimensional water quality assessment designs, integrating physical, microbiological, and chemical analyses with seasonal sampling to capture temporal variations. The use of more sensitive analytical methods will enable better detection of latent contamination risks and provide stronger evidence for policy development and groundwater safety management.

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