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Regional Case Study

The Effect of Pollution Source Distance, Construction, and Behavior of Dug Well Users on Total Coliform Content

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Abstract
Dug well is a water source that is located relatively close to the ground surface so it is prone to pollution. This research aims to analyze the effect pollution source distance, construction and behavior of dug well users on total coliform content in Karangturi Village. Data collection was carried out by examining samples of dug well water in the laboratory, observing and measuring well construction, and using questionnaires to measure the behavior of well users. The research results show that 23 (95.8%) wells have a total coliform >0 MPN/100ml and 1 (4.2%) well have a total coliform content of 0 MPN/100ml. Simultaneously (p value=0.106) the variable distance to the pollutant source and partially (p value= 0.998) each livestock pen and septic tank variable do not have a significant influence on the total coliform content. Simultaneous well construction (p value= 0.489) and partially (p value= 0.999) of each well construction variable did not have a significant effect on the total coliform content. The behavioral variable simultaneously (p value= 0.346) and partially the knowledge variable (p value= 1.000), the attitude variable (p value= 0.999), and the attitude variable (p value= 0.999) did not have a significant effect on the total coliform content.

Keywords: Dug well; total coliform; construction; human behavior

1. Introduction

Water is a natural resource that can be renewed and is dynamic in its nature, form and distribution (Santosan and Adji, 2018). Water resources can create prosperity for the community because of their role in meeting daily household needs ranging from cooking, drinking and bathing (Wahyuni and Junianto, 2017). Human need for water not only meets domestic household needs, but also to meet production needs, the recreation industry, agriculture and other needs (Manik, 2016). The potential for decreasing groundwater quality is increasing along with industrial development and population growth (Adnan and Setiawan, 2021). Head of the Public Health Division of the Karanganyar District Health Office in October 2021, Nuk Suwarni, stated that physically, 19 percent of non-*PDAM* drinking water was found to not meet the requirements for consumption. Meanwhile, chemically, 26 percent of PDAM's non-flow drinking water also does not meet the requirements for consumption. Several sub-district areas in Karanganyar Regency have poor water quality and levels, namely the Jaten, Kebakkramat, Gondangrejo and Colomadu areas.

Dug wells are still widely used by Indonesian people (Dharmayanti et al., 2022). According to Basic Health Research (Riskesdas) 2013, as many as 32.7% of rural residents use protected dug wells (Ministry of Health of the Republic of Indonesia, 2013). Dug wells are easily contaminated with dirt or pollutant substances originating from human, animal waste or domestic household waste that sticks to the ground through soil seepage (Yuliansari, 2019; Sari and Situmorang, 2020). So the distance between the well and the source of pollution needs to be considered because it can affect the quality of the well water which has the potential to cause disease (Tangkilisan et al., 2018). Apart from the distance between the pollutant source and the well, the physical condition or construction of the well such as well walls, well floor and drainage channels as well as the behavior of well users can also influence the quality of water contained in clean water (Malindo et al., 2020 & Diyani et al., 2018).

Contamination of well water with contaminants causes water to contain bacteria, including coliform bacteria (Al Qorni et al., 2022). According to the Republic of Indonesia, Minister of Health Regulation No. 492/MENKES/PER/IV/2010 concerning Drinking Water Quality Requirements, the quality standard for coliform bacteria in drinking water is 0MPN/100 ml. Coliforms include bacteria that can be found in the environment, namely in soil and water, which are affected by surface water as well as human and animal waste (Asrini et al., 2017). The higher the coliform content in water, the higher the presence of other pathogenic bacteria. These bacteria can cause health problems when water sources are used for daily activities (Widyaningsih et al., 2016). Diarrhea is a disease caused by coliform bacteria, and water is the main transmission route for these bacteria (Gruber et al., 2014). Based on data obtained from the Open Data of the Karanganyar Regency Government in the 2021 Karanganyar Regency Health Profile document, in 2020 and 2021, it is known that diarrhea is the first three biggest diseases experienced by residents in Karanganyar Regency, where Gondangrejo District is the area with the target number for finding diarrhea cases. the highest among all regions. Diarrhea sufferers in Gondangrejo District in 2020 amounted to 1,044 people and experienced an increase in the number of sufferers in 2021, namely 2,183 people, of which 1,362 people were toddlers.

Based on preliminary observations carried out in February 2023, Karangturi Village is a village where the majority of the people make their living as farmers and breeders of animals such as cows and goats to meet economic needs. Due to limited land, many livestock pens and other sources of pollution, namely septic tanks, are close to people's homes and dug wells; therefore, there is concern that the distance between the well and the source of pollution will affect the quality of the well water. Most people use water from dug wells for drinking, bathing, washing, toilets, and livestock needs. Globally, there is a decline in the quantity and quality of groundwater available at reasonable prices (Bouderbala et al. 2016). Water scarcity was determined to have its roots in the rapidly growing human population and their everyday activities (Eboh et al., 2017). Not only does improper solid waste management have negative effects on the environment and human health, it also has several ecological effects (Alam et al., 2017). The presence of large concentrations of bacteria in water either due to the impact of human activities or naturally occurring in groundwater is a threat to human life. Therefore, water under these conditions is not suitable for use in daily household life because bacteria-contaminated drinking water can threaten health conditions. Therefore, research on the bacterial quality test of well water needs to be conducted to evaluate water sources to confirm their adherence to water standards for citizen’s well-being. This study aims to analyze the effect of pollution source distance, construction and behavior of dug well users on total coliform Content in Karangturi, Gondangrejo, Karanganyar, Central Java.

2. Methods

Literature review studied from the latest references related to this research. The analysis in this study was carried out using three independent variables that influence the total coliform content of dug well water. The first variable is the distance to the source of pollution, namely the livestock pen and septic tank. The second independent variable is well construction, namely well walls, well floors, and well rims. The third independent variable is well user behaviour which is divided into sub-variables, namely knowledge, attitudes and actions. The three variables are hypothesized to have a significant influence on the total coliform content of dug well water. The statistical test method used to find the effect of distance from pollution sources on coliform content is the logistic regression test, with the following equation (1).

$$g(X) = \ln \left(\frac{\pi(X)}{1-\pi(X)}\right) = \beta_0 + \beta_1 CP + \beta_2 ST \quad (1)$$

The logistic regression test equation (2) to find the effect of dug well construction on the total coliform content of dug well water is as follows.

$$g(X) = \ln\left(\frac{\pi(X)}{1-\pi(X)}\right) = \beta_0 + \beta_1 WF + \beta_2 LW \quad (2)$$

The logistic regression test equation (3) for finding the behaviour of well users regarding the total coliform content of dug well water is as follows.

$$g(X) = \ln\left(\frac{\pi(X)}{1-\pi(X)}\right) = \beta_0 + \beta_1 K + \beta_2 At + \beta_3 Ac \quad (3)$$

Measurements and observations were carried out to determine and identify the distance between pollution sources and well construction in Karangturi Village. Questionnaires were given directly to respondents to determine and measure the level of behavior of dug well users. The number of wells and respondents was obtained by carrying out sample calculations according to Lemeshow (1997). The number of wells and respondents in this study was 24. Testing for the total coliform content of dug well water was carried out in the laboratory. Data on the total coliform content of dug well water will be analyzed based on the Republic of Indonesia Minister of Health Regulation No. 492/MENKES/PER/IV/2010 concerning Drinking Water Quality Requirements. Distance and construction will be analyzed based on SNI 03-2916-1992 concerning Specifications for Dug Wells for Clean Water Sources. The data that has been collected will be tested statistically using the logistic regression test

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3. Results and Discussion

Total coliform bacteria are microorganisms that are often used as biological indicators to determine whether a water or food source is contaminated with pathogens or not (Putri and Kurnia, 2018). Coliform bacteria do not cause serious disease and the presence of coliform bacteria is useful to indicate the potential for the presence of other pathogenic organisms originating from the feces of living creatures (Rahayu et al., 2018). The frequency distribution of total coliform content based on drinking water quality standards can be seen in table 1 below.

Table 1. Frequency distribution of total coliform content based on drinking water quality standards

Number.	Total coliform	Amount (n)	Percentage (%)
1.	0 MPN/100 ml (qualify drinking water quality standards)	1	4.2 %
2.	>0 MPN/100 ml (not qualify drinking water quality standards)	23	95.8%
	Total	24	100%

Based on the results of the total coliform examination test, the results obtained from 24 samples tested, 1 well water sample (4.16%) had a total coliform content of 0 MPN/100 ml (meeting quality standards) and 23 well water samples (95.83%) has a total coliform content > 0 MPN/100 ml (does not meet quality standards). The total coliform content value in the well water samples that have been tested is in the range of 0->2,400 MPN/100 ml. The presence of coliform bacteria found in well water in the Karangturi Village area indicates that the well water cannot be consumed directly. Drinking water that has been boiled until it boils will kill the microorganisms in the water, so that it does not cause disease (Susilawaty et al., 2016). Based on laboratory tests and distance measurements, 24 test results were obtained for the total coliform content of dug well water and the distance to sources of pollution, namely livestock pens and septic tanks with wells, which are shown in the table below

Table 2. Frequency distribution of distance categorization of pollution sources based on quality standards for total coliform content in drinking water

Type of Pollutant Source	Distance from Well to Pollutant Source	Total coliform Content				Total	
		Qualify Drinking Water Quality Standards		Not Qualify Drinking Water Quality Standards			
		n	%	n	%	n	%
Cattle Pen	> 11 meter	1	14.3	6	85.7	7	100
	≤ 11 meter	0	0	17	100	17	100
Septic Tank	> 11 meter	1	16.7	5	83.3	6	100
	≤ 11 meter	0	0	18	100	18	100

Based on table 2, it can be seen that there are 7 dug wells that have a distance of > 11 meters between the well and the livestock pen, of which 1 has a total coliform content that meets drinking water quality standards, and the remaining 6 have a total coliform content that does not meet the standards. drinking water quality. Then, there were 17 dug wells with a distance of ≤ 11 m between the well and the septic tank. All wells with a distance of > 11 m have a total coliform content that does not meet drinking water quality standards, so for wells with a distance of ≤ 11 m between the well and the livestock pen that has a total coliform content that meets drinking water quality standards is 0 wells. The second variable, namely the construction of the well, which was observed and measured in this research, was the walls, floor and rim of the well. The distribution of the results of these observations and measurements is shown in the table below.

Table 3. Frequency distribution of distance categorization of pollution sources based on quality standards for total coliform content in drinking water

Number	Well Construction	Well Construction Conditions	Total coliform Content				Total	
			Qualify Drinking Water Quality Standards		Not Qualify Drinking Water Quality Standards			
			n	%	n	%	n	%
1.	Well Wall	Qualify	1	4.2	23	95.8	24	100
		Not qualify	0	0	0	0	0	0
2.	Well Floor	Qualify (minimum 1 meter and/or waterproof)	1	6.3	15	93.8	16	100
		Not qualify (<1 meter and/or not waterproof)	0	0	8	100	8	100
3.	Lip of The Well	Qualify (minimum height 80 cm and/or waterproof)	1	5.9	16	94.1	17	100
		Not qualify (<80 cmand/or not waterproof)	0	0	7	100	7	100

Based on table 3, it can be seen that there are 24 wells with well wall conditions that meet the requirements, 1 of the dug wells meets drinking water quality standards and the remaining 23 do not meet drinking water quality standards. There are no dug wells with well wall conditions that do not meet the requirements. Then there are 16 dug wells that meet the well floor requirements, of which only 1 dug well meets drinking water quality standards and the remaining 15 do not meet drinking water quality standards. Then, there were 8 dug wells with well floors that did not meet the requirements and total coliform content that did not meet drinking water quality standards. Furthermore, there are 17 dug wells that meet the well lip requirements, of which only 1 dug well meets drinking water quality standards and the remaining 16 do not meet drinking water quality standards. Then there were 7 dug wells with well floors that did not meet the requirements and total coliform content that did not meet drinking water quality standards. Of the 24 wells observed, all had walls that met the requirements; therefore, the well wall variable was not included in the statistical testing of the well walls. The well construction variables tested for their influence on the total coliform content were the floor and rim of the well. Community behavior observed in this research is behavior on the scale of knowledge, attitudes and actions of well users in Karangturi Village. The frequency distribution of well user behavior categorization based on the quality standards for total coliform content of drinking water is shown in the table below.

Table 4. Frequency distribution of well user behaviour categorization based on quality standards for total coliform content of drinking water

Respondent Behavior Category	Total coliform Content						Total		
	Qualify Drinking Water Quality Standards			Not Qualify Drinking Water Quality Standards					
	K	At	Ac	K	At	Ac	K	At	Ac
Good	1	1	1	15	14	4	16	15	5
Enough	0	0	0	5	7	13	5	7	13
Not Good	0	0	0	3	2	6	3	2	6

Note: K; knowledge; At: attitude; Ac: action

Based on Table 4, it can be seen that there are 16 well users with a good level of knowledge, five well users with a sufficient level of knowledge, and three well users with a poor level of knowledge. Based on attitude, there are 15 well users who have a good attitude level, 7 well users with a fair attitude level, and 3 well users with a poor attitude level. Based on actions, there were 5 well users who had a good level of action, 13 well users with a sufficient level of action, and 6 well users with a poor level of action. The results of the analysis using binary logistics show the coefficient of determination, the significance value of the F test and the T test. Simultaneous and partial test values were obtained for the variable distance to the source of pollution, construction, and behavior of well users, namely p value > 0.05, which means that the variable distance to the source of pollution, construction, and behavior of well users did not have a significant influence on the total coliform content.

The results of the absence of a significant effect of the distance between pollutant sources on the total coliform content are in line with research by Diyani et al. (2018) which states that there is no relationship between the distance between feces and the microbiological quality (total coliform) of dug well water. Hasnawi, (2012) states that the construction of dug wells consisting of walls, floors, lips and SPAL does not have a significant effect on bacteria. The results of this research are also not much different from research by Pontoh et al., (2018) which also states that the construction of dug wells does not have a significant relationship with the MPN Coliform content of water in dug wells in West Bitung Village. Good knowledge is not necessarily in line with human behaviour in everyday life (Priawantriputri et al., 2019). Hapsari (2015) also stated that user behavior does not have a significant relationship with well water quality. The results of this research are also in line with research by Diyani et al. (2018) which states that there is no relationship between the behaviour of dug well users and the microbiological quality (coliform) of dug well water.

Table 7. Statistical test results

Variable	Coefficient of Determination	Sig value. (F Test)	Sig value. (T Test)
Type of Pollutant Source			
Cattle Pen	0.583	0.106	0.998
Septic Tank			0.998
Well Construction			
Well Floor	0.198	0.489	0.999
Lip of The Well			0.999
Behavior of Dug Well Users			
Knowledge	0.502	0.282	0.998
Attitude			0.1000
Action			0.998

Microbiological contamination with different results in dug well water at the research location is not caused by the distance to the source of pollution, construction, and behaviour of well users but there are other factors that were not examined in this study. One of the factors that plays a role in the infiltration of pollution into groundwater is the type of soil in Karangturi Village. The soil types in Karangturi Village are the Ultisol order with the Typic hapldults subgroup and the Inceptisol order with the Typic epiaquepts subgroup. The following is a map of the soil types of Karangturi Village.

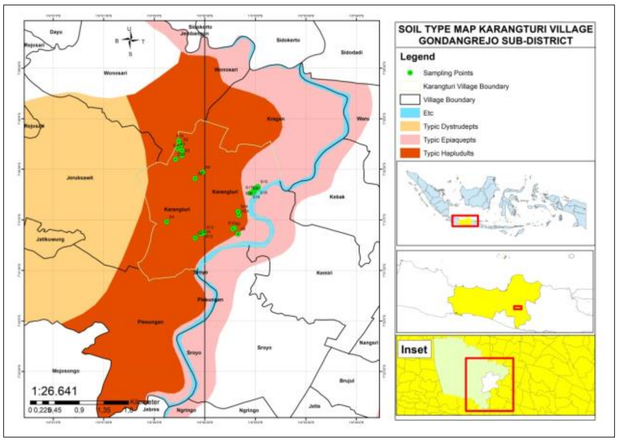

Figure 1. Map of soil types in Karangturi Village

Type hapludults are a subgroup of the Ultisol suborder. The parent material for ultisol is acid tuff, sandstone, and sedimentary material from acid sand. Ultisols in Indonesia generally develop from old parent materials, namely clay rocks (Munir, 1996). Ultisol has physical properties, namely the soil solum has a medium depth of around 1-3 meters, has a red to yellow color, a fine soil texture, and a blocky soil structure. Ultisol has a low (slow) to (good) permeability level (Munir, 1996). The aqupets suborder shows wet characteristics, the soil formation process produces low chroma soil, usually used for agricultural land, forests or nature reserves and is often found in basin areas (Munir, 1996). Typic epiaquepts are a soil subgroup of inceptisols with a soil horizon structure that has changed from the original soil type (Jimoh et al., 2020). Typic epiaquepts have poor drainage and a low color intensity level (2 or less than 2) (Havlin et al., 2013). Groundwater is influenced by the permeability of the soil layer (Fitri and Ayu, 2017). According to Rusydi et al., (2015), soil permeability and soil flow patterns at a location are the reasons for the transport of contaminants from a source of pollution (contaminants) to groundwater. Research conducted by Siregar et al., (2013) from the analysis and measurement of permeability rates in the laboratory and field states that it can be categorized that the permeability rate in Ultisol soil is relatively slow and the permeability rate in Inceptisol soil is moderate. Inceptisol soil has a greater permeability rate than Ultisol soil. The greater permeability rate in Inceptisol soil is caused by the porosity of the soil being greater than that of Ultisol soil. The soil permeability rate value using the laboratory test method is 1.06 cm/hour on Ultisol soil and 3.20 cm/hour on Inceptisol soil.

Well user activities that produce different types of domestic waste can also have an impact on the quality of well water. The higher the level of activity involving many people, the more domestic waste is produced and the greater the negative impact that will be on the quality of groundwater sourced from dug well water belonging to well users (Prabowo, 2016). The age of the well can also be another factor in influencing water quality. Wells that have been used for a long time and the volume of water taken are relatively large, which can cause groundwater flow to concentrate towards the well (Risqita and Anwar, 2017). Wells that are used for a relatively long time are more likely to experience pollution, because apart from increasing sources of pollution, it is also easier for sources of pollution to seep into the well following the flow of groundwater which concentrates towards the well. The depth of the well can also affect the total coliform content in the well water. The depth of the well samples studied in Karangturi Village varied from 15 to 30 meters. The deeper the well, the less the pollution value for water quality or water bacteria content. Pradiko and Yustiani (2019) analyzed the depth of wells and their relationship to the total content of E. coli bacteria, where the results showed that the total content of E. coli bacteria in wells with a high level of depth was lower than in wells with a lower (shallow) depth.

4. Conclusions

The dug well water in Karangturi Village, in terms of bacteriological quality, namely the total coliform content, has been contaminated. Of the 24 total wells, 1 well meets drinking water quality standards and the other 23 wells do not meet drinking water quality standards. The distance between the source of pollution and the dug well, the construction of the well, and the behavior of well users do not have a significant influence on the total coliform content of dug well water. The variable distance between the source of pollution and construction and its potential to influence the total coliform content is indirectly influenced by the type of soil in Karangturi Village, however This research has not identified and looked for a direct influence on the role of soil type on total coliform content. The novelty of this research is the use of a combined variable between livestock pens and septic tanks in influencing the total coliforms in dug well water. However, this study has the limitation that the independent variables, which can actually have mutual influence, have not been studied and modeled empirically in more depth. Other researchers have suggested that further research needs to be conducted to test the effect of soil type on the total coliform content of dug well water.

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