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Research

Relationships between Septic Tank Construction and Number of *Escherichia coli* in Dug Well Water in Rahandouna Village, Kendari, Southeast Sulawesi, Indonesia

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ABSTRACT

Background: Dug wells provide water from soil layer that is close to the surface of the soil, therefore it is susceptible to contamination through seepage from human waste, animals, and for domestic household use. This study aimed to determine the relationships between septic tank construction, dug well distance, and number of *E. coli* in Rahandauna Village, Kendari, Southeast Sulawesi, Indonesia.
Subjects and Method: A cross-sectional study was carried out at Rahandouna Village, Poasia Sub-District, Kendari, Southeast Sulawesi, Indonesia, in July 2019. The sample for this study was 70 units of dug well. The dependent variable was E. coli. The independent variables were septic tank construction and distance of dug well. Acceptable levels of E. coli are measured in Most Probable Number (MPN)/100 ml. The distance of the septic tank to the dug well was measured in meter. The data were analyzed by Chi square.
Results: Good septic tank construction (OR= 0.06; 95% CI= 0.01 to 0.31; p= 0.001) and the distance of the septic tank to the dug well ≥10 m (OR= 0.02; 95% CI= 0.01 to 0.06; p<0.001) decreased number of E. coli <1,000 MPN/100 ml.
Conclusion: Good septic tank construction and the distance of the septic tank to the dug well ≥10 m decrease number of E. coli <1,000 MPN/100 ml.

Keywords: *Escherichia coli*, septic tank construction, dug well

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BACKGROUND

Water is unsafe for human consumption when it is contaminated with pathogenic microorganisms (Mahmud et al., 2019). Waterborne diseases have a negative impact on public health in developing countries with poor quality drinking water (Mwabi et al., 2012).

Water requirements for hygiene and sanitation requirements are efforts to realize healthy drinking water quality from physical, chemical, biological, and social aspects (Cuffney et al., 2000). Water quality is affected by fecal matter, domestic, industrial, and agricultural sewages. The detection of bacterial indicators in drinking water suggests the presence of pathogenic organisms that are sources of waterborne diseases (Nogueira et al., 2003; Yassin et al., 2006). One of these indicator organisms includes Escherichia coli (Mukhopadhyay et al., 2012). World Health Organization (WHO) has developed a classification and color-code scheme for E. coli colonies per 100 mL water sample (Bartram and Pedley, 1996).

Diarrhea is an environmental-based disease that is still a public health problem. Globally, diarrheal disease is still the highest health problem in developing countries with high morbidity and mortality rates (Okhuysen and Dupont, 2010).

Microorganisms that cause diarrhea are transmitted most commonly by the fecal–oral route through water, food and person-to-person transmission (Doğan-Halkman et al., 2003; Sofyang, 2018). Bacteriological quality monitoring is conducted to assure the safety of drinking water for consumers (Geissler et al., 2000; Ellis et al., 2018).

The development of local or individual sanitation systems is regulated in Minister of Health Regulation number 3 year 2014, concerning community-based total sanitation (STBM) on the 5th pillar (securing household wastewater). It is stated that a septic tank is a watertight tub that functions as a reservoir of human waste (feces and urine), a solid part of human waste will be left in the septic tank, while the liquid part will come out of the septic tank and be absorbed through fields or infiltration wells. If it is not possible to absorb it then a filter is made to manage the liquid (Ministry of Health Republic of Indonesia, 2014).

Southeast Sulawesi Province, Indonesia, in 2014 had access to basic sanitation (private or shared facilities with lower structures, including goose necks and septic tanks) of 61.7% of the population of 2,400,000 people (Tasnim et al., 2017; Afifah et al., 2018).

Rahandouna village has a population density of 30,955 people with a total of 3,093 households. The number of households that use clean water sources of local water company (PDAM) is 1,322 heads of households and Non-PDAMs are 1,582 heads of households. About 63.5% of the people who use clean water sources for sanitation hygiene are sourced from dug wells and 36.4% are drilled wells. Soil type in the study area, top soil porosity (34.1%), sub soil (7.69%) and top soil permeability (0.99 cm/hour), sub soil (0.36 cm/hour) with clay texture, and sandy loam. This study aimed to determine the relationships between septic tank construction, dug well distance, and number of *Escherichia coli* in Rahandauna Village, Kendari, Southeast Sulawesi, Indonesia.

SUBJECTS AND METHOD

1. Study Design

This was a cross-sectional study was carried out at Rahandouna Village, Poasia Sub-District, Kendari, Southeast Sulawesi, Indonesia, in July 2019.

2. Population dan Sample

The study population was dug well in Rahandouna village as many as 119 units. A sample of 70 units of dug well was selected for this study by proportional simple random sampling.

3. Study Variables

The dependent variable was E. coli. The independent variables were septic tank construction and distance of dug well.

4. Operational Definition of Variables

Bacteriological quality of *E. coli* in dug well water. Number of E. coli in dug well water. Acceptable levels of E. coli are measured in Most Probable Number (MPN)/100 ml. The measurement scale was continous.

Dug well distance from the septic tank. A measure to state how far the contaminated area (dug well water) is from the pollutant source (septic tank). The distance is limited to a maximum of 10 meters, referring to the maximum pollution pattern of 10 meters. The data were measured by roll meter. The distance of the septic tank to the dug well was measured in meter. The measurement scale was continous.

Septic tank construction. A septic tank is an underground chamber made of concrete, fiberglass, or plastic through which domestic wastewater (sewage) flows for basic treatment. The construction of septic tanks shall be in accordance with the component standard from the Ministry of Health Regulation number 416 year 1990. The data were measured by observation sheet. The measurement scale was continous.

5. Data Analysis

Analysis of the quality of dug well water containing E. coli from estimator tests was carried out based on American Public Health Association (1989) standard methods and Standard Methods for the Examination of Water and Wastewater, 14th edition. American Public Health Association, American Water Works Association, Water Pollution Control Federation, Washington, D.C., 1975 compared to the MPN table (Sun et al., 2018). The table can be used to estimate the number of *E. coli* bacteria in 100 ml of water samples. The reading of the test results is seen from the number of test tubes that produce gas and acid (3 series first, second and third), the positive results of acid and gas compared to the MPN table. Data from dug well water samples were analyzed in the Laboratory of Analyst, Study Program of Diploma 4 Health Analyst, School of Health Sciences Mandala Waluya, Kendari, Indonesia, then compared with Ministry of Health Regulation number 416 year 1990 about the requirements and supervision of clean water quality. The associations between septic tank construction, dug well distance, and number of *Escherichia coli* were analyzed by Chi square.

6. Research Ethic

The study was approved by the Research and Development Agency No. 070/2331/ BALITBANG/2019.

RESULTS

A. Univariate analysis

70 units of dug well sumur (100%) had microbiological quality above the quality standards (≥0/100 ml water samples) by the Ministry of Health Republic of Indonesia number 416 year 1990 (categorized as not eligible).

Observation results of septic tank construction illustrated 100% of septic tank units are channeled with pipes from latrines or latrines, no septic tanks had inspection holes, 71.43% units had waterproof walls, 71.43% units had waterproof upper floor, and no carried out maintenance and centralized processing (communal).

B. Bivariate analysis

Table 1 showed the relationship of septic tank construction and number of E. coli in dug well water samples. Table 1 showed that good septic tank construction (OR= 0.06; 95% CI= 0.01 to 0.31; p= 0.001) decreased number of E. coli <1,000 MPN/100 ml.

Table 1. The relationship of septic tank construction and number of E. coli in dug well water samples

Septic tank construction	E. coli (MPN/100 ml)				OR	95% CI		p
	<1,000		≥1,000			Lower limit	Upper limit	
	n	%	n	%				
Poor	20	41.7	28	58.3	0.06	0.01	0.31	0.001
Good	22	91.7	2	8.3				

Table 2. The relationship of dug well distance from septic tank and number of E. coli in dug well water samples

Distance	E. coli (MPN/ 100 ml)				OR	95% CI		p
	<1,000		≥1,000			Lower limit	Upper limit	
	n	%	n	%				
<10 meter	6	17.6	28	82.4	0.02	0.01	0.06	<0.001
≥10 meter	36	94.7	2	5.3				

Table 2 showed the relationship of dug well distance from septic tank construction and number of E. coli in dug well water samples. Table 2 showed that the dug well distance from septic tank ≥10 m (OR= 0.02; 95% CI= 0.01 to 0.06; p <0.001) decreased number of E. coli <1,000 MPN/ 100 ml.

DISCUSSION

1. The relationship of septic tank construction and number of E. coli in dug well water samples

Public health protection requires an indicator of fecal pollution. In the 1890s, *E. coli* were chosen as the biological indicator of water treatment safety (Edberg et al., 2000; McLarnan and Sarah, 2017).

The results of this study showed that good septic tank construction decreased number of *E. coli* <1,000 MPN/100 ml. The high population density in Rahandouna Village caused clean water availability problems. Most residents get access to clean water from dug wells. The challenge in using dug well water in Rahandouna Village is its location which is close to the septic tank. The community uses water from dug wells to wash clothes, bathe, wash food, wash vehicles, and drink and cooking water needs, resulting in a relatively large volume of dug well water taken. This causes the groundwater to work extra to fill the empty space. Generally the community builds dug wells near or around the houses of residents, especially with limited land, forced to dug wells in the house. Water from a dug well that is located close to a pollutant source will cause health problems (Okotto et al., 2015; Ananth et al., 2018; Schram and Wampler, 2018).

The absence of technical handling from the government in implementing a good septic tank wastewater management system in Rahandouna village. The community still chooses a conventional or local system (on site system) to do household waste management (Jouhara et al., 2017; Abdel-Shafya and Mansourb, 2018).

The use of feces shelters for local systems that are not in accordance with the rules has the potential to pollute the surrounding groundwater. Seepage of wastewater from feces storage that is not processed properly will slowly penetrate the flow of underground water (aquifer) and this is where the process of water pollution (Ananth et al., 2018).

Septic systems are designed to hold, treat, and dispose household wastewater on site. Household or wastewater treatment by the traditional in site safe decomposed in common sense system such as septic tank/ soil absorption designs may be not feasible in some places because of soil type, adverse topography and or inadequate availability of suitable land area. Because many septic tank systems throughout the world are not functioning properly, various laws need to prevent the serious environmental and human health (Kamel and Hgazy, 2006).

Bacteriological analysis shows the high level of microbiological pollution of total coliform and faecal coliform-E. coli organisms is an indicator that the water is contaminated by human feces from septic tanks and is at risk of contamination by diseases that cause pathogens (Davis et al., 2009; Antony and Renuga 2012).

2. The relationship of dug well distance from septic tank and number of E. coli in dug well water samples

The results of this study showed that distance from septic tank decreased number of *E. coli* <1,000 MPN/100 ml. The presence of *E. coli* in dug well water is probably caused by seepage from septic tank or other anthropogenic wastewater such as the presence of livestock manure in the dug well facility. The observation also revealed that there were several pollutant sources around the dug wells, such as septic tanks, cattle pens, and cattle dung. The average measurement of distance dug wells from septic tanks was 10 m (Mean= 10.1; SD= 1.94). The nearest distance from the dug well to the septic tank was 4.45 m and the farthest distance was 14.07 m. Based on the results of laboratory analysis, it was found the presence of E. coli in all dug well water samples.

Wells must be located a safe distance from potential sources of contamination at least 14.07 meters. Microbiological contamination at a maximum distance (14.07 meters) may be caused by the condition of the area in the study area (Ministry of Health Regulation number 416 year 1990).

Rahandouna village is a pond, swampy area, and has a soil structure that is easily seeped when it rains. Compounded by the construction of the septic tank is not waterproof and gap in the cracked wall. Bacteria contained in wastewater by infiltration process can reach ground water and well water. The infiltration process is influenced by gravity and capillary forces. Gravitational force is to flow water vertically into the soil through the soil profile while the capillary force is to flow water perpendicularly up, down, and in the horizontal direction (lateral). The farther away the source of pollutants, the journey of wastewater that contains bacteria has a lot of filtering by soil constituent material, and vice versa (Wen et al., 2016; Kafle et al., 2018).

The soil which has sandy and rocky permeability is quite high so that the potential for pollution caused by the absorption of conventional septic tanks is also higher. Soil structure can be said to be good if it has good pore space, ie there are pores in and between aggregates that can be filled with water and air (Soeparman, 2002). Based on the results of soil tests in Rahandouna village conducted in the Soil Science Laboratory, Faculty of Agriculture, University of Haluoleo, the porosity of the top soil was 34.1% and the sub soil was 7.69%, while the permeability value of the first top soil was obtained 0.99 cm/hour and the sub soil was 0.36 cm/hour. According to the Soil Research Institute the factors that influence porosity are grain size or the size of the cavity that will form smaller and vice versa. Land in Rahandouna village has very slow permeability, but due to the long disposal of septic tank waste, contaminants have reached ground water. The condition of the distance of dug wells and sources of pollutants is also influenced by soil contour and topography in the Rahandouna village. This results in human waste from the impermeable septic tank easily absorbing with rain water and entering the well through its seepage.

AUTHOR CONTRIBUTION

Bromo Kusumo Achmad as the main contributor was responsible for the formulation of the problem, research objectives, data collection, and writing the script. Sunarsih and Erwin Azizi Jayadipraja, designed and developed the concept of the methodology. Muhammad Abdul Gafur Tirtayasa Mangidi, prepared laboratory examination tools and materials, conducted laboratory analysis, and conducted data analysis.

CONFLICT OF INTEREST

We declare that there was no conflict of interest.

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