Analysis of E. coli contamination in groundwater during the dry season

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Abstract. Changes in seasons or the occurrence of rain are factors that affect groundwater quality, especially in areas with low Drinking Water Distribution Companya coverage. The purpose of this study was to analyze the quality of groundwater during the dry season in three urban villages in Bekasi City, and the factors that influence it. Comparison of the values of pH, TDS, E. coli, and Total Coliform with clean water quality standards and descriptive statistical analysis was carried out to compare the level of risk of E. coli contamination, namely low-very high risk. Based on the results of the study, it was found that the concentration of E.coli and Total Coliform did not meet the quality standards of clean water and it was known that the risk of E.coli contamination was very high in Sumur Batu was 56%, Jatirangga 38%, and Jatiluhur 52%. Spearman rank statistical method was used to determine the factors that influence and obtained a very weak relationship on the occurrence of rain 7 days before sampling and the distance of wells and septic tanks to the concentration of E.coli in the dry season.

1 Introduction

Bekasi City is a metropolitan city with a population of 2,542,676 people in 2020 [1]. However, people who get drinking water distribution services are only 40% of the total population [2]. The service of clean water sources is still low, causing people to use groundwater as a source of clean water and drinking water. The use of wells can reduce the quality of groundwater. In addition, dug wells are constructions that already have bacteriological contamination that is easily contaminated, due to seepage originating from animal, human, and another household waste [3]. Based on research conducted by [3], there is an effect of season on the concentration of E. coli. In the research, it is known that the concentration of E. coli is higher in the rainy season, compared to the dry season. This study aims to check the quality of clean water in three urban villages in Bekasi City, namely Jatirangga, Jatiluhur, and Sumur Batu Villages. The parameters used are pH, Total Dissolved Solid (TDS), Total Coliform, and E. coli. In addition, analyzing influencing factors, such as the type of well, the distance between the septic tank and the well, and the event of rain. This study also analyzes the effect of seasonal variations on E. coli concentrations, using data from

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the rainy season in [4], and provides a treatment strategy to reduce E. coli concentrations in groundwater.

2 Methodology

2.1 Data collection

2.1.1 Rainfall data

In this study, there is a procedure for collecting rainfall data at every point in the village. In its implementation, it takes a funnel with a diameter of 5 cm which is placed on the top of the measuring cup. Next, the measuring cup is glued to the pole in an open area using adhesive. Rainfall checks are carried out every day, by noting the volume listed on the measuring cup. The measuring cup is emptied again, and glued as before, for further checking. Rainfall measurements are carried out every day during the process of taking groundwater sample data

2.1.2 Groundwater and drinking water

The research was conducted in the dry season (21 September – 14 October 2021) and used the Issac and Michael method to determine the number of samples points. The formula used is as follows:

$$N = \frac{64.813\ x\ 346}{75.000} \approx 300\ sampels$$

Sampling was carried out only on 251 houses, due to limited licensing and other reasons. The sample was taken as much as 100 mL from the faucet directly by the residents, and put into the whirl pack. Next, the whirl pack is tied and labeled. Next, the whirl pack is put into a cooler bag containing an ice pack, with a temperature of 4^{o}C

Samples were tested in the laboratory using a pH meter, and a TDS meter for pH and TDS parameters. E. coli and total coliform were tested using Quanti Tray. The first step is testing the biological parameters, by opening the wirl pack adhesive. Then, the sample water was added with IDEXX Colilert-18 reagent, and homogenized. The sample that has been mixed will be poured into the Quanti Tray. The quantity tray is placed into a rubber insert and inserted into the quantity tray sealer. the next step, the Quanti Tray was incubated for 18 hours at a temperature of 35 ± 0.5 °C, 44.5 ± 0.2 °C. the last step, reading the results of the quantitative tray using a UV lamp, by counting the number of yellow walls to determine the amount of E. coli and total coliform.

2.2 Data analysis

The data analysis used to check the quality of ground water and drinking water is a descriptive analysis type, by comparing it to quality standards. Meanwhile, the Spearman Rank test method and Generalized Linear Model were used to determine the factors related to the E. coli concentrations.

3 Results and discussion

3.1 Drinking water quality and clean water

Checking the quality of clean water is guided by Permenkes 32/2017 regarding clean water quality standards. To check the quality of drinking water, it is guided by Permenkes 492/2010.

Table 1. Drinking and clean water quality.

Parameters	Unit	*Range*		*Mean ± Std.Deviasi*		*Median*		Permenkes 32/2017	Permenkes 492/2010
		Clean Water	Drinking Water	Clean Water	Drinking Water	Clean Water	Drinking Water	Clean Water	Drinking Water
pH		4-8.3 (82%)	5.4 – 8.6 (51%)	5.9 ± 0.9	7 ± 0.9	5.9	6.9	6.5 – 8.5	6.5 – 8.5
Total Colifom	MPN/ 100 ml	0.5-2,420 (61%)	0.5 – 2,420 (100%)	775.9 ± 1,015.5	805.4 ± 974.8	135.5	307.6	50.0	0
E. coli	MPN/ 100 ml	0.5-2,420 (100%	0.5 – 547.5 (100%)	158.1 ± 509.1	10.56 ± 58,546	1	0.5	0	0
***Total Dissolved Solid* (TDS)**	Mg/l	19.0-558.0 (0%)	6.0 – 342.0 (0%)	155.0 ± 97.8	112.0 ± 71.0	133.5	108.0	1,000.0	500.0

Parameters that do not meet quality standards are biological parameters. The average concentration of E. coli in clean water was 158.1 MPN/100 mL, and 10.56 MPN/100 mL in drinking water. The last parameter that did not meet the standard was Total coliform, with an average of 755.9 MPN/100 mL in clean water and 805.4 MPN/100 mL in drinking water. The high contamination of groundwater can come from poor sanitation infrastructure and the cleanliness of the environment around the well. Meanwhile, in drinking water, contamination can occur due to poor cleanliness of the container, and the process of cooking water that is not optimal [5].

3.2 The risk level of E. coli contamination

In Figure 1, it is known that the three villages have a very high risk of contamination of e. coli by 52% in the dry season. In the rainy season, only 21% E. coli >100 MPN/100 mL with a very high risk. The quite high change in the percentage level of risk of E. coli contamination in the two seasons can be caused by several factors, such as rainfall, and contaminants around the sampling location. Meanwhile, Sumur Batu Village has 56% E. coli concentrations >100 MPN/100 mL with a very high-risk level in the dry season, and 22% in Jatiluhur Village. The location close to landfill can be one of the causes of the very high-risk percentage in Sumur Batu Village.

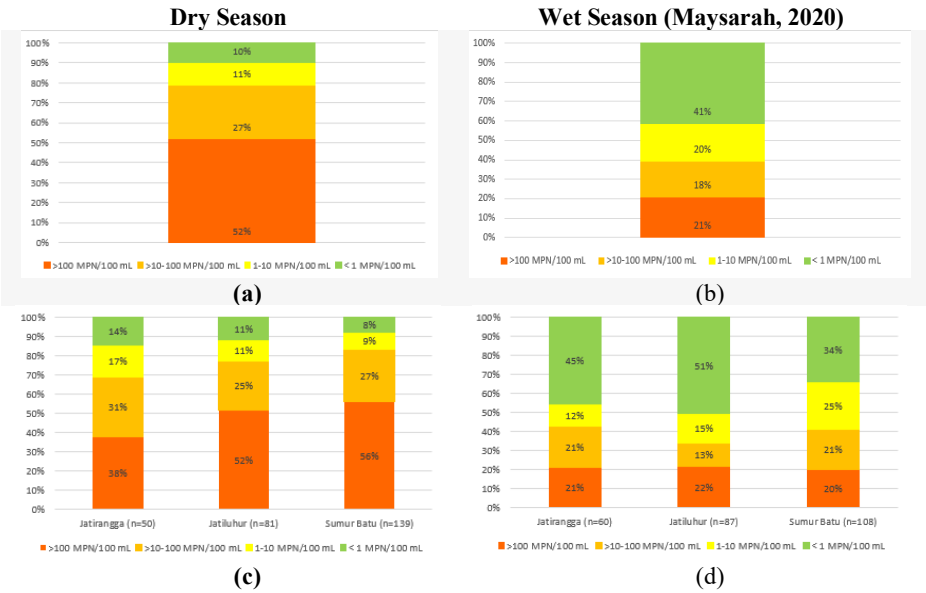

Fig. 1. (a) The risk level of E. coli contamination in 3 villages in the dry season, (b) The risk level of E. coli contamination in 3 villages in the rainy season, (c) The risk level of E. coli contamination per village in the dry season, (d) The risk level of E. coli contamination per village in the rainy season.

3.3 Rainfall intensity

The intensity of rainfall that was obtained during the research was 11.9 mm/day. Jatirangga village has an average rain intensity of 22 mm/day, Jatiluhur is 6.7 mm/day, and Sumur Batu is 6.9 mm/day. This rainfall data is used as material for analyzing the effect of rainfall on E. coli in the rainy and dry seasons (Fig. 2).

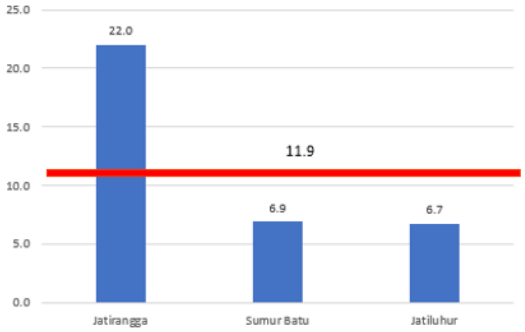

Fig. 2. Rainfall intensity (mm/ day).

3.4 Factor affecting E. coli concentration in groundwater

Testing of the factors that affect the concentration of E. coli in groundwater was carried out using two statistical methods, namely Spearman Rank and Generalized Linear Model. The control variables consisted of the distance between the well and the septic tank (<5 m, 5-10 m, 11-15 m, and >15 m), the incidence of rain based on the questionnaire and the field (1 day, 2 days, and 7 days) before sampling. The following are the results of the spearman rank method data processing:

Table 2. Correlation of E. coli and factors affecting groundwater.

Factor affecting	≥1 MPN/100ml		>10 MPN/100ml		>100 MPN/100ml	
	Correlation Coef	Sig	Correlation Coef	Sig	Correlation Coef	Sig
Distance between Septic Tank and Well (n=169)	0.152	0.034*	-0.196	0.009*	-0.028	0.692
Rain Event 1 Day Before Sampling (questionnaire) (n=251)	0.088	0.165	-0.010	0.877	0.104	0.100
Rain Event 2 Days Before Sampling (questionnaire) (n=251)	-0.064	0.313	0.068	0.285	-0.004	0.948
Rain Event 7 Day Before Sampling (questionnaire) (n=251)	-0.045	0.484	-0.049	0.442	-0.122	0.054
Rain Event 1 Day Before Sampling (Field) (n=169)	0.016	0.749	-0.006	0.910	0.023	0.632
Rain Event 2 Day Before Sampling (Field) (n=169)	-0.065	0.185	0.019	0.705	-0.005	0.914
Rain Event 7 Day Before Sampling (Field) (n=101)	0.018	0.756	-0.120	0.039*	0.059	0.309

In Table 2 there is a variable distance between the septic tank and the well, as well as the occurrence of rain 7 days before sampling which has a very low correlation with the concentration of E. coli. Next, Generalized Linear Model (GLM) data processing was carried out to determine the level of factors that affect E. coli based on the results of processing the rank spearman method.

Tabel 3. Generalized linear model data processing results.

Parameters	≥1 MPN/100 mL		>10 MPN/100 mL		>100 MPN/100 mL	
	OR	**p-value**	**OR**	**p-value**	**OR**	**p-value**
Distance between Well and Septic Tank (Ref: >15 meters)						
<5 meters	0,12	0,08	2,22	0,37	1,50	0,65
5-10 meters	0,79	0,74	1,183	0,84	0,75	0,73
11-15 meters	1,13	0,88	0,24	0,18	0,95	0,95
Rain Events Before Sampling (Questionnaire) (Ref: Rain)						
7 days						
Not raining	0,91	0,76	2,32	**0,04***	0,68	0,31

*: has a significant correlation at the level of 0.05

In Table 3, it is known that the distance between the well and the septic tank does not have a significant relationship with the concentration of E. coli. The different results of data processing using Spearman's rank can be due to a very weak relationship between the dependent variable and the control variable. The occurrence of rain 7 days before sampling also had a significant effect on the concentration of E. coli in the >10 MPN/100 mL category, which was indicated by a p-value of 0.04 < 0.05. The OR value for this variable is 2.32, which means that the absence of rain for 7 days before sampling has an effect on the concentration of E. coli in groundwater by 2.32, which is greater than when it rains. The high

concentration of E. coli when there is minimal rain can be caused by the high temperature which makes E. coli more survive and grow [6]. However, this is different from the results of research conducted by [7], which said that even the concentration of E. coli was found to decrease during the dry season.

4 Conclusions

(1) The TDS and pH parameters meet the quality standards for clean water and drinking water, with an average pH of 5.9 for clean water and 7 for drinking water. The average TDS concentration is 155 Mg/l in clean water and 112 Mg/l in drinking water. (2) A total of 52% of ground water in the three villages is contaminated with E. coli at a very high risk level. Sumur Batu is a village with an E coli risk level as high as 56% E. coli >100 MPN/100 mL. (3) There was no rain before sampling, it had an effect of 2.32 times greater than when it rained.

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