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Exploring The Correlation Between Well Construction Techniques and Well Water Quality in Simbang Kulon Village

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Abstract

Simbang Kulon Sub-District, one of the biggest batik producers in Pekalongan Regency produces a large amount of liquid waste contaminating rivers and potentially contaminating dug wells around rivers. Batik liquid waste generated from the coloring process and disposed of directly into the river without going through the processing process makes the Simbang Kulon River change its color to black. This study aimed to determine the relationship between the construction o dug wells and the distance to the Simbang Kulon River on the quality of well water in Simbang Kulon Village.

This research is observational with a quantitative method and a cross-sectiona study design. A sampling of Simbang Kulon River water was 1 sample, while dug well water sampling was 12 samples based on 6 levels of distance from the wes and east of the Simbang Kulon River. Sampling was carried out during the dry season from April to May. Data were obtained by interviews, observations measurements of the physical condition of dug wells and measurements of the laboratory's river and well water samples, and calculation of the Pollution Index (IP). Data were analyzed using SPSS with Spearman's Rank test to see whether there was a relationship between variables.

The results showed that the concentrations of temperature, BOD, COD, and tota ammonia in the Simbang Kulon River water exceeded the quality standards set by the Pollution Index (PI) calculation results obtained at 6 and were in the moderately polluted category. While the risk of contamination in the 5 dug wells showed a yield of 54.54% which was in the high category.

The conclusion of this study is that there is a significant relationship between the height of the well's lip and the concentration of TSS. However, there is no significant relationship between the height of the well wall and the width of the well floor, as well as the potential risk of contamination and distance wells from the Simbang Kulon River on concentrations of TSS, BOD, COD, and total ammonia. Suggestions for Simbang Kulon Village and related agencies to immediately operate the Simbang Kulon WWTP so that batik craftsmen do not dispose of batik liquid waste in the river.

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Introduction

The Pekalongan area, which is divided into Pekalongan City and Pekalongan Regency, is an area with superior potential in the batik industry sector, both small and medium scale industries, apart from Yogyakarta, Solo, Madura, and Cirebon (Sutrisno et al., 2018). The existence of a batik industry center with rapid development in Pekalongan Regency not only helps the local community's economy but also has a negative impact in the form of liquid waste from batik production which can pollute the surrounding environment.

The batik industry produces pollutant materials such as organic materials, non-organic materials, and heavy metals which are produced from the entire production process (Indrayani, Lilin ; Rahmah, 2018). The resulting batik waste can come from the use of chemicals in the batik coloring process. The batik waste contains high dyestuffs and synthetic materials which are difficult to dissolve or difficult to decompose so it can pollute the environment both in terms of physical and chemical parameters (Kiswanto et al., 2019). Simbang Kulon Village, Buaran District, Pekalongan Regency is one of the largest batik-producing villages in Pekalongan Regency. The Simbang Kulon Village has a large population with the majority of the people making a living as batik craftsmen with batik produced including written batik, stamped batik, and screen printing or printing batik. However, the existence of the Simbang Kulon WWTP which has not yet been operational has made the batik craftsmen immediately dispose of the batik liquid waste into the ditch which is the drain for household waste that flows into the river. The results of the research related to the analysis of the impact of batik waste on the Simbang Kulon River showed that the Simbang Kulon River was polluted from the DO parameters of 1,62 mg/L – 4,32 mg/L and the pH ranged from 6,70 – 6,94, while the temperature parameters are still within safe limits (Zammi et al., 2018). The impact of disposing of batik liquid waste in ditches or rivers can change the color of the water from red to black and can affect the quality of groundwater for the people living around the stream.

Central Java Provincial Regulation No. 5 of 2012 concerning Wastewater Quality Standards has regulated the levels and quantities of batik waste contaminants that will be discharged into the environment including TSS, BOD, COD, and total ammonia (NH3-N). The maximum levels allowed for these parameters are TSS of 50 mg/L, BOD of 60 ml/L, COD of 150 mg/L, and total ammonia (NH3-N) of 8.0 mg/L (Peraturan Daerah Provinsi Jawa Nomor 5 Tahun 2012 Tengah Tentang Baku Mutu Air Limbah, 2012). The existence of these polluted materials in the environment that exceed quality standards can disrupt aquatic ecosystems (Indrayani, Lilin ; Rahmah, 2018). The results of laboratory tests on Simbang Kulon river water which were carried out as an initial research survey in August 2022 showed results that the levels of TSS, BOD, and COD had exceeded the specified quality standards with successive results of 70 mg/L, 200 mg/L, and 450 mg/L, while the total ammonia content (NH3-N) still meets the established quality standard of 5,9 mg/L. In addition, the pH level of the Simbang Kulon river water showed the same results as research conducted by Muhammad Zami, et al (2018), namely 6,70 with a water temperature of 28°C which is still within safe limits.

Most of the people of Simbang Kulon still use clean water sources in the form of dug wells and PDAM. "PDAM" is a regional company that provides and distributes clean water to the community. Data obtained based on an initial survey conducted in April - May 2022 related to observations of the quality of well water and the physical condition of the wells around the river where batik waste is disposed of in 7 dug wells, 2 wells were found to have cloudy and slightly smelly water, 2 wells had black and smelly water conditions, and 3 other wells in clear condition. From the results of interviews, the condition of well water can change in terms of color, taste, and smell depending on the condition of the wastewater in the river. The physical condition of dug wells must also meet several requirements related to the height of the well wall, the height of the well lip, the condition of the floor, and the distance of the well from pollutant sources following regulations determined by the Ministry of Health of the Republic of Indonesia in 2005 (Rizza, 2013). The risk of contamination of clean water sources can be caused by the construction of dug wells that are not suitable and the location of wells that are built close to pollutant sources (Rizza, 2013).

The results of research conducted by Rafikhul Rizza (2013) showed that there were 34.78% of dug wells containing levels of nitrite exceeding the quality standard around the river in the area of batik waste disposal in Podosugih Village, West Pekalongan District, Pekalongan City (Rizza, 2013). A similar study conducted by Kharisma Izzatunnisa, et al (2018) showed that there was no effect of Cr (VI) levels in river water and the distance between dug wells and rivers on CR (VI) levels in dug well water (Izzatunnisa et al., 2019).

Based on the background of the problems that have been described, this study aims to determine the relationship between the construction of dug wells and the distance from the Sambang Kulon river with the concentrations of TSS, BOD, COD and total ammonia on the quality of well water in the Simbang Kulon Village community.

Methods

This research is a type of observational research with quantitative methods using a cross sectional design. The population of this study was divided into the population of the Simbang Kulon River which stretches along the Simbang Kulon Village and the population of wells taken based on the distance of the dug wells from the Simbang Kulon River with 6 levels of distance covering distances of 90 m, 100 m, 120 m, 150 m, 180 m, and 210 m in the west and east of the Simbang Kulon River where each distance is only taken 1 well, so that the total sample of dug wells is 12 samples.

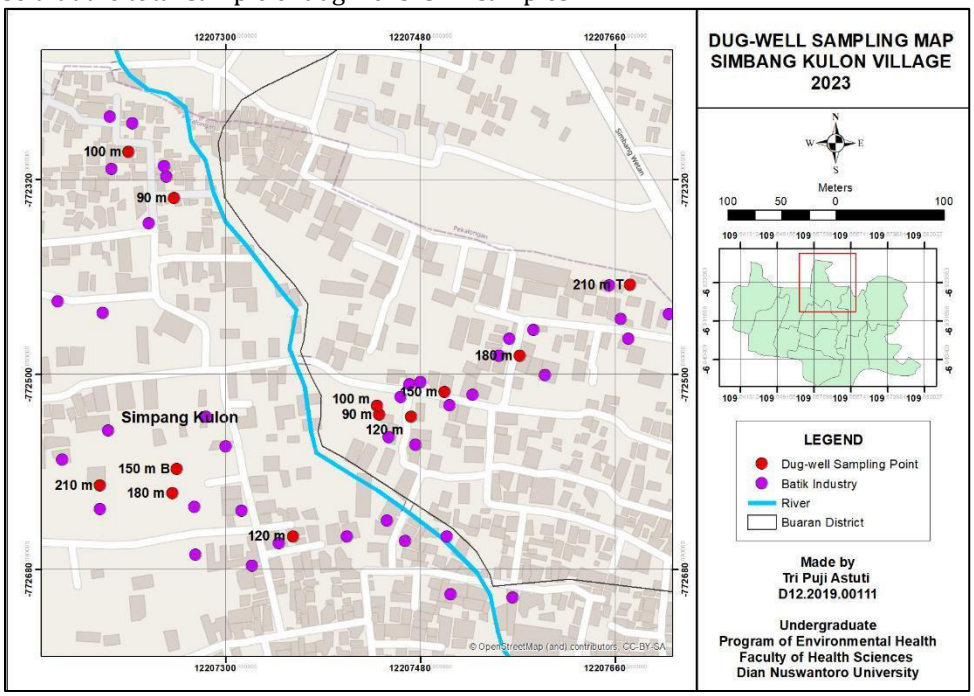

Figure 1. Dug well sampling point scheme

The independent variable studied was the distance of the dug well to the Simbang Kulon River and the physical condition of the dug well, while the dependent variable was the quality of the dug well water based on the parameters TSS, BOD, COD, and total ammonia. Data collection techniques were carried out through interviews and observations using questionnaires to obtain data on the physical condition of dug well water and the physical condition of dug wells. Samples of river water and water from dug wells were subjected to laboratory analysis to determine concentrations of TSS, BOD, COD, and total ammonia. The results of the laboratory analysis are used to calculate the pollution index (PI). The use of the Pollution Index (PI) method is based on the Decree of the Minister of Environment Number 115 of 2003 Appendix II concerning the Determination of Water Quality Status, where the calculation of river pollution levels can use the formula:

$$PI_j = \sqrt{\frac{(C_i/L_{ij})_M^2 + (C_i/L_{ij})_R^2}{2}}$$

Figure 2. Pollution Index Formula (PI)

The Pollution Index (PI) value is determined from the calculation of the maximum value and average value of the levels of each parameter against the quality standard. The results of the IP value will be adjusted according to the index class category which is divided into 4, among others: (Keputusan Menteri Negara Lingkungan Hidup, 2003).

Score $0 \le PIj \le 1{,}0$ = good
Score $1{,}0 < PIj \le 5{,}0$ = slightly polluted
Score $5{,}0 < PIj \le 10$ = fairly polluted
Score $PIj > 10$ = heavily polluted

The assessment of dug wells was calculated to determine the pollution risk score. Observation data on the physical quality of water and assessment of dug wells based on questionnaires according to RI Minister of

Health No. 736 of 2010 concerning Procedures for Monitoring the Quality of Drinking Water is attached, the contamination risk score is calculated using the formula:

$$\frac{Total\ of\ yes\ answer}{\text{Total Score}}\ x\ 100\%$$

Figure 3. Contamination Risk Score Calculation Formula

The calculation results in Figure 3 will be categorized into 4, including:

<25% = low risk
25% - 50% = moderate risk
51% - 75% = high risk
>75% = very high risk

Bivariate analysis of the study used the Spearman Rank correlation test to see the relationship between the distance of the well from the Simbang Kulon River and the construction of dug wells on the concentrations of TSS, BOD, COD, and total ammonia.

Results

Water Quality of the Simbang Kulon River

The results of laboratory tests carried out at the Environmental Laboratory of the Pekalongan City Environment Service on the Simbang Kulon River water compared to the river water quality standards according to Government Regulation Number 82 of 2001 for class II water quality standards can be seen in table 1 with the obtained water pollution index calculation results Simbang Kulon River in table 2.

Table 1.
Results of Water Testing of the Simbang Kulon River

Parameter	Units	Test Result	Class II Quality Standard
Temperature	°C	31	22°C – 28°C
pH		7,82	6 – 9
TSS	mg/L	40	50
BOD	mg/L	60	3
COD	mg/L	70	25
NH3 As N (Total Ammonia)	mg/L	4	0,2

Table 2.
Results of Calculation of Water Pollution Index of Simbang Kulon River

Parameter	Units	Ci	Lix	Ci/Lix	New Ci/Lix
Temperature	°C	31	22°C – 28°C	2	2
pH	-	7,82	6 – 9	0,2133	0,2133
TSS	mg/L	40	50	0,8	0,8
BOD	mg/L	60	3	20	7,5051
COD	mg/L	70	25	2,8	3,2357
NH3 As N (Total Ammonia)	mg/L	4	0,2	20	7,5051
		Total			21,2592
		Average			3,5432
		Maximum			7,5051
		PIj			6
		Category			Fairly Polluted

Laboratory test results from table 1 show that the parameters of temperature, BOD, COD, and total ammonia have concentrations that have exceeded the established quality standards. Meanwhile, based on the results of the Pollution Index (PI) calculation in table 2, it also shows that the water quality status of the Simbang Kulon river is in the fairly polluted category.

Water Quality of Simbang Kulon Dug Well

Based on the results of laboratory tests on water from the Simbang Kulon dug well compared to the river water quality standards, namely Government Regulation Number 82 of 2001 for class II water quality standards, the results obtained can be seen in table 3.

Table 3.
The Results of Water Testing in the Simbang Kulon Dug Well

Distance	Sample Code	Sample Number	Parameter					
			Temperature	pH	TSS	BOD	COD	Total Ammonia
Quality Standards			22°C – 28°C	6 – 9	50 mg/L	3 mg/L	25 mg/L	0,2 mg/L
90 m	West	01	27 °C	7,19	10	2	(*)41	<0,033
100 m	West	02	27 °C	7,12	4	0,6	(*)32	<0,033
120 m	West	03	28 °C	7,18	10	(*)20	(*)35	0,009
150 m	West	04	28 °C	7,35	10	1	21	0
180 m	West	05	28 °C	7,32	20	(*)4	(*)43	0,02
210 m	West	06	27 °C	7,16	4	1,2	24	0,006
90 m	East	07	27 °C	7,15	2	0,6	22	<0,033
100 m	East	08	27 °C	7,15	1	0,6	(*)87	<0,033
120 m	East	09	28 °C	7,10	1	2	(*)29	0,007
150 m	East	10	27 °C	7,15	1	3	<2,9	<0,007
180 m	East	11	27 °C	7,20	3	(*)3,3	(*)65	<0,033
210 m	East	12	28 °C	7,16	3	0,2	(*)43	<0,033

Information:
(*) = Parameter indicates a concentration that exceeds the quality standard

Tests on dug well water in table 3 showed that the BOD and COD parameters in some samples showed results that exceeded the established quality standards. The distribution of dug well water test results can be seen more clearly in the following Figures 4 and 5.

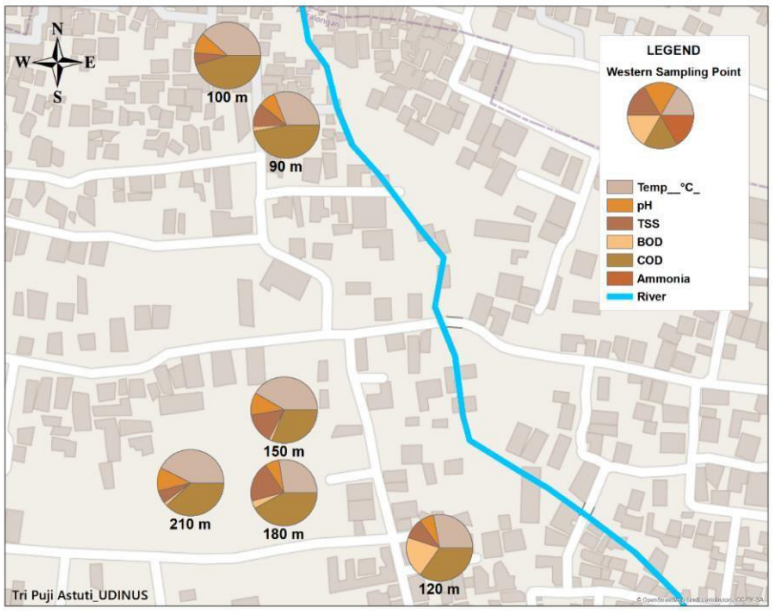

Figure 4. Distribution of Water Well Test Results in the West Part of the River

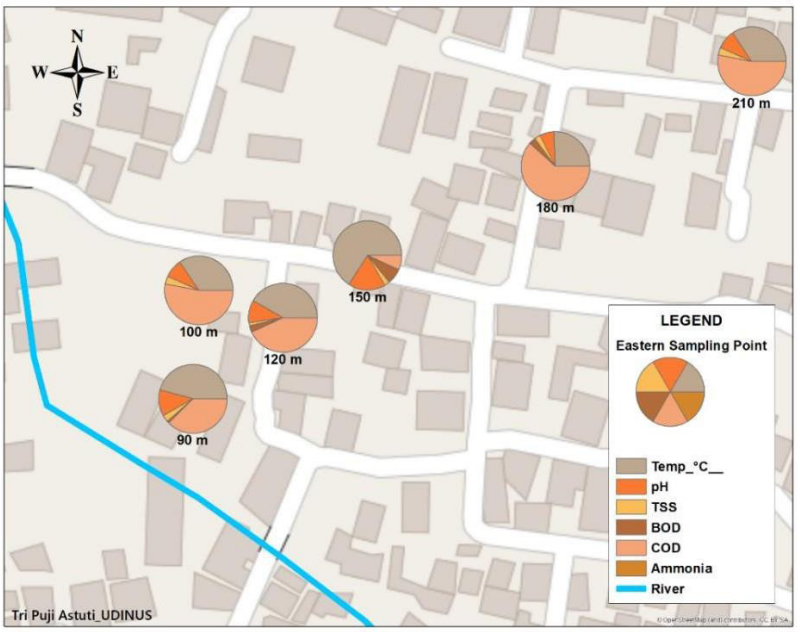

Figure 5. Distribution of Water Well Test Results in the East Part of the River

The results of the dug well water test in table 3 can be calculated for the Pollution Index (PI) of well water obtained in table 4.

Table 4.
Calculation results of Pollution Index (PI) of Dug Well Water

Sample Code	Sample Number	Distance	Pollution Index (IP)	Category
West	01	90 m	1,405	Slightly polluted
West	02	100 m	1,049	Slightly polluted
West	03	120 m	3,498	Slightly polluted
West	04	150 m	0,654	Good
West	05	180 m	1,417	Slightly polluted
West	06	210 m	0,640	Good
East	07	90 m	0,589	Good
East	08	100 m	2,567	Slightly polluted
East	09	120 m	0,876	Good
East	10	150 m	0,682	Good
East	11	180 m	2,094	Slightly polluted
East	12	210 m	1,472	Slightly polluted

Based on the results of the calculation of the Pollution Index (PI) of well water in Simbang Kulon Village, the highest IP score is in sample number 03 in the western part with a well distance of 120 m from the river. While the lowest PI score was obtained in sample number 07 on the east side of the river with a distance of 90 m from the well. The high Pollution Index (PI) in the dug well sample 03 was due to the close proximity of the dug well to the Simbang Kulon River or the batik-making industry so that most of the concentrations of TSS, BOD, COD and total ammonia contamination increased.

Physical Condition of Dug Wells in Simbang Kulon Village

The results of measuring the physical condition of the dug wells related to the height of the well wall, the height of the well lip, and the width of the well floor in the 12 dug wells obtained results which can be seen in table 5.

Table 5.
Measurement Results of Dug Well Construction

Sample Code	Sample Number	Height of the wall of the well (cm)	Height of the lip of the well (cm)	Width of the well floor (cm)
West	01	300	67	78
West	02	310	64	95
West	03	300	74	110
West	04	300	40	96
West	05	300	76	0
West	06	300	70	96
East	07	300	53	70
East	08	260	30	110
East	09	300	30	130
East	10	260	66	90
East	11	300	47	105
East	12	270	50	105

Based on the results in table 5, it can be concluded that the physical condition of the dug wells in the 12 wells did not meet the construction requirements of the dug wells, where there were 3 dug wells that did not meet the construction requirements for the height of the well walls and the height of the lip of the 12 dug wells which had a height of less than 80 cm. While the floor width of the wells in the 5 dug wells shows a width of more than 1 meter, the floor width does not surround the well so that it does not meet the construction requirements of dug wells.
In addition, the results of observations of the physical quality of the water and the assessment of the Simbang Kulon dug wells based on the questionnaire sheet, obtained the results of a contamination risk score with a high category of 54.54% obtained for sample numbers 03, 04, 05, and 08 which can be seen in the table 6.

Table 6.
Dug Well Contamination Risk Score

Distance	Sample Code	Sample Number	Contamination Risk Score	Risk Category
90 m	West	01	45,45%	Moderate
100 m	West	02	45,45%	Moderate
120 m	West	03	54,54%	High
150 m	West	04	54,54%	High
180 m	West	05	54,54%	High
210 m	West	06	45,45%	Moderate
90 m	East	07	45,45%	Moderate
100 m	East	08	54,54%	High
120 m	East	09	45,45%	Moderate
150 m	East	10	36,36%	Moderate
180 m	East	11	45,45%	Moderate
210 m	East	12	45,45%	Moderate

Relationship of Physical Conditions of Dug Wells to Contamination Concentrations of TSS, BOD, COD, and Total Ammonia

Table 7.
Results of the Relationship between Well Wall Height and Contamination

Independent variable	Dependent variable	P-value	r	Conclusion
The physical condition of the dug well	Temperature	0,928	0,029	There is no relationship
	pH	0,687	0,126	There is no relationship
	TSS	0,073	0,535	There is no relationship

Independent variable	Dependent variable	P-value	r	Conclusion
is based on the height of the well wall	BOD	0,696	0,126	There is no relationship
	COD	0,683	-0,132	There is no relationship
	Total Ammonia	0,869	0,054	There is no relationship

Based on table 7, the results of the Rank Spearman relationship test on the physical condition of dug wells in relation to the height of the well walls and the concentrations of TSS, BOD, COD, and total ammonia contaminants show no significant relationship.

Table 8.
The results of the relationship between the height of the lip of the well and contamination

Independent variable	Dependent variable	P-value	r	Conclusion
The physical condition of dug wells is based on the height of the lip of the well	Temperature	0,880	-0,049	There is no relationship
	pH	0,592	0,172	There is no relationship
	TSS	0,024	0,642	There is a relationship with a strong correlation
	BOD	0,095	0,504	There is no relationship
	COD	0,778	-0,091	There is no relationship
	Total Ammonia	0,689	-0,129	There is no relationship

Based on table 8, the results of the Rank Spearman relationship test on the physical condition of dug wells in relation to the height of the well's lip and the concentrations of TSS, BOD, COD, and total ammonia contaminants show that there is only a strong significant relationship between the height of the well's lip and TSS contamination.

Table 9.

Results of the Relationship between Well Floor Width and Contamination

Independent variable	Dependent variable	P-value	r	Conclusion
The physical condition of dug wells is based on the width of the well floor	Temperature	0,761	0,098	There is no relationship
	pH	0,991	0,004	There is no relationship
	TSS	0,212	-0,388	There is no relationship
	BOD	0,930	-0,028	There is no relationship
	COD	0,384	0,276	There is no relationship
	Total Ammonia	0,789	-0,086	There is no relationship

Based on table 9, the results of the Rank Spearman relationship test on the physical condition of dug wells related to the floor width of the well and the concentrations of TSS, BOD, COD, and total ammonia contaminants show no significant relationship.

Table 10.
Results of Potential Contamination Risk Relationship with Contaminants

Independent variable	Dependent variable	P-value	r	Conclusion
Physical condition of dug well based on	Temperature	0,096	0,502	There is no relationship
	pH	0,054	0,568	There is no relationship
	TSS	0,095	0,503	There is no relationship
	BOD	0,663	0,141	There is no relationship

Independent variable	Dependent variable	P-value	r	Conclusion
contamination risk score	COD	0,232	0,373	There is no relationship
	Total Ammonia	0,818	-0,075	There is no relationship

Based on table 10, the results of the Spearman's Rank correlation test between the physical condition of the dug well and the concentration of TSS, BOD, COD, and total ammonia contaminants show no significant relationship.

The Relationship between the Distance of a Dug Well from the Simbang Kulon River to Contamination Concentrations of TSS, BOD, COD, and Total Ammonia

Table 11.
Results of the Relationship Between Well Distance and Contamination

Independent variable	Dependent variable	P-value	r	Conclusion
Distance of the dug well from the Simbang Kulon river (90m, 100m, 120m, 150m, 180m and 210m)	Temperature	0,270	0,346	There is no relationship
	pH	0,184	0,411	There is no relationship
	TSS	0,672	0,137	There is no relationship
	BOD	0,626	0,157	There is no relationship
	COD	0,810	0,078	There is no relationship
	Total Ammonia	0,216	-0,386	There is no relationship

Based on table 11, the results of the Spearman Rank correlation test between the distance of the dug well from the Simbang Kulon river and the concentrations of TSS, BOD, COD, and total ammonia contaminants show that there is no significant relationship.

Discussion

Water Quality of the Simbang Kulon River

The number of batik home industries in Simbang Kulon Village is around 173 industries which are scattered and actively produce batik (Dinas Perumahan Rakyat dan Kawasan Pemukiman dan Lingkungan Hidup, 2020). The batik industry, whether written batik, stamped batik, or screen printing/printing batik, has several stages that are not much different in the process of making batik. The most important stage in making batik is the coloring process to produce various colors of batik patterns, but in this process, the batik craftsmen in the Simbang Kulon Subdistrict have switched to using synthetic dyes so that the batik wastewater produced from the coloring process harms the environment because the synthetis of the dyes is more difficult and takes longer to decompose. Synthetic dyes have the advantage that the resulting colors are more stable so if they are thrown into the river directly they will change the color of the river to purplish, reddish, or black depending on the synthetic dyes used.

Batik liquid waste produced by the batik industry in the Simbang Kulon Sub-District does not go through a processing process before being disposed of environment, this is due to the fact that the Simbang Kulon WWTP has not yet been operational, causing batik craftsmen to dispose of batik liquid waste directly into the river. The results of the calculation of the water quality status (PI) of the Simbang Kulon River obtained a result of 6 where the quality status of the Simbang Kulon River was in the moderately polluted category. The test results on the concentration of contaminants in the Simbang Kulon River showed that the pH and TSS concentrations were still within the specified quality standard range, while the temperature, BOD, COD, and total ammonia concentrations exceeded the quality standards.

pH is a parameter that has a direct effect on aquatic ecosystems. The increase in water pH can be affected by organic or inorganic waste discharged into river water (Naillah et al., 2021). However, testing the pH of the Simbang Kulon River water which was carried out directly at the research location obtained a result of 7.82, which still met the quality standards and tended to be alkaline. While the concentration of TSS in the Simbang Kulon River obtained quite high yields but still met the established quality standard of 40 mg/L. High amounts of suspended solids in water are characterized by increasing amounts of organic or inorganic matter which have a negative impact on water quality, such as increasing turbidity. Increased turbidity

inhibits the process of penetration or entry of sunlight into the waters thereby disrupting the growth of aquatic organisms (Indrayani, Lilin ; Rahmah, 2018).
The temperature parameter is a parameter that needs to be measured in determining water quality because the temperature has a significant influence on aquatic ecosystems (Sari & Wijaya, 2019). The results of measurements of temperature concentrations carried out directly at the study site obtained results of 31°C, where the water temperature of the Simbang Kulon River has exceeded the established quality standard, namely ± deviation 3 which ranges from 22°C - 28°C. The water temperature of the Simbang Kulon River which has passed this threshold is due to sampling of river water which is carried out during the day, where the temperature of a water can change due to various factors including humidity and exposure to heat from sunlight. Exposure to heat from sunlight has a major influence on changes in water temperature (Sari & Wijaya, 2019).
In addition, the concentrations of BOD and COD contamination in the Simbang Kulon River water respectively by 60 mg/L and 70 mg/L have exceeded the established class II water quality standards, whereas the COD concentration increases, the BOD concentration also increases. In addition, an increase in COD concentration means that the level of pollution in the waters is getting bigger (Widyastuti et al., 2019). Research conducted by Pramudya Bagas Utama, et al (2022) on the contamination of batik waste in the Bedog river, Batul Regency, also showed results of BOD and COD concentrations that exceeded the quality standards (Utama & Fitriyani, 2022). The batik industry is known to be one of the industries producing liquid waste with a high content of dyes. The water of the Simbang Kulon River which is purple to blackish red is because the batik craftsmen in the Simbang Kulon Village have switched to using synthetic dyes in their batik production. The use of chemicals in the dyeing process produces batik liquid waste with organic and inorganic content so that water quality parameters such as COD, BOD, TDS, and TSS have high concentrations (Kiswanto et al., 2019). Batik production that goes through the stages of fabric processing and dyeing has the potential to increase COD contamination and watercolor in the resulting liquid waste, besides that the process of *pelorodan (*the process of removing wax that sticks to the fabric*)* or wax release on batik cloth also provides the potential to increase BOD contamination in batik wastewater (Apriyani, 2018).
The test results on the total ammonia concentration in the Simbang Kulon River water have also exceeded the established quality standard of 4 mg/L. The presence of ammonia in high concentrations reduces dissolved oxygen levels and tends to be toxic so that it can have an indirect effect on aquatic ecosystems. In addition, the high total ammonia content in river water can also increase the concentration of nitrite and nitrate (Rizza, 2013).

Water Quality of Simbang Kulon Dug Well

The results of laboratory tests on dug well water in Simbang Kulon Village with water quality parameters namely TSS, BOD, COD, and total ammonia compared to quality standards according to Government Regulation Number 82 of 2001 concerning Water Quality Management and Water Pollution Control obtained different results. different. Testing of dug well water in Simbang Kulon Village was carried out by taking 6 samples in the western and 6 eastern parts of the river with distances of dug wells and rivers being 90 m, 100 m, 120 m, 150 m, 180 m, and 210 m.
The results of measurements of temperature and pH parameters in 12 dug wells in the Simbang Kulon Village are still in the safe category. The temperature of dug well water shows results in the range of 27°C – 28°C where these results are still in the normal temperature category. While the pH parameter in dug well water shows results in the range of 7.10 – 7.35 and is neutral. In addition, the TSS parameters in the 12 dug wells also showed results that still met the established quality standards. The concentration of TSS in dug well water ranges from 1 mg/L – 20 mg/L with the highest concentration of 20 mg/L obtained from a sample of dug well number 05 on the west side of the river. The high concentration of TSS in the dug well sample number 05 may come from the proximity of the dug well to the batik-making industry, besides that the construction of the dug well in sample number 05 does not have a standard well floor and the physical condition of the dug well water is cloudy and yellowish. A high TSS concentration indicates a high level of contamination in water (Korbafo & Mere, 2022).
The concentration of BOD contamination in 12 dug wells in the Simbang Kulon Village showed results that exceeded the quality standard. The concentration of BOD found in the dug well water ranged from 0,6 mg/L – 20 mg/L where the highest BOD concentration of 20 mg/L was in the sample dug well number 03 on the west side of the river. The existence of BOD contaminants with high concentrations in dug well water is not only close to the pollutant source, namely the Simbang Kulon River but also close to the batik-making industry. The batik industry produces batik liquid waste which contains organic and inorganic materials where the abundance of organic matter increases the concentration of BOD contamination (Indrayani, Lilin ;

Rahmah, 2018). The presence of BOD contamination in dug well water in Simbang Kulon Village makes the dug well water unfit for consumption.
Test results for COD contamination in dug well water in the Simbang Kulon Subdistrict showed that most of the 12 dug well water had COD concentrations exceeding the established quality standards. The concentration of BOD contamination ranged from <2,9 mg/L – 87 mg/L where the highest COD concentration was in dug well number 08 in the eastern part of the river. The dug wells in Sambang Kulon Subdistrict which have high COD concentrations can be caused by the close distance between the dug wells and the Simbang Kulon river and the existence of these dug wells close to the batik-making industry. In the process of coloring batik, the batik industry in Simbang Kulon has switched to using synthetic dyes which are difficult to decompose so the resulting batik wastewater contains chemicals that have the potential to increase COD concentrations (Apriyani, 2018). The presence of concentrations of COD contamination in dug well water in the Simbang Kulon Sub-district makes the dug well water unfit for consumption.
Total ammonia is one of the parameters contained in batik wastewater. The results of laboratory tests related to the presence of total ammonia contamination in 12 dug wells in the Simbang Kulon sub-district showed that the concentration of total ammonia contamination was still in the safe category. The highest total ammonia concentration of 0,009 was in the sample dug well number 03 on the west side of the river. The presence of total ammonia in the dug well sample number 03 was due to the fact that the dug well was close to the batik-making industry, besides that the construction of the floor of the dug well sample number 03 also did not meet predetermined standards.
The results of laboratory tests related to TSS, BOD, COD, and total ammonia contamination in dug well water in the Simbang Kulon Sub-district can be used to determine the quality status of dug well water by calculating using the Pollution Index (PI) method. Based on Table 4, the calculation of the Pollution Index (PI) of dug well water results in the status of water quality being in the good and slightly polluted category. The highest Pollution Index (PI) of dug well water was in sample number 03 with a score of 3.498 and the lowest was in sample number 07 with a score of 0.589. The high Pollution Index (PI) in the dug well sample 03 was due to the close proximity of the dug well to the Simbang Kulon River or the batik-making industry so most of the concentrations of TSS, BOD, COD, and total ammonia contamination increased.

Relationship of Physical Conditions of Dug Wells to Contamination Concentrations of TSS, BOD, COD, and Total Ammonia

The results of observations and measurements of the physical condition of the wells in 12 dug wells related to fulfilling the requirements for well wall height, well lip height, and well floor width can be concluded that there were 3 wells with wall heights of less than 3 meters and all samples of dug wells studied did not meet The requirement for the height of the lip of the well is at least 80 cm, where some wells have a lip height that is too low. While as many as 5 dug wells showed a floor width of more than 1 m, even though the width of the wells did not surround the well so they did not meet the requirements.
Based on the results of the relationship test between the height of the well wall and TSS, BOD, COD, and total ammonia contamination showed no significant relationship. The results of field observations showed that most of the construction of the well walls used waterproof cement ring walls with a well wall height that met the requirements of 3 meters, where the fulfillment of the well wall height requirements was an effort to protect the well from seepage of batik liquid waste.
Based on the results of the relationship test between the height of the well lip and TSS, BOD, COD, and total ammonia contamination, it was shown that there was a strong relationship between the height of the wellhead and TSS contamination, which was 0.024. The results of testing the quality of well water for TSS concentrations showed that the results were still below the quality standard, however, the 12 dug wells studied had a well lip height of less than 80 cm and some were even too low. The height of the lip of the well that does not meet the requirements can endanger the safety of the well owner and also has the potential for water contamination from outside the well to enter. Batik liquid waste contains high organic matter, thus increasing the concentration of BOD, COD, and TSS. In addition, the concentration of suspended solids in large quantities can increase the turbidity of the water and block the entry of sunlight (Indrayani, Lilin ; Rahmah, 2018).
Based on the correlation test between the width of the well floor and TSS, BOD, COD, and total ammonia contamination, it showed that there was no significant relationship. The results of field observations showed that the floor width was mostly less than 1 meter and the floor did not surround the well, in fact there was 1 well that did not have a well floor. The width of the well floor that does not meet these requirements is prone to infiltration of contaminants around the well.
Based on the correlation test using the Rank Spearman alternative test, all variables showed a p-value greater than 0.05 so it can be concluded that there is no significant relationship between the potential contamination risk score and the concentration of TSS, BOD, COD, and total ammonia contaminants. The

results of observations and assessments of 12 samples of dug wells showed that the height of the well walls in some wells was less than 3 m, the height of the lip of the well did not meet the requirements, which was below 80 cm and the width of the well floor was less than 1 m. Apart from that, of the 12 samples, most were close to other sources of pollution in the form of the batik industry and the presence of stagnant water.
The people in Simbang Kulon Village still use dug wells to support their daily activities such as bathing, washing, and so on. Test results on 12 well-water samples showed that 6 well-water samples on the west side of the river had higher concentrations of TSS, BOD, COD, and total ammonia than 6 well-water samples on the east side of the river. This is not only due to differences in land elevation between the west and east but also due to the existence of the batik industry which is too close to the wells which can contaminate the dug wells. The process of making batik goes through the coloring stage to washing the cloth and produces some batik liquid waste that flows into the gutters but seeps into the ground. Making batik in a place that does not have a watertight floor will result in seepage of batik liquid waste into the ground which provides a greater potential for contaminating water in dug wells. In addition, almost every house yard in Simbang Kulon Village which is not watertight is used as a place for drying batik where in the process of drying batik there are water droplets left over from washing batik cloth that can seep into the ground. Batik-making activities up to the drying stage of batik are carried out every day and for a long time so that the water from the community's dug wells has the potential to be polluted.

The Relationship between the Distance of a Dug Well from the Simbang Kulon River to Contamination Concentrations of TSS, BOD, COD, and Total Ammonia

Based on the correlation test using the Rank Spearman alternative test, all variables show a p-value greater than 0.05 so it can be concluded that there is no significant relationship between the distance of the dug well from the Simbang Kulon River and the concentration of TSS, BOD, COD, and ammonia total contaminants.
The test results on 12 samples of well water did not show the concentration of contaminants the further away from the river the concentration of contaminants would be smaller. This is due to the presence of confounding variables, namely the location of other pollutant sources in the form of the batik industry which is too close to community dug-wells. There is a batik industry which, in the process of making batik, goes through the coloring stage to washing the cloth and produces batik liquid waste, some of which flows into the gutters but some seeps into the ground. Making batik in a place that does not have a watertight floor will result in seepage of batik liquid waste into the ground which provides a greater potential for contaminating water in dug wells.

Conclusion

From the results of the study it can be concluded as follows:

1. According to the Pollution Index (PI) calculation, the water quality status of the Simbang Kulon river is 6, where the results are in the moderately polluted category with parameters that exceed quality standards including temperature, BOD, COD, and total ammonia.
2. Based on the Pollution Index (PI) calculation, the quality status of well water is in the range of meeting quality standards and being moderately polluted with parameters that exceed quality standards, mostly BOD and COD parameters.
3. Most of the physical conditions of dug wells do not meet the predetermined construction requirements of dug wells, where the height of the lip of the well is less than 80 cm and the width of the floor around the well is less than 1 m.
4. There is a relationship between the height of the lip of dug wells in the Simbang Kulon sub-district and TSS contamination. However, there is no significant relationship between the height of the well wall, the width of the floor of the well, and the potential risk of contamination of dug wells in the Simbang Kulon Sub-District for TSS, BOD, COD and total ammonia contamination.
5. There is no significant relationship between the distance of the dug well from the Simbang Kulon river and the concentration of TSS, BOD, COD and total ammonia contaminants.

Simbang Kulon Village is known as the largest batik-producing village in Pekalongan Regency. Around 173 batik industries are scattered and actively produce and produce batik liquid waste in the Simbang Kulon Village. The batik liquid waste generated from the batik coloring process is disposed of directly into the Simbang Kulon River without going through a processing process to reduce the concentration of contaminants in the batik liquid waste. This causes the Simbang Kulon River to turn purplish, reddish, to black according to the dye used which harms the aquatic ecosystem or the quality of the water around the

Simbang Kulon River. The Simbang Kulon sub-district has a WWTP which functions to process batik waste produced by the Simbang Kulon batik industry before being discharged into the environment but the WWTP is not yet operational, so it is hoped that the Simbang Kulon WWTP can operate soon so the batik industry can dispose of batik liquid waste to the WWTP.

Author Contributions

This research has been conducted in collaboration between the two authors. The TPA authors designed the study, took samples, conducted statistical analysis, and wrote the first draft of the manuscript. Author EH wrote the protocol, managed the research analysis, and wrote a draft of this article. All authors have read and approved the final manuscript.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

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Appendix B

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