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Relationship of season and water quality of Way Umpu river to public health in Way Kanan district-Lampung-Indonesia

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ABSTRACT

This work aims to investigate the water quality of the Way Umpu River in Way Kanan District-Lampung Province-Indonesia in terms of parameters including pH, BOD (Biochemical Oxygen Demand), TSS (Total Suspended Solids), COD (Chemical Oxygen Demand), DO (Dissolved Oxygen), and Phosphate. In addition, this work also purposes to investigate the relationship between seasons and the water quality of the Way Umpu River on public health. The relationship between season and water quality of the Way Umpu River on public health was analyzed using a two-way ANOVA statistical test. Based on the six parameters of the research results, the Pollution Index value in April 2019 fulfilled the river water quality status, while in October 2019, the Pollution Index (IP) value stated that the water quality status of the Way Umpu River was lightly polluted. The p-value in the season is 0.438 or > 0.05 and the water quality is 0.320 or > 0.05.

***Key words**: Pollution index, Public health, Water quality, Way Umpu river.*

Introduction

Studies on water quality management are very important because there are many factors that influence it. In particular, this concept relates to different water use purposes and requires different criteria. In Indonesia, this has been controlled by Regulation of Indonesian Government No. 22 of 2021 specifically regulates Water Quality Management and Water Pollution Control (Government Regulation Number 22 Year 2021).

Quality of water is one of the most significant components that should be regarded when considering the sustainable construction of an area. In recent years the study of how to properly calculate quality of water has improved significantly. Many other empirical studies have conducted research related to water quality management (Pratama *et al*., 2020; Prambudy *et al*., 2019; Wulandari *et al*., 2019; Hua *et al*., 2017; Naubi *et al*., 2016; Lešèešen *et al*., 2015; Bu *et al*., 2014; Parmar *et al*., 2013; Pantelic *et al*., 2012; Martinez *et al*., 2011). The quality of water should be determined with regarding to a set of physical and chemical parameters which are tightly linked to the intended use of water. Water whose parameters comply the predetermined standards for certain uses are considered to meet the quality standards for the quality of the water used. If water

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does not fulfill this standard, it should be managed before use (Co´rdoba *et al*., 2010).

The water quality index based on the National Sanitation Foundation of US defines the quality index for each water use by specifying only the required specifications for that use. This factor includes a variety of physical and chemical properties. In each factor, the index includes a (generally linear) quality value function that describes the equivalency between the parameter and its quality grade. These models are determined with direct measurements from the concentration of a material or physical parameter values obtained through analysis of a water sample.

Each river has its own characteristics that are different from one another. The differences can be seen from the physical, chemical, and environmental conditions in the river. The characteristics of river water depend on the season and the pattern of human life around it. These conditions cause the quantity and quality of water to change according to the development of the environment and human life (Lešèešen *et al*., 2015). Along with the rate of development and population growth, rivers have become a place for accumulated waste disposal from all human activities. This causes pollutants to enter the river flow before finally being channeled into the sea or lake, and at a certain point, when the river's capacity for the pollution load reaches its limit, river pollution will occur and cause new problems. The main problems faced with regard to water resources are the quantity of water that is no longer able to meet the increasing needs and the quality of water for domestic needs which has decreased from year to year (Lee *et al*., 2009; Tran *et al*., 2010; Rothwell *et al*., 2010).

The Way Umpu River is one of the rivers that is the location for gold mining. The gold mining is considered to be a major polluter in river waters. Besides, various land use activities in the area around the Way Umpu River such as settlement, agriculture, fishery, mining, and industrial activities seem to have affected the quality of water from Way Umpu River. The decline in the quality of water from the Way Umpu River deserves the attention of all parties, because the river is used for many purposes by the community. Judging from the evenness, the distribution of pollutant sources that pollute the Way Umpu River is not evenly distributed along the river flow. Water contamination parameters can be analyzed physically, chemically, and biologically (Hua *et al*., 2017).

Total Suspended Solids (TSS) in water are in the form of organic and inorganic materials which have a negative impact on quality of water due to they reduce the sun penetration into water bodies (Pratama et al., 2020). Dissolved Oxygen (DO) is a key parameter of water quality. As it is known, oxygen acts as an oxidizer and a reduction of toxic chemicals into other compounds that are simpler and non-toxic (Simanjuntak 2007). BOD indicates the amount of oxygen used to oxidize organic substances in an aerobic state. BOD parameters are usually applied to identify the grade of wastewater pollution. Waters with high BOD values indicate that the water occurs pollution by organic matter. COD describes the oxygen amount applied to oxidize organic substances to CO_2 and H2O. The level of COD in wastewater decreases along with the decrease in the organic substance concentration in the wastewater. The main factors that can produce high phosphate degrees in the waters is because of the existence of domestic waste conceiving detergents (Tungkadkk, 2016). The phosphate content in waters has no direct impact on humans or animals. However, if consumed continuously, it will have an impact on digestive problems.

The main objective of this work is to evaluate quality of water of the Way Umpu River by reviewing several parameters such as pH, BOD, DO, COD, TSS, and Phosphate. Based on the results of the data obtained, the Pollution Index was determined and the possibility of a relationship between season and river water quality was studied on public health using the Analysis of Variance (ANOVA) method.

Materials and Methods

The Study Area

Water samples were taken in two seasons, namely the dry season (April 2019) and the rainy season (October 2019). The water sampling points were identified by the "sample survey method," which is a sampling method performed with distributing the research region into segments or points which are assumed to indicate the research population. The identification of the point of taking river water quality was based on the simple access, low cost, and efficient in the research. In the study, four stations from Way Kanan District Indonesia were deter-

mined which may be able to provide the greatest amount of information. The code and name of the river from this station are: WU 1 (Way Umpu 1 is located in the KasuiPasar area), WU 2 (Way Umpu 2 is located in the Ojolali area), WU 3 (Way Umpu 3 is located in the Negeri Baru area), and WU 4 (Way Umpu 4 is located in the Blambangan Umpu area).

General procedure

The research method used in this research was observational using descriptive analysis because the writing was based on a complete description of the conditions that occur in the environment around the Way Umpu River. Six representative water quality parameters are chosen to be measured, including pH, TSS, DO, BOD, COD, and Phosphate. The pH and DO values were determined on the spot by an instrument of multiparameter water quality monitoring. Sensor calibration was performed prior to measurement. Pre-treatment and determination of other parameters in the laboratory follow the Indonesian National Standard method (SNI 6989.57 / 58/59: 2008). Sample analysis was carried out at the UPTD Environmental Laboratory DLH Lampung Province and at the UPT Integrated Laboratory and Technology Innovation Center (LTSIT), University of Lampung. The data obtained was then contrasted with the quality standard criteria of Indonesian Government Regulations No. 22 of 2021 for class II water which is designated as water for freshwater fish farming, water recreation infrastructure/ facilities, animal husbandry, irrigation, and or other applications involving the similar water quality.

Detection Method

Data analysis carried out in this research is to investigate the water quality in the river and analysis of the Pollution Index (IP) which requires data on the water quality of the Way Umpu River obtained from observations and testing of water to relate several parameters, as well as ANOVA (Analysis of Variance) (Lešèešen *et al.*, 2015, Panteliæ *et al.*, 2012) to compare the equations with the parameter conditions in the field (Way Umpu River). In this research, the predetermined basic parameters were usually used to calculate the Pollution Index (IP). Sources of data on the number of diseases and public health in 2019 were obtained from the commu-

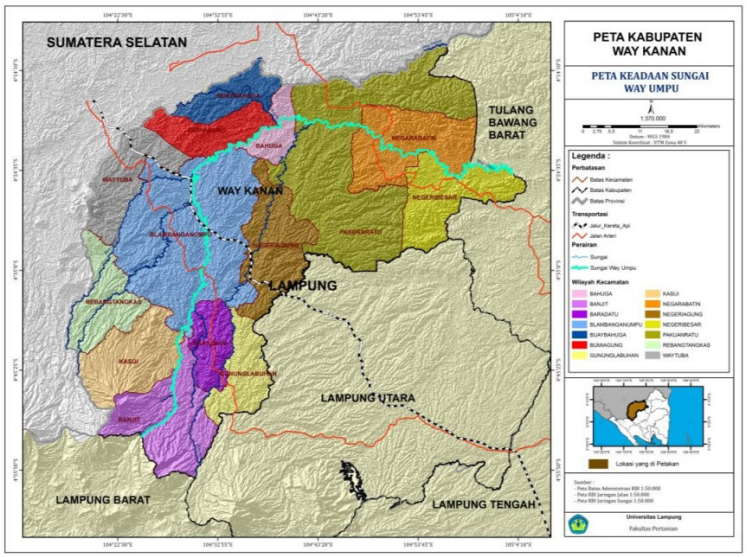

Fig. 1. Research location map

Table 1. Sampling Stations Locations

Stations	River Codes	Observation Locations	Coordinate Points
I	WU 1	Kasui Pasar	4°42′34.73"S ; 104°28′39.99"E
II	WU 2	Ojolali	4°41′08.64"S ; 104°29′50.02"E
III	WU 3	Negeri Baru	4°34′45.85"S ; 104°31′25.56"E
IV	WU 4	Blambangan Umpu	4°29′52.86"S ; 104°31′35.92"E

nity health center. Table 2 shows the six parameters considered and the units of measurement.

Table 2. Water Quality Parameters and Measurement Units

Parameters	Unit
Water acidity (pH)	
Total Suspended Solids (TSS)	mg/L
Dissolved Oxygen (DO)	mg/L
Biological Oxigen Demand (BOD)	mg/L
Chemical Oxygen Demand (COD)	mg/L
Phosphate	mg/L

Previous researchers used DO, BOD, and COD parameters as chemical indicators to evaluate water quality (Pratama*et al*., 2020; Hua*et al*., 2017; Bu *et al*., 2014; Pantelic*et al*., 2012; Martinez *et al*., 2011). The condition of water quality was determined by the PI method based on the Decree of the State Minister for the Environment No. 115 of 2003 Annex II concerning Guidelines for Determining Water Quality Status. In the IP method, various water quality parameters were used. The method relates the level of pollution of a waters applied for a special purpose by the grade of specific parameters as shown in the following Table 3.

Table 3. Relationship Between Pi Values and Water Quality Status

PI Values	Water Quality
0-1,0	Good condition
1,1-5.0	Lightly polluted
5,1-10.0	Moderately polluted
>10.0	Severely polluted

Source: The Decree of the State Minister for the Environment No. 115 of 2003

The data that has been obtained were then analyzed using quantitative analysis techniques using models presented in numbers which are then interpreted and described. To answer the hypothesis in the study, a statistical analysis was carried out using ANOVA. The formula used is based on the results of statistical calculations, namely if the value of f > f table and probability (p-value) 0.05 implies that the hypothesis is received. If the value of f < f table and probability (p-value) > 0.05, it implies that the hypothesis is rejected.

Results and Discussion

The data analysis of the measurement of water quality parameters on the Way Umpu River which were contrasted with the water quality standard criteria as contained in the attachment to Indonesian Government Regulation number 22 of 2021 concerning Water Quality Management and Water Pollution Control, can be seen in Table 4.

River Water Acidity (pH)

Based on the measurement results of parameters of water quality, the water acidity (pH) of the surface of the Way Umpu River shows a minimum pH of 6 and a maximum of 7. In Indonesian Government Regulation No. 22 of 2021, it is stated that the range of pH values for class II water is 6-9. Therefore, the results of pH measurements at the monitoring location have met the quality standard criteria and indicate that the Way Umpu River water is still in good condition for the utilization of raw water to be consumed as drinking water and to irrigate paddy water.

TSS (Total Suspended Solids)

High TSS can increase temperature of water due to heat from sunlight was adsorbed by the solid materials (Martinez and Galera, 2011). Rainfall can reduce the TSS value because it can help dilution, but it is also able to raise TSS concentration depending on watershed conditions (Amneera *et al*., 2013). The TSS value for class II water quality standards was 50 mg/L, the Way Umpu River TSS values in April still met the Class II water quality standards. This indicated that the Way Umpu River had not been polluted by particulates which can increase turbidity. The open space in the form of empty land which is not too much in the area around the monitoring stations makes the TSS value not too high. But in October, the TSS value on the Way Umpu River exceeded the standard of water quality of the class II, so it can be concluded that in October, the quality of water from the Way Umpu River was lightly polluted.

DO (Dissolved Oxygen)

From the results of water examinations, it can be observed that the dissolved oxygen content in the Way Umpu River ranges from 3-5 mg/l which means it is close to the specified class II water quality criteria. Dissolved oxygen statistical analysis

Table 4. Result of Analysis of Water Quality Parameters of Way Umpu River

No.	Parameters	Class II Water Quality Criteria	April				October			
			St I	St II	St III	St IV	StI	StII	St III	St IV
1.	pH	6-9	6	6	6	6	7	7	7	7
2.	TSS (mg/l)	50	32	45	42	35	158	120	113	95
3.	DO (mg/l)	4	4	5	3	4	4	4	5	4
4.	BOD (mg/l)	3	3	4	3	3	11	14	9	8
5.	COD (mg/l)	25	14	18	17	15	31	35	23	20
6.	Phospate (mg/l)	0.2	0.2	0.4	0.2	0.1	1	1	1	0.5

St: Station

measurement results for all stations showed insignificant differences. The dissolved oxygen content in the Way Umpu III River sample in April was less than the predetermined quality standard, while the Way Umpu River sample taken in October had met the water quality class II standard. There is no significant deviation between these values. The things that result in high dissolved oxygen in water are caused because water contains few aquatic organisms, while those that result in low dissolved oxygen in water are due to the increase in aquatic organisms that need oxygen for survival.

BOD (Biochemical Oxygen Demand)

The lower the BOD content indicates that the organic pollutant content in the river is low (Saksena *et al.*, 2008). The greater the BOD value of a water, the higher the concentration of organic substances in the water. It was found a significant difference from the measurement results of the statistical analysis of BOD in Way Umpu River water, where the BOD content taken in October all exceeded the quality standard for the water quality of class II. The BOD content measured in October was higher than the measured BOD content in April. This might be because the river water samples taken in October were already polluted.

COD (Chemical Oxygen Demand)

River bodies that contain high COD and BOD indicate pollution in the river body is high. The results of COD analysis in the Way Umpu River ranged from 14-35 mg/l. From the results of parameter measurement, there are differences in COD concentrations at each sampling location at different times. The COD value of Way Umpu River Station I and Station II in October exceeded the quality standard. This was probably because the waters of the Way Umpu River had accumulated household waste and other community activities that were difficult to decompose, so that conditions on the ground showed that the Way Umpu River looked cloudy. The COD value obtained in this study was much greater than BOD. The difference between COD and BOD values usually occurs in polluted waters because the organic matters that are able to be chemically decomposed are bigger than that of biological decomposition.

Phosphate

The results of the analysis of Phosphate content (PO_4-P) in Way Umpu River water showed that the Phosphate concentration at Station II taken in April exceeded the water quality standard (Table 4). Meanwhile, at Stations I, III, and IV, the concentration of Phosphate met the water quality standards. Then in October, the concentration of Phosphate had increased by 0.5-1.0 mg/l. According to the results of measuring the phosphate content in Way Umpu River water, the condition of the Way Umpu river water in several river flow locations for the Phosphate parameter is in accordance with its function and this can also be influenced by differences in time or weather when sampling.

Pollution Index (IP)

A river is called to be polluted if it is not able to be utilized based on its normal function. In this work, the parameters performed in analyzing the status of water quality consisted of COD, pH, DO, TSS, BOD, and Phosphate which are compared with the water quality criteria of class II according to Indonesian Government Regulation number 22 of 2021. The status of water quality from the Way Umpu River was calculated by method of the IP or Nemerow Pollution Index (NPI) according to the Decree of the

State Minister of the Environment of Republic of Indonesia number 115 of 2003 regarding Guidelines for Determining Water Quality Status. The results of the calculations are then evaluated according to the IP rating in Table 5.

Table 5. Determination of Water Quality Status of Pollution Index (PI) Method

No.	Value	Status
1.	$0 \leq Pij \leq 1.0$	Meets quality standard
2.	$1.0 < Pij \leq 5.0$	Lightly polluted
3.	$5.0 < Pij \leq 10.0$	Moderately polluted
4.	$Pij \geq 10.0$	Severely polluted

Source: The Decree of the State Minister for the Environment No. 115 of 200

The results of calculating the status of water quality of the Way Umpu River utilizing the method of IP are displayed in Table 6.

According to the results of the calculation of the IP, it is able to be observed that the status of water quality from the Way Umpu River in April and October had decreased from a good condition that met quality standards to a lightly polluted condition. This is indicated by the increase in the value of the IP (Figure 2).

This means that the quality of water from the Way Umpu River cannot be utilized in accordance with Class II water functions, namely as a means or infrastructure for freshwater fish farming, water recreation, water irrigation of crops, animal husbandry, and or other functions requiring the similar water quality as the utilitization. Therefore, it is necessary to control Way Umpu River water pollution so that it can be utilized and to maintain its water quality so that it remains in accordance with the target water quality, namely the water quality criteria of class II based on Indonesian Government Regulation number 22 of 2021.

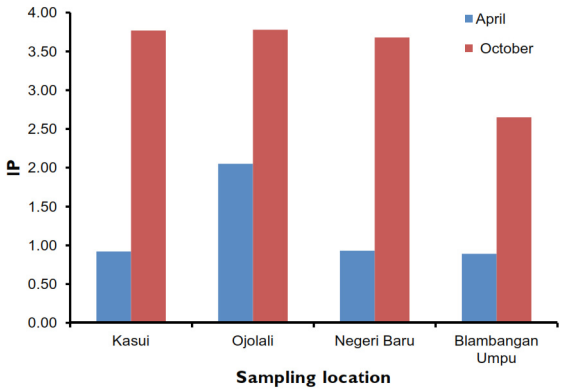

Fig. 2. Graph of the quality status of the Way Umpuriver in 2019 based on the IP Method of class II Water Quality Standards

The highest concentration of pollutant parameters in the Way Umpu River is the TSS, BOD, and COD parameters. This is due to a lack of law enforcement and implementation of Indonesian Government Regulation No. 22 of 2021 regarding Water Management and Water Pollution Control, where all domestic wastewater must be treated first before being discharged into public channels. The same thing is also written in the Decree of the Minister of Environment of Republic of Indonesia No. 115 of 2003 regarding Domestic Wastewater Quality Standards where every person in charge of business and or activities of restaurant settlements, offices, commerce, and apartments is obliged to carry out domestic wastewater treatment so that the quality of domestic wastewater discharged into the environment does not exceed the quality standard of domestic wastewater which is has been established.

ANOVA Statistical Method (Lešèešen*et al.*, 2015; Panteliæ *et al.*, 2012).

In conducting the Analysis of Variance (ANOVA), it is necessary to be performed the assumptions test first.

Table 6. Relationship Value (PI) and Way Umpu River Water Quality Status

Monitoring Time	Location	IP	Water Quality Category
April	Kasui	0.92	Meets Quality Standards
	Ojolali	2.05	Lightly polluted
	NegeriBaru	0.93	Meets Quality Standards
	BlambanganUmpu	0.89	Meets Quality Standards
October	Kasui	3.77	Lightly polluted
	Ojolali	3.78	Lightly polluted
	NegeriBaru	3.68	Lightly polluted
	BlambanganUmpu	2.65	Lightly polluted

1. Normality Assumption

In performing the normality assumption test, the ryan-joiner or shapiro-wilk test is used.

H_0 = normally distributed data

H_1 = data is not normally distributed

From the graph above, it can be seen that the p-value is 0.063, where the value exceeds the value, namely 0.05, so it fails to reject H_0 and it can be concluded that the data is normally distributed.

2. Assumption of Homogeneous Variance

In the homogeneous variance test, Bartlett's test is used. With the statistics program, the following results are obtained:

If the image above is noticed, it can be seen that p-value in Bartlett's test of 0.94 is greater than the a value, which is 0.05, it fails to reject H_0 or it means

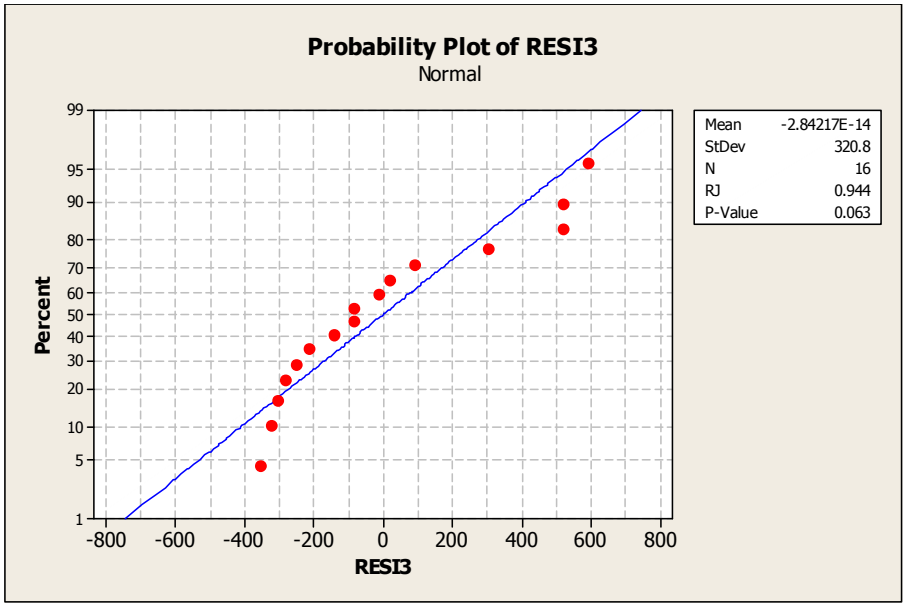

Fig. 3. Probability plot of RESI 3

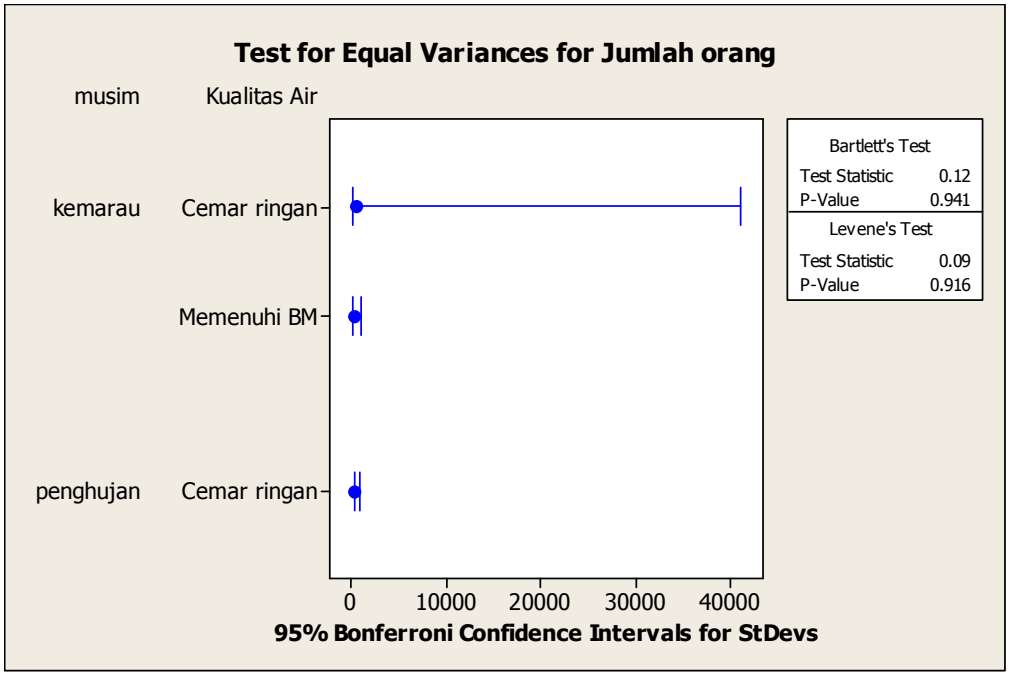

Fig. 4. Test for equal variances for number of people

that the variance of disease names is very homogeneous.

After the assumption test has been carried out, a one-way ANOVA was carried out using the Minitab program and the following results were obtained:

1. ANOVA to see the relationship between seasonality and water quality in four districts (Table 7)

Table 7. Result of the Analysis of Variance

Factors	Type	Level	Values
Season	Fixed	2	Dry, Rainy
Water Quality	Fixed	2	Lightly polluted, meets quality standards

In the study, it can be seen that there are two seasons compared, namely the dry and the rainy season. Then in water quality, there are two characteristics, namely lightly polluted and meeting Quality Standards. The purpose of doing the Analysis of Variance is to observe the correlation between season and water quality on public health (the amount of people influenced by the disease).

From the results above (Table 8), the p-value in the season is 0.438 or > 0.050 and the water quality is 0.320 or > 0.050, so it can be concluded that it was not found the difference in the effect of water quality (meeting Quality Standards and light pollution) on the number of people, there is also no difference in the effect between the dry and the rainy season on the amount of people influenced by the disease. For the interaction between season and water quality is undefined or it can be said that the interaction between the two has no effect on the amount of people influenced by the disease. In other words, season and water quality do not explain the amount of people influenced by the disease.

Table 8. Analysis of variance for Number of people using Adjusted SS for Tests

Source	DF	Seq SS	Adj MS	F	P-*Value*
Season	1	3505356	3505356	0.54	0.495
Water Quality	1	2336904	5842261	0.90	0.386

Table 9. Grouping Information Using Tukey Method and 95.0% Confidence

Seasons	N	Mean	Grouping
Dry	4	7271	A
Rainy	4	5177	A

The seasonal variable returns to be explained in the Table 9 and Table 10, that there is no difference in effect between the dry and rainy seasons, so that the season has no effect on the number of people affected by the disease.

For water quality variables (Table 11 and 12), at first glance there is a difference between light pollution and meeting Quality Standards, or it can be said that water quality has no significant effect on the amount of people influenced by the disease.

2. ANOVA to see the connection between season and water quality per district. At this stage, an investigation of the connection between seasonality and quality is carried out for each district.

Based on Table 13, it is clear that water quality (fulfilling Quality Standards and lightly polluted) and season (dry and rainy) has no effect on the amount of people influenced by the disease in each district, because although the water quality is lightly polluted and meets Quality Standards, the number of cases is the same arise in exactly one district. To ensure this, an analysis is carried out through a statistical program which obtained the following results:

Based on Table 14, using the p-value, it can be seen that the p-value on the variable season and water quality is 1.0, so that water quality and season

Table 10. Comparison Between Dry and Rainy Season

	Difference	SE of		Adjusted
Season	Of Means	Difference	T-*Value*	P-*Value*
Dry	2093	2845	0.7358	0.4949

Table 11. Grouping Information Using Tukey Method and 95.0% Confidence

Water Quality	N	Mean	Grouping
Lightly Polluted	5	7619	A
Meets Quality Standards	3	4828	A

Table 12. Comparison Between Lightly Polluted with Water Quality

	Difference	**SE of**		**Adjusted**
Water Quality	Of Means	Difference	T-*Value*	P-*Value*
Meets Quality Standards	-2791	2938	-0.9500	0.3258

Table 13. Relationship Between Season and Water Quality on Public Health

Districts	Seasons	Water Quality	Number of People Affected by the Disease
Kasui	Dry	Meets Quality Standards	5368
	Rainy	Lightly polluted	5368
Ojolali	Dry	Lightly polluted	8666
	Rainy	Lightly polluted	8666
NegeriBaru	Dry	Meets Quality Standards	3591
	Rainy	Lightly polluted	3591
BelambanganUmpu	Dry	Meets Quality Standards	8666
	Rainy	Lightly polluted	8666

Table 14. Analysis of Variance for Number of People Using Adjusted SS for Tests

Sources	DF	Seq SS	Adj SS	Adj MS	F	P
Season	1	0	0	0	0.000	1.000
Location	3	879841	752965	250988	3.170	0.072
Water Quality	1	0	0	0	0.000	1.000
Error	10	790721	790721	79072		
Total	15	1670562				

have no effect when viewed per district, in the sense that any season and water quality is no matter what will result in the same amount of people influenced by the disease for one district. For example, Kasui District with lightly polluted water quality and meeting Quality Standards results in a total amount of community influenced by the disease as many as 5368, and the result does not change even though it is the dry season or the rainy season.

Conclusion

1. Concentration of river water quality parameters can be influenced by weather conditions or the current season. The rainy season can increase the concentration of several parameters and increase the organic matter in river waters.
2. In April, the IP value that met the river water quality status was obtained. Meanwhile, in October, the IP value stated that the water quality status of the Way Umpu River was lightly polluted.
3. There is no difference in the season variable (dry and rainy) or it can be said that the season has no effect on the amount of community influenced by the disease.
4. There is no difference in the water quality variables (contaminated with water and fulfilling Quality Standards), or it can be said that each water quality does not have a significant effect on the amount of community influenced by the disease.
5. Differences in weather conditions or seasons can affect the concentration of several quality standard parameters of river water quality, so it can be said that the water quality of the Way Umpu River is not completely polluted.

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