



## RESEARCH ARTICLE

# Lithological Control on Variations in Total Dissolved Solids (TDS) and pH of Auya River Water, Obano Area, Paniai Regency, Central Papua, Indonesia

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## Abstract

This study focuses on the study of the influence of lithology and the level of rock weathering on the water quality of the Auya River located in Obano District, Paniai Regency, Central Papua, using Total Dissolved Solids (TDS) and pH as the main indicators. The approach applied is a quantitative descriptive method, which was carried out through field surveys at six observation points, direct measurement of water quality parameters, and statistical analysis including descriptive statistics, Pearson correlation, and linear regression. The results of the study indicate an increasing trend in TDS and pH values from upstream to downstream, which is related to changes in lithology from intrusive igneous rocks to sedimentary rocks, accompanied by an increase in weathering intensity. The correlation test shows a very strong relationship between TDS and pH ( $r = 0.975$ ), as well as a significant relationship between water quality parameters with lithology and weathering levels. The results of the regression analysis show that lithology contributes to TDS variations by (84.1%), while the level of weathering affects pH variations by (71.4%). These findings confirm that geological factors play a dominant role in controlling the hydrogeochemical characteristics of river water through the process of mineral dissolution and ion release. Furthermore, the presence of sulfide minerals such as pyrite contributes to increased dissolved ions through natural oxidation processes. Furthermore, anthropogenic activities also contribute to variations in water quality. TDS (17–63 mg/L) and pH (6.6–7.9) indicate that the Auya River water quality remains within clean water quality standards. This study emphasizes the importance of geological aspects as a basis for water quality management in areas with high geological complexity.

**Keywords:** lithology, TDS, pH, river water quality, hydrogeochemistry, Auya River.

## 1. Introduction

River water quality is an important indicator used to assess the condition of the aquatic environment and the ecosystem of water resources utilized by humans and other organisms. Water quality evaluation is generally conducted through measuring physical and chemical parameters that can describe the natural condition of the water and the influence of environmental factors on the hydrological system. Among these parameters, Total Dissolved Solids (TDS) and pH are often used as primary indicators to understand the chemical characteristics of water because they are closely related to the geochemical processes that occur between water and the surrounding geological material. The TDS value indicates the total concentration of dissolved solids originating from mineral weathering, rock leaching processes, and the contribution of dissolved elements from the surrounding environment. Meanwhile, pH describes the level of acidity or alkalinity of water formed by chemical reactions and ion balance in the aquatic system (Gaur et al., 2022; Duan et al., 2023). Therefore, analysis of TDS and pH parameters can provide a clearer picture of the hydrogeochemical dynamics of water in a river basin.

Various international studies have shown that geological and lithological conditions play a significant role

in controlling the chemical characteristics of water in natural aquatic systems. Differences in rock type, mineral composition, and the degree of rock weathering can influence the mineral dissolution process, which then determines the concentration of dissolved ions in water. Hydrogeochemical studies have shown that the interaction between water and rock is the primary mechanism controlling variations in TDS, pH, and water chemical composition in natural aquatic environments (Islam & Mostafa, 2024; Basharat et al., 2025). Furthermore, studies conducted in aquifer systems and karst areas also indicate that lithological characteristics have a significant influence on water quality through various geochemical processes, such as carbonate mineral dissolution, ion exchange, and the ongoing chemical weathering of rocks within the geological system (Duan et al., 2023). This demonstrates that lithology is a fundamental factor determining the hydrogeochemical characteristics of water in a region.

In the context of research in Indonesia, the relationship between geological conditions and water quality also shows a similar trend. Variations in lithology are known to influence the chemical properties of water through interactions between water and the rocks that make up the watershed. Research conducted by Hartanto et al. (2023) shows that the distribution of lithology in a region can control the hydrogeochemical characteristics of

groundwater through weathering and mineral leaching processes. Furthermore, several other studies have also revealed that water quality parameters such as TDS, pH, and turbidity can experience variations influenced by geological conditions and land use activities around the watershed (Ayuningrum et al., 2023; Ayu et al., 2024). In the Papua region itself, research on water quality generally focuses more on assessing water quality status or the level of water pollution, without examining in-depth the relationship to local geological conditions (Rumabar & Gaspersz, 2024; Iriyanto et al., 2022).

However, research specifically examining the relationship between lithology and the hydrogeochemical characteristics of river water in Papua is still relatively limited. This is despite the fact that Papua has complex geological diversity and has the potential to cause variations in water chemistry characteristics in each river basin. Several previous studies have shown that variations in lithology can have a significant influence on dissolved mineral content in water and determine TDS and pH values through weathering processes and rock geochemical reactions (Tuska et al., 2025). However, research specifically examining the control of lithology on river water quality parameters in the Obano area, Paniai Regency, Central Papua, is still very rare. This condition indicates a research gap that needs further study to gain a more comprehensive understanding of the relationship between geological conditions and water quality in the region. This study offers a novelty in the form of integrating quantitative statistical analysis with a geological approach to explain the control of lithology on river water quality in the Papua region, which until now has received limited comprehensive study.

Based on this background, this study aims to analyze the influence of lithology on variations in Total Dissolved Solids (TDS) and pH in Auya River water in the Obano area, Paniai Regency, Central Papua. In more detail, this study is directed to: (1) identify the lithological conditions that develop in the research area, (2) analyze variations in TDS and pH values in Auya River water, and (3) explain the relationship between lithological characteristics and variations in TDS and pH values of the river water. The results of this study are expected to provide scientific contributions in enriching the understanding of the relationship between geological conditions and river water quality, especially in the Papua region which still has limited hydrogeochemical data. In addition, the findings of this study are also expected to provide basic information for water resource management and river water quality monitoring activities by local governments and communities who use Auya River water.

## 2. Regional Geology

This research was conducted in Obano District, Paniai Regency, Central Papua Province. Geologically, the area is included in the Enarotali Sheet Regional Geological Map, which shows the variety of rock units that make up the study area. The geological information on the map shows that the Obano area has a diverse lithology, formed through different geological processes, both related to magmatic activity and sedimentation. This lithological diversity plays a significant role in influencing the physical environmental conditions and the dynamics of the hydrological system that develops in the study area.

One of the rock units encountered is the Timepa Monzonite Formation (Tmpt), which is dominated by intrusive igneous and volcanic rocks. This formation is

composed of several rock types, including quartz diorite, monzonite, porphyry diorite, quartz andesite, and muscovite-biotite granite. The presence of these rocks indicates that this region experienced significant magmatic activity in a previous geological period. Furthermore, the Kemelangan Group (JKk) is a clastic sedimentary rock unit. This group is primarily composed of siltstone, which in the northern part has undergone deformation to transform into slate. This unit also contains layers of alternating siltstone and sandstone, and locally, muddy limestone, reflecting variations in the depositional environment during its formation. Another geological unit is the Lake Sediment (Ql), which generally consists of loose sediments in the form of mud and sand formed through depositional processes in a lake environment.

The selection of research locations focused on river basin (DAS) areas, taking into account the geological conditions developing in the area and the presence of human activity in the surrounding area. This consideration is important because the lithological characteristics and land use patterns around the watershed can influence environmental conditions and the dynamics of the water system developing in the study area.

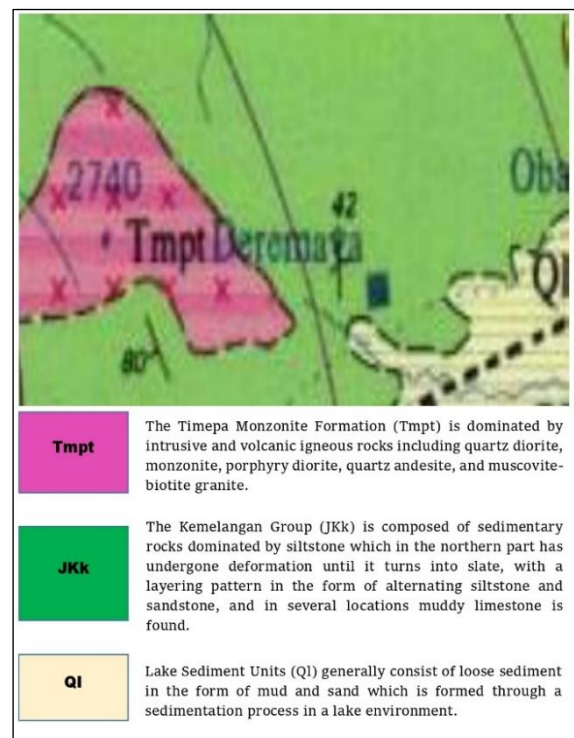


Fig 1. Regional Research Area

## 3. Research Methods

This study uses a descriptive quantitative approach to analyze the relationship between geological conditions, particularly lithology and rock weathering levels, with variations in river water quality parameters represented by Total Dissolved Solids (TDS) and pH. The quantitative approach is used to obtain numerical data from field measurements and statistical analysis, while the descriptive approach is used to explain the relationship between geological conditions and hydrogeochemical characteristics of river water.

The research was conducted in the Auya River, Obano District, Paniai Regency, Central Papua Province, which is geologically composed of intrusive igneous and

sedimentary rocks with varying degrees of weathering. Data collection was conducted through field surveys at six observation points (ST01–ST06) representing variations in lithology and environmental conditions along the river flow. At each point, lithology types were identified, rock weathering levels were observed, and environmental conditions such as vegetation and human activities around the river were recorded. In addition, direct measurements of water quality parameters in the form of TDS and pH were carried out using a portable water quality meter.

The data obtained were then analyzed using several statistical methods. Descriptive analysis was used to describe the characteristics of water quality data through minimum, maximum, average, and standard deviation values. Furthermore, Pearson and Spearman correlation analyses were performed to determine the relationship between TDS, pH, and the level of rock weathering. To determine the effect of weathering level on changes in water quality, simple linear regression analysis was used, with weathering level as the independent variable and TDS and pH as the dependent variables.

The results of the statistical analysis were then interpreted geologically, taking into account lithology, rock weathering, the presence of sulfide minerals such as pyrite, and anthropogenic activity around the watershed. This approach was used to identify the main factors controlling variations in water quality in the Auya River.

## 4. Results and Discussion

### 4.1 Geological Conditions of the Research Area

The study area, located around the Auya River in Obano District, Paniai Regency, Central Papua, is generally composed of several main lithological units, including intrusive igneous rocks, sandstone, and loose sand. Intrusive igneous rocks are predominantly found in the upper reaches of the river and generally exhibit a relatively low level of weathering. Several rock outcrops show the development of fractures or joints in the rock body, and sulfide minerals such as pyrite are found in some parts of the rock.

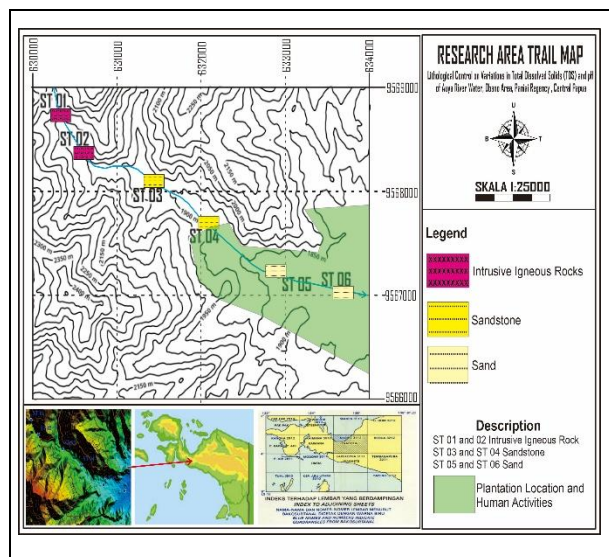


Fig 2. Map of the Research Area Location

Entering the middle to downstream parts of the study area, the lithology changes, becoming dominated by sedimentary rocks in the form of sandstone and loose sand deposits. The rocks in this zone generally exhibit moderate

to high levels of weathering. This indicates that weathering and erosion processes are more intense in this area. The weathering processes occurring in these sedimentary rocks contribute to the increased release of dissolved elements and minerals into the river flow.

Besides being controlled by geological factors, the geomorphology of the study area is also characterized by the presence of quite diverse vegetation with densities ranging from moderate to dense. Furthermore, anthropogenic activity, such as plantations and community activities, was also found in several locations around the Auya River. The interaction between lithological variations, rock weathering levels, and the influence of human activities collectively influence the characteristics of river water quality in the study area.

### 4.2 Field Data Results

The results of field observations at six station points (ST01–ST06) show variations in geological and environmental conditions and water quality parameters that form a gradual change pattern from the upstream to the downstream of the Auya River.

At (Station ST01), the TDS value was recorded at (17 mg / L) with (pH 6.60), which reflects the low dissolved substance content and water conditions that tend to be neutral. The lithology at this location is dominated by intrusive igneous rocks with a low level of weathering, and is supported by dense heterogeneous vegetation. Morphologically, the rocks show the presence of joint structures or cracks, and pyrite minerals were found in the rock body, which indicates that the rock conditions are still relatively fresh and have not experienced intensive weathering.

At (Station ST02), there was an increase in TDS value to (31 mg/L) with (pH 7.21). The lithology is still intrusive igneous rock with a low level of weathering and dense heterogeneous vegetation. The field characteristics are relatively similar to (ST01), characterized by the presence of cracks/joints and pyrite minerals, which have the potential to be a source of dissolved ions although their contribution is still limited.

Entering (Station ST03), the lithology changes to sandstone with a moderate level of weathering. The TDS value increases to (38 mg/L) and the pH to (7.46). In addition to geological influences, human activity and plantation activities are beginning to be seen at this location, which have the potential to affect environmental conditions. In addition, pyrite mineral deposits were found in igneous rock fragments, indicating a contribution of material from the original rock.

At (Station ST04), the lithology remains dominated by sandstone with a moderate level of weathering. The TDS value increased quite significantly to (55 mg/L), with a (pH 7.75). Vegetation is still classified as dense heterogeneous, but human activities and plantations are still found, which have the potential to increase the input of dissolved materials into the water system. The presence of pyrite deposits in rock fragments is also still identified.

Next, at (Station ST05), the lithology changes to loose sand material with a moderate level of weathering and moderate heterogeneous vegetation. The TDS value reaches (60 mg/L) with a pH of (7.82). At this location, the intensity of human and plantation activities is relatively high, which has the potential to increase the content of dissolved substances in the water. In addition, the presence of pyrite mineral deposits in rock chunks is still found.

At (Station ST06), which represents the downstream section, the TDS value reached (63 mg/L) with (pH 7.93), as the highest value of all observation points. The lithology is sand with a high level of weathering and moderate heterogeneous vegetation. Human activities and plantations are also classified as intensive at this location. These conditions, together with the presence of pyrite mineral deposits, indicate that more intense weathering processes and environmental influences contribute to increased dissolved substance content and changes in water chemical characteristics.

Overall, field data shows a trend of increasing TDS and pH values from upstream to downstream, consistent with changes in lithology from intrusive igneous rock to sedimentary rock and loose material, increased weathering rates, and the intensity of human activity. The interaction of these factors is the primary driver of water quality variations in the Auya River.

#### 4.3 Descriptive Statistical Analysis

Based on the results of descriptive statistical data processing, all variables were analyzed with a uniform sample size (N = 6). In general, the data distribution shows a fairly wide variation in values, particularly for the TDS parameter. In contrast, other variables display a relatively more homogeneous distribution pattern.

- **Total Dissolved Solids (TDS)**  
The TDS value is in the range of (46.0), with a minimum value of (17.0) and a maximum of (63.0). The total (sum) of (264.0) produces an average value (mean) of (44,000). The high standard deviation value (18.2866) and variance (334,400) indicate that the TDS data has a fairly large level of spread. This indicates a significant variation in dissolved substance content between observation locations, which is likely influenced by different geological conditions in the study area.
- **pH**  
The pH parameter has a relatively small range of values, namely (1.3), with a minimum value of (6.6) and a maximum of (7.9). The total value of (44.8) produces an average of (7.462). The low standard deviation (0.4973) and variance (0.247) indicate that the pH variation between samples is relatively small. Thus, the acidity condition of the water is relatively stable and is in the neutral to slightly alkaline range.
- **Lithology Type**  
The lithology type variable has a range of values of (2.0), with a minimum value of (1.0) and a maximum of (3.0). The total value of (12.0) produces an average of (2.000). The standard deviation value of (0.8944) and variance (0.800) indicate the existence of a fairly clear category of lithology diversity. This indicates that the research area is composed of several different rock types.
- **Weathering Level**  
The weathering level has a range of values of (2.0), with a minimum value of (1.0) and a maximum of (3.0). The total value of (11.0) produces an average of (1.833). The standard deviation value of (0.7528) and variance (0.567) indicate that the level of weathering variation is in the moderate category. This condition indicates that the level of rock weathering in the research area varies from low to quite high.

Overall, the TDS parameter exhibited the greatest degree of variation compared to other variables, as evidenced by its high range, standard deviation, and variance. This indicates that the dissolved substance

content in water is significantly influenced by environmental conditions and local geological factors.

pH parameters were relatively stable, so the water chemistry did not experience significant changes. Meanwhile, variations in lithology and weathering levels reflect the heterogeneity of geological conditions in the study area, which have the potential to be major factors in controlling variations in water quality, particularly TDS values.

Table 1. Descriptive Statistics Analysis

|                    | Descriptive Statistics |       |                |                  |       |
|--------------------|------------------------|-------|----------------|------------------|-------|
|                    | TDS                    | pH    | Lithology Type | Weathering Level | Valid |
| N                  | 6                      | 6     | 6              | 6                | 6     |
| Range              | 46.0                   | 1.3   | 2.0            | 2.0              |       |
| Min                | 17.0                   | 6.6   | 1.0            | 1.0              |       |
| Max                | 63.0                   | 7.9   | 3.0            | 3.0              |       |
| Sum                | 264.0                  | 44.8  | 12.0           | 11.0             |       |
| Mean               | 44,000                 | 7,462 | 2,000          | 1,833            |       |
| Standard Deviation | 18.2866                | .4973 | .8944          | .7528            |       |
| Variance           | 334,400                | .247  | .800           | .567             |       |

#### 4.4 Hydrogeochemical Characteristics and Lithological Controls

The hydrogeochemical characteristics of the Auya River are significantly influenced by the lithology of the watershed and the degree of rock weathering occurring in the area. These two geological factors play a crucial role in controlling the dissolution of minerals and the release of chemical elements into the water system.

In areas dominated by intrusive igneous rocks with relatively low weathering rates, TDS values tend to be lower. This occurs because the mineral dissolution process in these rocks is still limited, resulting in relatively few dissolved ions entering the water. Although some rock structures contain fractures and joints that serve as water infiltration pathways, the contribution of dissolved minerals resulting from these processes is still relatively low.



Fig 3. Appearance of the Joints at ST01 (Left) and ST02 (Right)

Conversely, in areas composed of sandstone and sandy materials with moderate to high levels of weathering, TDS values generally show an increasing trend. This is related to the higher intensity of physical and chemical weathering processes in these sedimentary rocks. This weathering process releases mineral ions into the river flow, increasing the concentration of dissolved substances in the water.

Furthermore, the presence of sulfide minerals such as pyrite at the study site also has the potential to influence the water's chemical characteristics. The oxidation process of these sulfide minerals can produce various dissolved ions, which then contribute to changes in the water's chemical composition. Therefore, variations in lithology and the degree of rock weathering can be considered the main factors controlling the hydrogeochemical characteristics of the Auya River water in the study area.

#### 4.5 Pearson Correlation Test Analysis

Pearson correlation analysis was used to evaluate the relationship between the parameters TDS, pH, Lithology type and level of rock weathering at the research location.

Table 2. Pearson Correlation Test Analysis

|                |                     | Correlations |         |                |                  |
|----------------|---------------------|--------------|---------|----------------|------------------|
|                |                     | TDS          | pH      | Lithology Type | Weathering Level |
| TDS            | Pearson Correlation | 1            | .975 ** | .917 *         | .857 *           |
|                | Sig. (2-tailed)     |              | .001    | .010           | .029             |
|                | N                   | 6            | 6       | 6              | 6                |
| pH             | Pearson Correlation | .975 **      | 1       | .872 *         | .845 *           |
|                | Sig. (2-tailed)     | .001         |         | .023           | .034             |
|                | N                   | 6            | 6       | 6              | 6                |
| Lithology Type | Pearson Correlation | .917 *       | .872 *  | 1              | .891 *           |
|                | Sig. (2-tailed)     | .010         | .023    |                | .017             |
|                | N                   | 6            | 6       | 6              | 6                |
| Weathering     | Pearson Correlation | .857 *       | .845 *  | .891 *         | 1                |
|                | Sig. (2-tailed)     | .029         | .034    | .017           |                  |
|                | N                   | 6            | 6       | 6              | 6                |

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

#### Interpretation of Relationships Between Variables

- Relationship of TDS with Other Variables**

The relationship between TDS and pH shows a correlation coefficient value of ( $r = 0.975$ ) with ( $p = 0.001$ ), which indicates a very strong and significant correlation at the (99%) confidence level ( $\alpha=0.01$ ). This condition suggests that an increase in TDS values tends to be followed by a consistent increase in pH.

Furthermore, the relationship between TDS and lithology type has a value ( $r = 0.917$ ) with ( $p=0.010$ ), which is included in the category of very strong and significant correlation at the level (5%) ( $\alpha=0.05$ ). This finding indicates that differences in lithology types have a large influence on the concentration of dissolved substances.

Meanwhile, the correlation between TDS and the level of weathering was recorded at ( $r=0.857$ ) with ( $p=0.029$ ), which is categorized as strong and significant. This indicates that the higher the level of rock weathering, the TDS value also tends to increase.

- Relationship between pH and Geological Variables**

The correlation between pH and lithology type showed a value of ( $r=0.872$ ) with ( $p=0.023$ ), which is considered strong and significant. This indicates that variations in lithology play a role in influencing the chemical balance of water.

The relationship between pH and weathering level yielded a value of ( $r=0.845$ ) with ( $p=0.034$ ), which is also included in the strong and significant category. This finding confirms that the rock weathering process also contributes to changes in water acidity.

- Relationship between Geological Variables**

The relationship between lithology type and weathering level shows a correlation coefficient value of ( $r=0.891$ )

with ( $p=0.017$ ). This value reflects a very strong and significant correlation, so it can be interpreted that lithology characteristics are closely related to the intensity of weathering that occurs.

Scientifically, the results of this analysis indicate that geological factors, particularly lithology type and weathering level, play a dominant role in controlling water quality parameters, namely TDS and pH. Rock weathering processes are known to contribute to the release of ions into the water, ultimately increasing TDS values. Furthermore, the mineral composition of rocks also influences the geochemical reactions that occur, thus directly impacting pH variations.

#### 4.6 Linear Regression Analysis

Linear regression analysis is a statistical technique used to examine relationships between variables, identify the influence of independent variables on dependent variables, and estimate or predict the value of one variable based on other variables. Therefore, this method plays a crucial role in quantitative research, including geological studies and water quality analysis.

#### Relationship between TDS and Lithology Type

Table 3. Summary Model Test

The correlation coefficient (R) value of (0.917) indicates a strong relationship. Meanwhile, the coefficient of determination ( $R^2$ ) value of (0.841) or (84.1%) indicates that most of the TDS variation can be explained by the lithology type variable. The adjusted  $R^2$  value of (0.801) strengthens this finding. Thus, approximately (15.9%) of

| Model Summary |                   |          |                   |                                |
|---------------|-------------------|----------|-------------------|--------------------------------|
| Model         | R                 | R Square | Adjusted R Square | Standard Error of the Estimate |
| 1             | .917 <sup>a</sup> | .841     | .801              | 8.1509                         |

a. Predictors: (Constant), Lithology Type

TDS variation is influenced by factors outside the model, such as weathering levels, flow discharge, and anthropogenic activities.

Table 4. ANOVA test

| ANOVA <sup>a</sup> |                |    |             |        |                   |
|--------------------|----------------|----|-------------|--------|-------------------|
| Model              | Sum of Squares | df | Mean Square | F      | Sig.              |
| 1 Regression       | 1406.250       | 1  | 1406.250    | 21,167 | .010 <sup>b</sup> |
| Residual           | 265,750        | 4  | 66,437      |        |                   |
| Total              | 1672,000       | 5  |             |        |                   |

a. Dependent Variable: TDS  
b. Predictors: (Constant), Lithology Type

The ANOVA test results showed an F value of (21.167) with a significance of (0.010) ( $<0.05$ ). This indicates that the regression model used has statistical significance, so that the lithology type variable as a whole has an effect on TDS variations.

Table 5. Coefficient Analysis

| Model            | Coefficients <sup>a</sup>   |                           |       |       | Collinearity Statistics |       |
|------------------|-----------------------------|---------------------------|-------|-------|-------------------------|-------|
|                  | Unstandardized Coefficients | Standardized Coefficients | t     | Sig.  | Tolerance               | VIF   |
|                  | B                           | Beta                      |       |       |                         |       |
| (Constant)       | 6,500                       | .738                      |       | .804  |                         |       |
| 1 Lithology Type | 18,750                      | .917                      | 4,601 | 4,075 | .010                    | 1,000 |

a. Dependent Variable: TDS

- Regression Equation**

Based on the results of the coefficient analysis, the constant value (a) was (6.500) and the regression coefficient (b) was (18.750). Thus, the regression equation formed is:

$$TDS = 6,500 + 18,750 (\text{Lithology Type})$$

This equation shows that every one-unit increase in the lithology variable will increase the TDS value by (18.75). Meanwhile, the constant value of (6.500) represents the TDS condition when the lithology value is at zero.

- Significance Test Variable (t-Test)

The t-test value of (4.601) with a significance of (0.010 < 0.05) indicates that the lithology type variable has a significant effect on TDS. This confirms that lithology is one of the main factors controlling variations in water quality, particularly in terms of dissolved substance content.

- Beta Coefficient (Standardized)

The beta coefficient value of (0.917) indicates that the influence of lithology type on TDS is very strong and unidirectional (positive), so that changes in lithology directly result in changes in TDS values.

- Multicollinearity Test

A tolerance value of (1.000) and a VIF of (1.000) indicate no indication of multicollinearity in the model. This condition is understandable considering the model only involves one independent variable.

Based on the statistical analysis, it can be concluded that lithology type has a very strong and significant influence on Total Dissolved Solids (TDS) values in river water. This is indicated by a high correlation value ( $r = 0.917$ ) and significance test results that meet statistical criteria ( $p = 0.010 < 0.05$ ).

In addition, the coefficient of determination ( $R^2 = 0.841$ ) shows that (84.1%) of the TDS variation can be explained by variations in lithology types, while the remainder is influenced by other factors outside the model. The regression equation obtained also shows that an increase in lithology values is directly proportional to an increase in TDS values.

Overall, these results confirm that lithological characteristics are the main factors controlling river water quality, especially in determining the dissolved substance content, which is closely related to the mineral composition and rock weathering processes in the study area.

#### Relationship between pH and Weathering Rate

Table 6. Summary Model Test

| Model | Model Summary     |          |                   |                                |
|-------|-------------------|----------|-------------------|--------------------------------|
|       | R                 | R Square | Adjusted R Square | Standard Error of the Estimate |
| 1     | .845 <sup>a</sup> | .714     | .642              | .2974                          |

a. Predictors: (Constant), Weathering Rate

The R value of (0.845) indicates a strong relationship between the variables. The coefficient of determination ( $R^2$ ) of (0.714) or (71.4%) indicates that most of the pH variation can be explained by the level of weathering. The adjusted ( $R^2$ ) value of (0.642) further strengthens this finding. Thus, approximately (28.6%) of the pH variation is influenced by factors outside the model, such as mineral composition, water-rock interactions, and local environmental conditions.

Table 7. ANOVA test

| Model      | ANOVA <sup>a</sup> |    |             |       |                   |
|------------|--------------------|----|-------------|-------|-------------------|
|            | Sum of Squares     | df | Mean Square | F     | Sig.              |
| Regression | .883               | 1  | .883        | 9,984 | .034 <sup>b</sup> |
| 1 Residual | .354               | 4  | .088        |       |                   |
| Total      | 1,237              | 5  |             |       |                   |

a. Dependent Variable: pH  
b. Predictors: (Constant), Weathering Rate

The ANOVA test results showed an F value of (9.984) with a significance level of ( $0.034 < 0.05$ ). This indicates that the regression model used is statistically significant, so that the overall weathering level influences pH variations.

Table 8. Coefficient Analysis

| Model              | Coefficients <sup>a</sup>   |            |                           |        | Collinearity Statistics |           |       |
|--------------------|-----------------------------|------------|---------------------------|--------|-------------------------|-----------|-------|
|                    | Unstandardized Coefficients |            | Standardized Coefficients | t      | Sig.                    | Tolerance | VIF   |
|                    | B                           | Std. Error | Beta                      |        |                         |           |       |
| (Constant)         | 6,438                       | .346       |                           | 18,613 | .000                    |           |       |
| 1 Weathering Level | .558                        | .177       | .845                      | 3,160  | .034                    | 1,000     | 1,000 |

a. Dependent Variable: pH

- Regression Equation

Based on the results of the coefficients, the constant value (a) was obtained as (6.438) and the regression coefficient (b) was (0.558). Thus, the regression equation formed is:

$$pH = 6.438 + 0.558 (\text{Decomposition Level})$$

This equation shows that each unit increase in the weathering rate will increase the pH value by (0.558). The constant value of (6.438) represents the basic pH condition when the weathering rate is zero.

- Significance Test Variable (t-Test)

The t-test value of (3.160) with a significance of ( $0.034 < 0.05$ ) indicates that the weathering level variable has a significant effect on pH. Thus, the rock weathering process can be considered as one of the main factors influencing the degree of water acidity.

- Beta Coefficient (Standardized)

The beta coefficient value of (0.845) indicates that the influence of the weathering level on pH is strong and unidirectional, so that changes in the weathering level will be followed by changes in pH in the same direction.

- Multicollinearity Test

The tolerance value of (1,000) and VIF of (1,000) indicate that there are no symptoms of multicollinearity in the model, which is a normal condition considering there is only one independent variable.

Based on the results of statistical data processing, it can be concluded that the level of weathering shows a strong and significant influence on the pH value of water. This is reflected in the large value of the correlation coefficient ( $r=0.845$ ) and the level of significance that is below the specified limit ( $p=0.034 < 0.05$ ), so that the relationship formed can be stated as statistically significant.

Furthermore, the coefficient of determination ( $R^2 = 0.714$ ) indicates that (71.4%) of the pH variation can be explained by the weathering level variable, while the remaining proportion is influenced by other factors outside the model used. The results of the regression equation obtained also show a tendency that an increase in weathering intensity will be followed by an increase in pH values.

Overall, these findings confirm that the rock weathering process plays an important role as a controlling factor in water chemical conditions, especially in determining the degree of acidity (pH), which occurs through the process of releasing weathered minerals into the water system.

#### 4.7 The Influence of Anthropogenic Activities and the Environment

Based on the results of the regression analysis, it can be concluded that geological factors reflected through the level of weathering and lithology types play a major role in controlling the water quality of the Auya River. This is

supported by the relatively high coefficient of determination values, namely (71.4%) for pH and (84.1%) for TDS, which indicate that most of the variations in both parameters are controlled by natural processes, especially the interaction between water and rocks. In this case, the weathering process functions as the main mechanism that releases mineral ions into the water, thus directly affecting the chemical balance, especially the degree of acidity (pH) and the concentration of dissolved substances (TDS).

However, there was still a remaining variation of (28.6%) in pH and (15.9%) in TDS that could not be explained by geological factors. This proportion indicates the influence of other factors, which in this study were associated with anthropogenic activities. Beyond geological control, the water quality of the Auya River is also affected by various human activities that occur around the study area. At several observation points, particularly at stations five to six, plantation activities and community activities were found along the river flow.

These activities have the potential to increase the influx of various types of materials into aquatic systems, such as organic matter, sediment, and certain chemical elements. The presence of these materials can increase the concentration of dissolved solids and affect the chemical balance of the water, although their contribution is relatively small compared to the influence of geological factors. Therefore, anthropogenic factors can be viewed as additional components that play a role in modifying the natural conditions that have been formed by lithology and weathering processes.

On the other hand, variations in vegetation conditions at each observation location also contribute to the environmental dynamics surrounding the river. Differences in vegetation density and type influence water infiltration into the soil, surface erosion rates, and sediment transport mechanisms. These factors indirectly affect water quality through changes in sediment load and dissolved material content carried into the river flow.

Overall, the water quality of the Auya River is the result of an interaction between natural and external factors. However, geological factors remain the primary controlling factor, while anthropogenic activity and vegetation conditions serve as supporting factors that influence water quality variations at the local scale.

#### 4.8 Factors Affecting River Water Quality

Based on the analysis, the water quality of the Auya River is influenced by several key factors that interact within the watershed's environmental system. The first factor is the lithology of the area, as the mineral characteristics and rock composition can determine the amount of dissolved elements entering the water.

The next factor is the degree of rock weathering, which plays a role in the release of minerals from the rock into the aquatic system. The more intensive the weathering process, the greater the potential for dissolved minerals to be carried by river flow. Furthermore, the presence of sulfide minerals such as pyrite is also important because the oxidation process of these minerals can produce dissolved ions that affect the chemical composition of the water.

In addition to geological factors, anthropogenic activities around river basins also contribute to changes in water quality. Various human activities can introduce organic material, sediment, and certain chemical elements into water systems.

In addition, vegetation conditions and the characteristics of the surrounding environment also play a

role in controlling the processes of infiltration, erosion, and sediment transport along the river flow.

The interaction of these various factors together causes variations in TDS and pH values at each observation point in the Auya River.

#### 4.9. Comparison of Clean Water Quality Standards

Based on the reference to clean water quality standards, the permitted Total Dissolved Solids (TDS) levels for drinking water generally do not exceed (500 mg/L), while the pH value considered ideal is in the range (6.5–8.5). This provision refers to (Regulation of the Minister of Health of the Republic of Indonesia No. 492 of 2010) which was later updated through (Permenkes No. 2 of 2023), which regulates the physical-chemical parameters of drinking water to make it suitable for consumption. On the other hand, (Government Regulation of the Republic of Indonesia No. 22 of 2021) stipulates that the pH quality standard for river water is in the range (6–9), thus still providing room for natural variations that occur in the water system.

The measurement results on Auya River water show that the TDS value ranges between (17–63 mg/L), while the pH is in the range (6.6–7.9). This value not only meets the criteria for drinking water, but is also far below the TDS threshold for river water which in various water quality literature can reach around ( $\pm 1000$  mg/L) under certain conditions. This indicates that the concentration of dissolved substances in the Auya River is still relatively low, while the pH value shows a relatively stable condition in the neutral to slightly alkaline range according to applicable standards.

Based on this comparison, it can be concluded that the water quality of the Auya River, when viewed from the TDS and pH parameters, is generally in the good category and meets the requirements for clean water. This condition reflects that the characteristics of the waters at the research location are still dominated by natural processes, particularly the interaction between water and rock material, without any indication of significant pollution pressure. Nevertheless, environmental management remains necessary in order to maintain the stability of water quality and anticipate the possibility of increased pollution in the future, especially that which potentially originates from human activities around the river basin.

Table 9. Water Quality Standards

| No | Parameter                    | Unit | Quality Standards (Standards)        | Information                                       |
|----|------------------------------|------|--------------------------------------|---|
| 1  | Total Dissolved Solids (TDS) | mg/L | ≤ 500 mg/L (drinking water)          | Shows the amount of dissolved substances in water |
|    |                              |      | ≤ 1000 mg/L (river water class I-II) | General limits for river water quality            |
| 2  | pH                           | -    | 6 – 9 (river water)                  | Based on national quality standards               |
|    |                              |      | 6.5 – 8.5 (drinking water)           | Ideal range for consumption                       |

#### 5. Conclusion

Based on a series of analyses including field observations, statistical data processing, and geological studies, it can be concluded that the water quality of the Auya River in Obano District is predominantly influenced by geological factors, particularly the type of lithology and the degree of rock weathering. These two variables function as primary controls in the hydrogeochemical processes that

determine the concentration of Total Dissolved Solids (TDS) and the acidity (pH) of the river water.

Spatially, the pattern of water quality changes shows a consistent trend from upstream to downstream, with TDS and pH values increasing. This condition correlates with changes in lithology, from relatively fresh intrusive igneous rocks in the upstream to sedimentary rocks and loose materials with a higher degree of weathering in the middle to downstream. Fresh igneous rocks generally contribute only a small amount of dissolved ions, while sedimentary rocks that have undergone intensive weathering tend to release more minerals into the water, thereby increasing the dissolved substance content.

These findings are supported by statistical analysis. The strong correlation between TDS and pH ( $r=0.975$ ), as well as the significant correlation between water quality parameters and lithology and weathering level, indicate that the interaction between water and rock is the primary mechanism controlling the chemical characteristics of river water. Furthermore, the regression results indicate that (84.1%) of TDS variation is influenced by lithology type, while (71.4%) of pH variation is explained by weathering level. This confirms the dominance of rock composition over dissolved substance content and the importance of weathering processes in regulating water chemistry.

Thus, lithology can be viewed as the primary factor determining mineral resources, while weathering acts as a mechanism for releasing these minerals into the aquatic system. The interaction of these two factors results in the unique hydrogeochemical characteristics of the Auya River.

Beyond geological factors, this study also shows the additional influence of anthropogenic activities and vegetation conditions. Human activities, particularly downstream, have the potential to increase the input of organic material and sediment into river flow. However, this contribution is relatively small compared to the influence of geological factors, which remain the primary drivers of the system.

In terms of quality, TDS (17–63 mg/L) and pH (6.6–7.9) indicate that the Auya River water is still considered good and meets standards for clean water, both for river water and drinking water. This indicates that the water is still dominated by natural processes and has not experienced significant pollution pressure. Conceptually, this research confirms that river water quality in areas with high geological complexity, such as Papua, is closely related to lithological characteristics and weathering intensity. Therefore, water resource management needs to be based on an understanding of geology, coupled with control of human activities to maintain the system's natural balance.

This sample size is relatively limited ( $N=6$ ) due to accessibility constraints in the study area. Therefore, the results are exploratory and require further testing with larger data sets to increase generalizability.

Ultimately, this research provides a scientific contribution in clarifying the relationship between geological conditions and water quality in the Papua region, while also confirming that a geology-based hydrogeochemical approach is key in understanding and maintaining the sustainability of river water quality.

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