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Chromophoric Dissolved Organic Matter (CDOM) and Dissolved Nutrients in Water Sources in North Bali

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ABSTRAK

Penelitian ini dilakukan dengan tujuan untuk menentukan absorbansi chromophoric dissolved organic matter (CDOM) dan konsentrasi nutrien terlarut di sumber air di Sanggalangit, Kecamatan Gerokgak, Kabupaten Buleleng yang terletak di Bali Utara, serta menganalisis pengaruh curah hujan terhadap sumber air ini. Subjek dalam penelitian ini adalah air yang diambil dari sumber air di Sanggalangit yang telah disaring menggunakan kertas saring GF/F 0,7 µm. Objek penelitian ini adalah absorbansi CDOM dan konsentrasi nutrien terlarut. Pengukuran absorbansi CDOM dan konsentrasi nutrien dilakukan dengan menggunakan instrumen spektrofotometer Ultraviolet Visible (UV-Vis). Dari nilai absorbansi yang diperoleh, kemudian dihitung parameter $S_{275-295}$, $S_{350-400}$, dan E_2:E_3. Hasil penelitian menunjukkan bahwa nilai dari $S_{275-295}$ dan $S_{350-400}$ menunjukkan kecenderungan nilai maksimum dan minimum yang terbalik dengan curah hujan. Curah hujan berpengaruh terhadap rasio E_2:E_3, tetapi tidak terlihat mempengaruhi konsentrasi nutrien terlarut (nitrat, nitrit, amonia, dan fosfat). Berdasarkan peraturan yang berlaku, kualitas air di sumber air Sanggalangit tergolong baik secara kimiawi.

ABSTRACT

The objective of this study was to determine the absorbance of chromophoric dissolved organic matter (CDOM) and dissolved nutrient concentration in a spring water located at Sanggalangit, Kecamatan Gerokgak, Kabupaten Buleleng in North Bali, and to analyze the effect of rainfall on the water. The subjects in this study were filtered spring water using 0.7 µm GF/F filter paper. The object of this research were CDOM absorbance and dissolved nutrients concentration. Absorbance and dissolved nutrients concentration was measured using UV-Vis spectrophotometer. The absorbance was then used to calculate $S_{275-295}$, $S_{350-400}$, and E_2:E_3. Results show that $S_{275-295}$ and $S_{350-400}$ have a negative trend with rainfall. Rainfall affects E_2:E_3 but does not influence dissolved nutrients concentration (nitrate, nitrite, ammonia, and phosphate) and pH parameters both in environmental conditions when it is raining or hot. According to the regulation, the quality of spring water is categorized good, chemically.

1. INTRODUCTION

In aquatic environments, chromophoric dissolved organic matter (CDOM) is the colored component of dissolved organic matter (DOM). CDOM absorbs solar radiation (UV) to protect biota from harmful UV radiation, and it is largely responsible for natural water's bio-optical properties (Wen et al., 2015). Because CDOM absorbs light, its presence can have a negative impact on primary productivity, but it can also have a positive impact on secondary productivity via photodegradation (Del Vecchio & Blough, 2002). CDOM has an impact on aquatic ecosystem productivity, water optical properties, and biochemical processes (Zhang et al., 2007). CDOM is a source of nutrition and energy for heterotrophic bacteria, which act as chemical environment intermediaries by producing organic acids and enhancing or alleviating toxic forms of heavy metals such as aluminum or mercury (Song et al., 2019).

CDOM can be measured using absorption and fluorescence methods in general. CDOM absorption measurements have previously been used to explain the dynamics of aquatic ecosystems. Weishaar et al. (2003) linked absorption changes to decreased humification and aromatization. CDOM is calculated using several factors, including photodegradation, microbial production, and organic matter decomposition (Lübben et al., 2009). CDOM photodegradation affects nutrient concentrations in water as well. CDOM photodegradation can generate NH_4^+ and PO_4^{3-} ions, which are essential nutrients for phytoplankton growth (Zhang et al., 2007).

Climate influences DOM in addition to photodegradation, but the dynamics in tropical and subtropical regions are poorly understood. Seasonal changes may have a greater influence on DOM quality

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in highly dynamic waters than tides and photodegradation (Catalán et al., 2014). In contrast to CDOM in rivers, which is dominated by humic acid, CDOM in water sources exhibits CDOM characteristics caused by microbiological processes (Birdwell & Summers, 2010).

It is critical to understand the characteristics and resources of CDOM in order to maintain the quality of groundwater and ecosystems (Birdwell & Summers, 2010). CDOM-related studies on water sources have not been conducted in Bali, despite the fact that they are frequently used for drinking water. Based on this, research into the effect of rainfall on CDOM and dissolved nutrients in Sanggalangit water sources is required.

2. MATERIALS AND METHODS

A drinking water source in Sanggalangit Village, Gerokgak District, Buleleng Regency, Bali, was sampled (Figure 1). Local residents frequently use this spring for untreated drinking water. Water samples were collected on January 4, 21, and 24, 2019. The water samples were filtered using a 0.7 mm GF/F filter and a hand vacuum pump before being placed in dark glass bottles. The sample bottle is then placed in an ice-cube-filled cooler, transported to the laboratory, and stored in the refrigerator at 0oC. The samples were allowed to reach room temperature before being measured for nutrient and absorbance parameters.

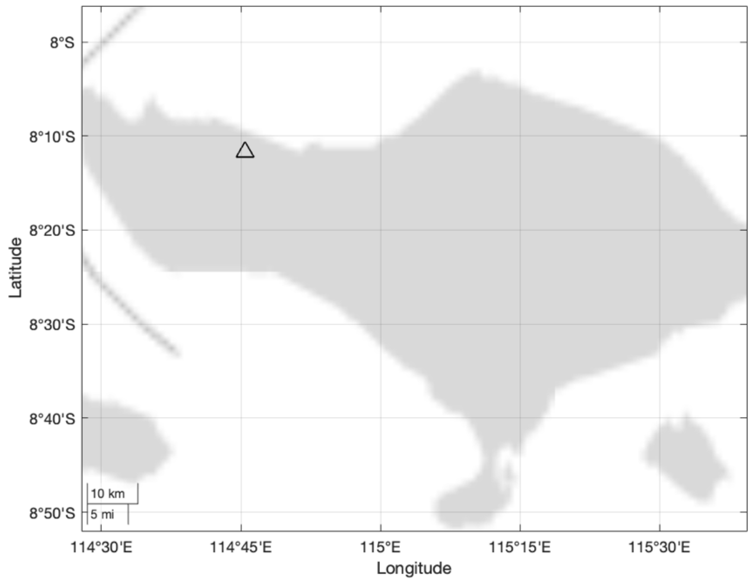

Fig. 1. Sampling Area at Sanggalangit (Δ).

CDOM absorbance was measured with a Shimadzu UV-1800 Spectrophotometer at a wavelength of 200-800 nm and a resolution of 0.5 nm. The spectral slope parameter is then calculated using CDOM absorbance data ($S_{275-295}$, $S_{350-400}$). The spectral slope is calculated using linear regression at the appropriate wavelength (Helms et al., 2008), as follows:

$$A(\lambda) = A(\lambda_0)e^{-S(\lambda-\lambda 0)}$$

Where A denotes absorbance at wavelength (nm), S denotes spectral slope, and 0 denotes the reference wavelength. Aside from the spectral slope, one of the parameters used to describe CDOM is the absorbance ratio at 254 nm and 365 nm (E_2: E_3). The dissolved nutrients (nitrate, nitrite, ammonia, and phosphate) were measured using a Shimadzu UV-1800 Spectrophotometer in accordance with the procedure and at the SNI wavelengths, namely nitrate at 220 nm and 275 nm (SNI 3554: 2015), nitrite at 190 nm-900 nm (SNI 3554: 2015), ammonium at 736 nm ((SNI-06-6989.31-2005). The results of nitrate, nitrite, ammonia, and phosphate concentration measurements are compared to the quality standards established by Regulation of the Minister of Health of the Republic of Indonesia Number 492/MENKES/PER/IV/2010 concerning Drinking Water Quality Requirements.

3. RESULTS AND DISCUSSION

Result

CDOM in springs can be analyzed by comparing the absorbance at a wavelength of 254 nm and 365 nm (E_2:E_3), as well as the absorbance spectral slope ($S_{275-295}$, $S_{350-400}$). Changes in each parameter calculated through the absorbance of the CDOM are shown in Table 1.

Table 1. CDOM Absorbance at The Water Source.

Date	$S_{275-295}$	$S_{350-400}$	E_2:E_3
4 Jan	0.000141463	2.09202×10^{-5}	4.33
21 Jan	0.000168641	4.63599×10^{-6}	5.25
24 Apr	0.000256098	4.49621×10^{-5}	3.9

This study also analyzed nutrient concentrations in water sources. The presence of nutrients has an important role in the abundance of phytoplankton. The growth of this phytoplankton is commonly used as an indicator of water quality and the level of fertility of a waters. The concentration of each nutrient is shown in Table 2.

Table 2. Nutrients Concentration at The Water Source.

Date	Dissolved Nutrient (mg/L)			
	Nitrate	Nitrite	Phosphate	Ammonia
4 Jan	0.013	0	0.102	0.062
21 Jan	0	0.001	0.127	0.034
24 Apr	0.045	0.001	0.127	0.040

Discussion

Effect of Rainfall on CDOM

Rainfall is one indicator of local climate change. Rainfall increased in the sampling area in Gerokgak District, Buleleng Regency, from December 2018 to March 2019, then decreased in April 2019 as the dry season began (Figure 2).

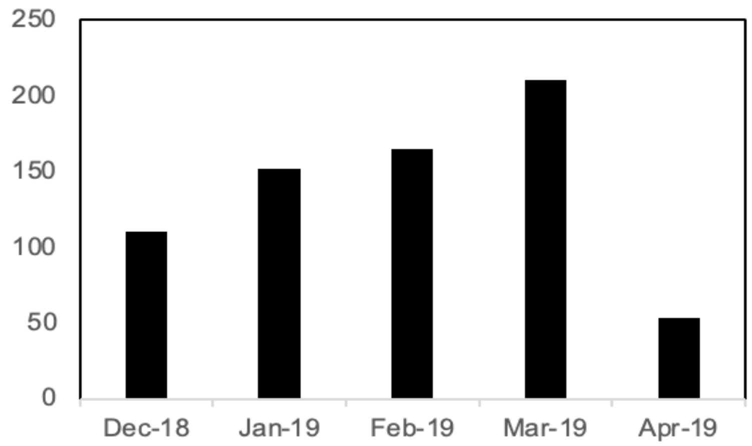

Fig. 2. Rainfall Data in Gerokgak District, Buleleng Regency.

DOM is a parameter used to calculate the amount of dissolved organic matter in water. The CDOM and TOC parameters were used in this study to represent the DOM analysis. CDOM was examined using the absorbance ratio at 254 nm and 365 nm (E_2:E_3), as well as the absorbance spectral slope ($S_{275-295}$, $S_{350-400}$).

E_2:E_3 values are related to rainfall. When the rainfall in January exceeds 150 mm, the absorbance ratio rises from early to late January. The E_2:E_3 ratio then fell in April as rainfall fell to 50 mm as summer approached (Figure 3a). Rainwater seeps into the soil layers until it reaches the springs when it rains. Rainwater containing dissolved materials or other materials on the surface will bind to soil organic matter, increasing the E_2:E_3 value. Strack et al. (2015) discovered that rain dissolves organic carbon in the soil, increasing the E_2:E_3 ratio, after studying changes in dissolved organic carbon due to peatland restoration over a 10-year period. Other research has found that rain does not always correlate with the $E_2:E_3$ ratio (Li et al., 2020), depending on the composition of organic matter in the soil.

One of the parameters in the CDOM analysis is $S_{275-295}$ and $S_{350-400}$. An increase in $S_{275-295}$ and $S_{350-400}$ values is associated with a decrease in molecular weight, an increase in DOM photodegradation, and a decrease in CDOM aromaticity (Helms et al., 2008). (Del Vecchio & Blough, 2002). The analysis revealed that the summer samples had higher values of $S_{275-295}$ and $S_{350-400}$ (Fig. 3b, 3c). This suggests that DOM undergoes increased photodegradation into smaller molecules during the summer.

CDOM's molecular composition and photochemical reactivity can be significantly altered by photodegradation (Mu et al., 2021). According to research, CDOM photodegradation can reduce the molecular weight and humic content (Zhuang et al., 2022). Furthermore, CDOM photodegradation can result in the production of low molecular weight organic compounds that can be used by microbes to release nutrients that phytoplankton can use as a source of nutrition. Photodegradation can also have an effect on CDOM's photochemical reactivity by increasing the rate of indirect photodegradation (Tang et al., 2021). Furthermore, the effect of photodegradation on the molecular composition of CDOM and photochemical reactivity may have significant implications for dissolved organic carbon transport in aquatic systems (Wagner & Jaffé, 2015).

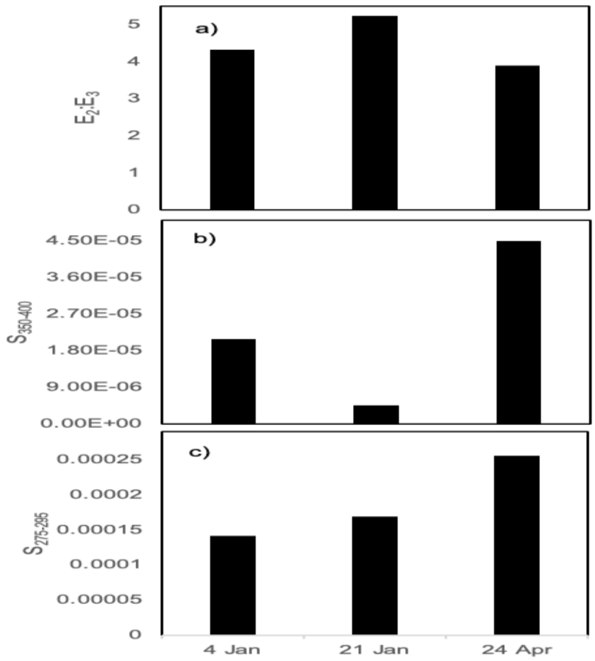

Fig. 3. Data of $S_{275-295}$ (a), $S_{350-400}$ (b), and $E_2:E_3$ (c) at The Water Source.

Effect of Rainfall on Dissolved Nutrients

The results of the measurements show that the concentration of nitrate in water sources is higher at the start of the dry season than it is during the rainy season (Figure 4a). This indicates that the soil around the water source does not contain a high concentration of nitrate, so rainwater that enters the soil does not dissolve nitrate and flows to the water source. Higher nitrate concentrations during the dry season indicate that plant remains are decomposing near water sources. However, measurements of nitrite concentrations in the three samples revealed no differences between the rainy and dry seasons (Figure 4b). Because nitrite is unstable in the presence of oxygen and is quickly oxidized to nitrate, it is usually found in very small amounts, much less than nitrate. The presence of nitrite demonstrates the ongoing biological process of organic matter decomposition with low dissolved oxygen levels (Trisnawulan et al., 2007). Nitrite (NO_2^-) is a nitrogen compound formed by Nitrosomonas bacteria in low dissolved oxygen conditions during the transition between ammonia and nitrate (nitrification) and between nitrate and nitrogen gas (denitrification). The following is the reaction equation:

$$2NH_{3(aq)} + 3O_{2(g)} \longrightarrow 2NO_2^-{}_{(aq)} + 2H^+{}_{(aq)} + 2H_2O_{(l)}$$
$$2NO_2^-{}_{(aq)} + O_{2(g)} \longrightarrow 2NO_3^-{}_{(aq)}$$

Ammonia measurements in the three samples revealed results that were not consistent and inconsistent with rainfall (Figure 4c). Because it is easily oxidized to nitrite compounds during the nitrification process, ammonia, a component of nitrogen compounds, is unstable. Nitrite compounds oxidize easily to form nitrate compounds with little dissolved oxygen. The results of phosphate measurements showed an increase from the beginning of January to the end of January, but it was the same concentration in April as it was at the end of January (Figure 4d). This demonstrates that rain water dissolves phosphate sources in the soil during the rainy season and peaks at the end of the rainy season and the start of the dry season. Local residents use the water sources in this area for drinking water. According to PERMENKES RI Number 492 of 2010 concerning Drinking Water Quality Requirements, the maximum nitrate, nitrite, and ammonia concentrations that are allowed are 50 $mg.L^{-1}$, 3.50 $mg.L^{-1}$, and 1.5 50 $mg.L^{-1}$, respectively. Because the concentrations of these three chemical parameters are below the allowable threshold, the water sources in Sanggalangit are chemically good.

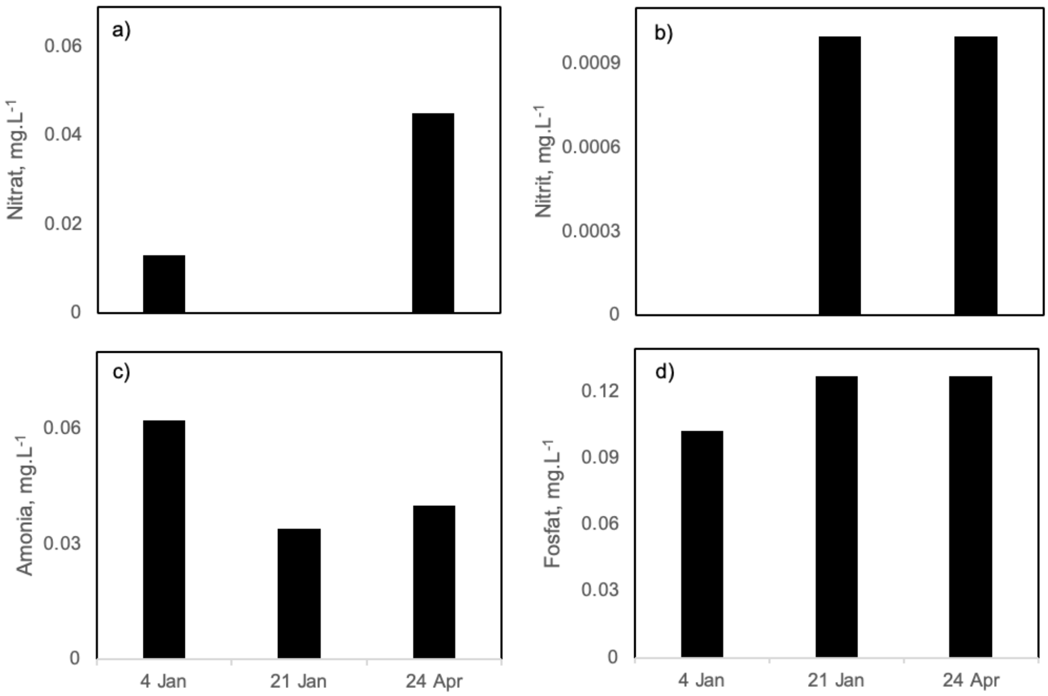

Fig. 4. Data of Dissolved Nutrient (Nitrat (a), Nitrit (b), Amonia (c), and Fosfat (d)) at The Water Source.

4. CONCLUSION

The maximum and minimum values of the two spectral slopes, $S_{275-295}$ and $S_{350-400}$, are inversely proportional to rainfall, while the E_2:E_3 values are inversely proportional to the average molecular weight. Rainfall influences CDOM absorbance, specifically E_2:E_3, but not nutrient concentrations (nitrate, nitrite, phosphate, and ammonia). Concentrations of nitrate, nitrite, and ammonium are still below the permissible threshold in this water source, indicating that the quality is quite good.

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