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Riparian tree diversity and water quality of Teunbaun spring Kupang regency

Keanekaragaman pohon riparian dan kualitas air di mata air Teunbaun Kabupaten Kupang

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ABSTRACT

Springs are water resources for human. One of the components that maintain the springs is the riparian tree. The study aims to identify the diversity of riparian tree species and water quality in Teunbaun (Sonaf) spring, Kupang district. Measurement of tree samples used the Quadrant Sampling Technique, while water quality measurements included physical, chemical, and microbiological (MPN) parameters. Collected tree and water quality data were analyzed to determine endemism status, species richness index (Dmg), Shannon-Wiener diversity index (H'), and gap analysis (conformity of water quality profile with water quality standards). The results showed that 16 species of riparian trees from 12 families were found. The species that are often found are from the Arecaceae family. The value of Dmg and H' were classified as moderate. The results of the physical and chemical quality tests of water revealed that almost all parameters achieved the quality standards, except for COD, cadmium and nickel. Futhermore, the MPN value found did not achieve the quality standar..

Keywords: Riparian tree, Spring, Teunbaun, Water quality

INTISARI

Mata air merupakan sumber air bersih bagi manusia. Salah satu komponen yang berperan menjaga mata air adalah pohon riparian. Penelitian bertujuan untuk mengidentifikasi keanekaragaman spesies pohon riparian dan kualitas air di mata air Teunbaun (Sonaf), kabupaten Kupang. Pengukuran sampel pohon menggunakan *Quadrant Sampling Technique* , sedangkan pengukuran kualitas air meliputi parameter fisik, kimia, dan mikrobiologi (MPN). Data jenis pohon dan kualitas air yang terkumpul dianalisis untuk menentukan status endemisme, indeks kekayaan spesies (Dmg), indeks keanekaragaman Shannon-Wiener (H'), dan analisis gap (kesesuaian profil kualitas air dengan baku mutu air). Hasil penelitian menunjukkan ditemukan 16 spesies pohon riparian dari 12 famili. Spesies yang sering ditemukan berasal dari famili Arecaceae. Nilai Dmg dan H' tergolong sedang. Hasil pengujian kualitas fisika dan kimia air menunjukkan hampir seluruh parameter memenuhi baku mutu, kecuali COD, kadmium, dan nikel. Selain itu, nilai MPN yang ditemukan belum memenuhi baku mutu kualitas air.

Kata kunci: Pohon Riparian, Mata Air Teunbaun, Kualitas Air

INTRODUCTION

Riparian zones are ecotone areas that has unique characteristics as the transition between terrestrial and aquatic ecosystems (Dwirastina et al., 2021; Pinto et al., 2021) which provide various ecological services to support biodiversity (Izzati et al., 2019), carbon storage and water quality (Semiun et al., 2023). Riparian tree has long, large , and strong roots which can reduce the risk of erosion (Hairiah et al., 2020). Riparian trees play a very important ecological role, including maintaining water quality (Semiun et al., 2020), supplying litter (Nakamura, 2022), as habitat, food source, and natural filters for various pollutants (Semiun et al., 2013). Therefore, the existence of riparian trees determines the quality of water bodies, in this case springs.

Springs are an important hydrological element of rivers and have significant ecological value as unique natural habitats and stable environmental conditions, as well as inhabited by unique fauna (Pakulnicka et al., 2016). In addition, springs emerge naturally from the ground (Erlinawati et al., 2021) and generally, the water is of good quality due to filtering through the soil layers (Ameen, 2019). Maintaining native tree diversity in the spring can have an impact on the quality of the spring. Native trees have been widely used for restoration because they can remediate (Jaja et al., 2023) a body of water from pollutants. Trees can absorb and degrade organic matter and heavy metals so that they can be used to control and restore polluted environments (Herlina et al., 2020). Riparian trees can be used for phytoremediation of various organic and inorganic waste types. Phytoremediation is the use of plants to reduce the concentration or toxic effects of pollutants entering the environment (Liang et al., 2022) through the mechanisms of phytoextraction, phytostabilization, phytofiltration, phytovolatilization, and rhizodegradation (Bhat et al., 2022). Using trees to restore polluted environments is more profitable than chemical and physical technology because it is cheap, environmentally friendly, several types of contaminants can be removed with the same plant, and is aesthetic

This research is located in Teunbaun (Sonaf) village, Kupang district. The spring is classified as semi-natural, surrounded by large trees. There is a part of the spring that contains sulfur. This is a unique condition and it has become an attraction for visitors. Apart from that, people use spring water for daily life such as washing, bathing, and drinking water. Human activity can influence the existence of waste that can infiltrate into the soil thereby changing the physical, chemical, and biological parameter of water (Semiun et al., 2020).

Research on riparian trees in determining the quality of springs has been carried out, but there is still a little information available in the current literature. Some studies that have been conducted by Semiun & Lenggur (2018), Mamulak & Semiun (2021), Liunima et al. (2022), and Bano et al. (2023) focused on vegetation diversity. Therefore, it is essential to identify tree species on the riverbank by collecting data on tree and water quality in springs. The information obtained can be used to recommend appropriate strategies in the context of restoration, rehabilitation, and remediation of degraded riverside tree vegetation and springs.

MATERIALS AND METHOD

Time and location of research

The research was carried out in November 2022 – July 2023. Sampling collection was located in Teunbaun village, West Amarasi sub-district, Kupang regency (Figure 1).

Materials and tools

The tools used in this study were GPS to determine location coordinates; and Multi-parameter Digital (Ez-9909) water quality to measure conductivity, pH, salinity, TDS, and temperature. The materials used in this research were riparian trees and water samples from the spring.

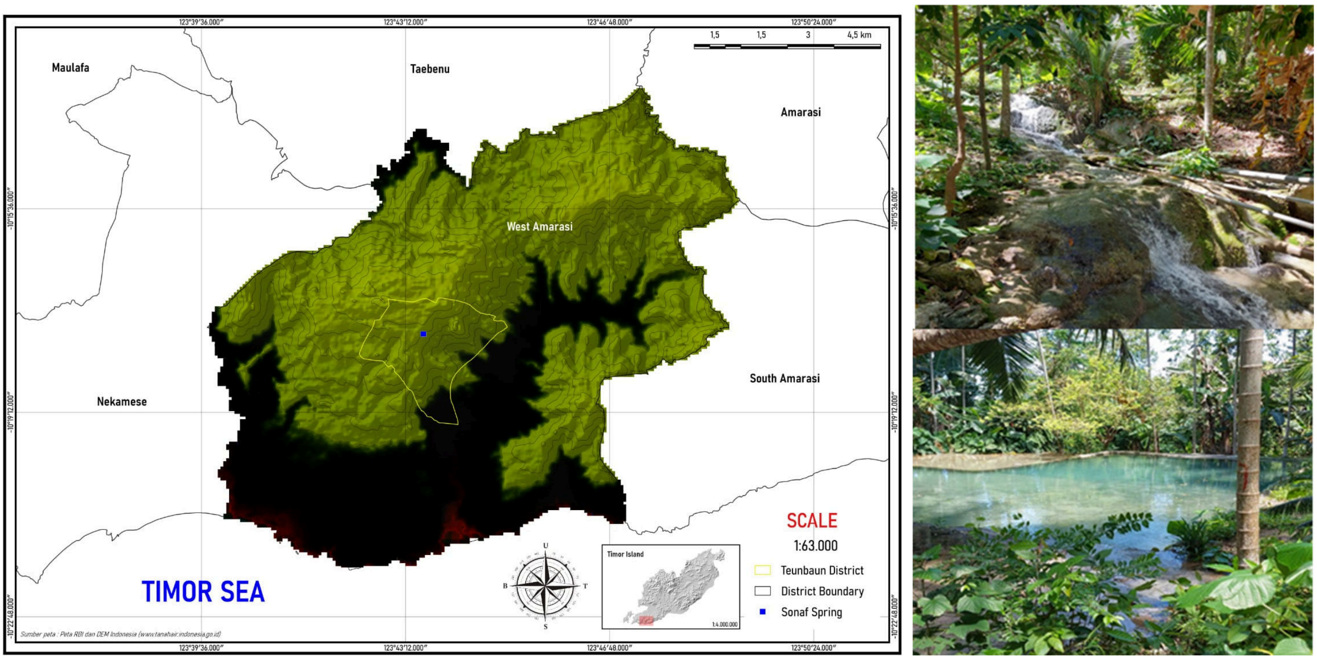

Figure 1. Research Location

Method

The sampling technique was applied using the quadrant method which was carried out randomly. The quadrant method is a method of vegetation analysis by using observations of sample plots in which area is measured in square units (Fathoni et al., 2021). There were nine plots with a size of 20 m × 20 m. Plots were placed randomly around the spring with a distance of 10 m between plots. The tree category was plants that have a height of > 5 m and a trunk diameter of ≥ 10 cm. The introduction of plant names used local names then were referred to as scientific names (Steenis, 2008; Banilodu et al., 2018).

Table 1. Physical-chemical measurement methods of water quality

No	Parameter	Method
1	DO	SNI 06-6989.14-2004
2	COD	SNI 6989.2:2019
3	Iron	SNI 6989.84:2019
4	Manganese	SNI 6989.84.2019
5	Cadmium	SNI 6989.84.2019
6	Nickel	SNI 6989.84:2019
7	Chloride	SNI 6989.19-2009
8	Nitrate	SNI 6989.79:2011
9	Nitrite	SNI 06-6989.9-2004
10	Sulfate	SNI 6989.20-2019

Note: SNI = *Standar Nasional Indonesia* (Indonesia National Standard)

Measurements of physical-chemical water quality including TDS (Total Dissolved Solid), water temperature, pH, conductivity, and salinity were conducted directly at the location. The parameters of DO (Dissolved Oxygen), COD (Chemical Oxygen Demand), iron (dissolved metal), manganese (dissolved metal), cadmium (dissolved metal), sulfate, chloride, nitrate, nitrite, and nickel (dissolved metal) were done at the *UPTD* Environmental Laboratory of the Environment and Forestry Service of Nusa Tenggara Timur Province (Tabel 1). In addition, microbiological parameters were determined by the MPN (Most Probable Number) test. MPN testing was done in the microbiology laboratory of Widya Mandira Catholic University.

Data analysis

Data analysis consisted of endemism status, species richness index, Shannon-Wiener diversity index, and gap analysis between the physical-chemical water variable data and the standard criteria for water quality.

a. Endemism status (Semiun et al., 2023)

Tree species were determined for their endemism status through a literature study. The endemism boundaries used in this study were species that grew naturally within the Malesiana phyto-region. On the other hand, species originating from outside the area were considered exotic plants.

b. Margalef species richness index (Rambey et al., 2021)

The richness value of a species was obtained using the formula:

$$\mathrm{Dmg} = \frac{\mathrm{S} - 1}{\ln \mathrm{N}}$$

Notes:
Dmg = Margalef species richness index
S = number of species (n_1,n_2,n_3,…)
N = The total number of all individuals

The Margalef species richness value category is presented in Table 2:

Table 2. Category of species richness index (Dmg)

No	Value interval	Category
1	Dmg < 2.5	Low
2	2,5> Dmg> 4	Moderate
3	Dmg > 4	High

c. Shannon-Wiener diversity index (Ekawaty et al., 2022)

$$\mathrm{H'} = -\sum \mathrm{PiLnPi}$$

Notes:
H = Indeks Shanon-Wiener
Pi = Propotion of density species i = (ni/N)
ni = Density species i
N = Density of all species

The category of diversity index is presented in Table 3 (Liunima et al., 2022).

Table 3. Diversity index category (H')

No	Value interval	Category
1	< 1.5	Very poor
2	1.5 - 2.0	Poor
3	2.6 – 3.0	Moderate
4	2.6 – 3.0	Good
5	> 3.0	Very good

d. Gap Analysis

The water quality profile at the observation site was known by using gap analysis (comparison) between the physical and chemical variable data of water quality obtained with the criteria for water quality standards based on Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management (Class I - for drinking water) and Minister of Health Regulation No. 32 of 2017 (for Sanitation Hygiene). Variables that can achieve the quality standard criteria then become an advantage. On the other hand, if a variable did not meet quality standards, it was considered a weakness and had the potential to become an ecological problem in the future.

RESULTS

Riparian tree of Teunbaun spring

The species of riparian trees found in the Teunbaun spring consisted of 16 species belonging to 12 families. The family included Anacardiaceae, Annonaceae, Arecaceae, Bombacaceae, Euphorbiaceae, Fabaceae, Lauraceae, Malvaceae, Moraceae, Myrtaceae, Verbenaceae, and Thymelaeaceae (Table 4). The most commonly found family was Arecaceae (palms).

Table 4. Riparian tree found in the Teunbaun spring

No.	Family	Local name	Scientific Name	Total of Individual	Endemism Status	IUCN status
1	Anacardiaceae	Mangga	*Mangifera indica* L.	3	Exotic	DD
2	Annonaceae	Kenangan	*Cananga odorata* (Lam.) Hook.f.	5	Endemic	LC
3	Arecaceae	Kelapa	*Cocos nucifera* L.	20	Endemic	-
4	Arecaceae	Pinang	*Areca catechu* L.	22	Endemic	DD
5	Arecaceae	Aren/enau	*Arenga pinnata* Merr.	8	Endemic	LC
6	Bombacaceae	Kapuk	*Ceiba pentandra* (L.) Gaertn.	1	Endemic	LC
7	Euphorbiaceae	Kemiri	*Aleurites moluccana* (L.) Willd	1	Endemic	LC
8	Fabaceae	Sepe/ flamboyan	*Delonix regia* (Bojer ex Hook.) Raf.	3	Exotic	LC
9	Lauraceae	Advokat	*Persea americana* P. Mill.	1	Exotic	LC
10	Malvaceae	Asam	*Tamarindus indica* L.	2	Exotic	LC
11	Moraceae	Beringin	*Ficus benjamina* L.	3	Endemic	LC
12	Moraceae	Pohon ara	*Ficus carica* L.	1	Exotic	LC
13	Myrtaceae	Jambu air hutan	*Syzygium samarangense* (Blum e) Merr. & L.M. Perry	1	Endemic	LC
14	Verbenaceae	Jati merah	*Tectona grandis* L. F	3	Endemic	EN
15	Verbenaceae	Jati putih	*Gmelina arborea* Roxb.	5	Endemic	LC
16	Thymelaeaceae	Gaharu	*Aquilaria* sp.	1	Endemic	-
		TOTAL		**80**		

Note: DD = Data Deficient; LC = Least Concern; EN = Endangered; - : Not found in https://www.iucnredlist.org/

H' and Dmg of riparian tree

The diversity index (H') and richness index (Dmg) of riparian trees found in the springs were classified as moderate (Table 5). The values of H' and Dmg were 2.19 and 3.42 respectively. The highest H' values were showed by *Areca catechu*, *Cocos nucifera* , dan *Gmelina arborea*.

Table 5. H' and Dmg values of riparian trees in Teunbaun springs

No	Index	Value	Category
1	H'	2.19	Moderate
2	Dmg	3.42	Moderate

Spring water quality parameter

Based on table 6, almost all water quality parameters had met quality standards, except for COD, cadmium and nickel. COD levels were found to be higher i.e. 115.12 mgL^{-1} (>10 mgL^{-1}). Cadmium levels were also found to be higher, namely 0.033 mgL^{-1} (> 0.01 mgL^{-1}). The nickel (dissolved metal) content found was 0.099 mgL^{-1}, higher than the quality standard with value of 0.05 mgL^{-1}.

Based on the results of the microbiology laboratory examination, the fecal coliform value obtained was 920 MPN/100 mL, higher than the specified standard, namely 100 MPN/100 mL (Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management (Class I-for drinking water) and 50 MPN/100 mL (Minister of Health Regulation No. 32 of 2017 – Sanitation Hygiene). Species of bacteria found were *Proteus mirabilis, Klebsiella* sp., and *E. coli.* The high MPN fecal coliform value at the spring is thought to be due to its sloping location so that waste from the upper area flows down to the spring, and livestock activity is also found in the upper area. Apart from that, fish can enter the springs, thereby polluting the water.

Table 6. Water quality parameter of Teunbaun spring

Parameter	Units	Value	Water Quality Standard	Gap Analysis
Physic				
TDS	Ppm	319	1000 ppm(1)	+
Water temperature	^{0}C	27.05	Dev 3(1, 2)	+
Conductivity	ms/cm	637	Not indicated	
Color		Colorness	Colorness (2)	+
Smell		No smell	No smel; (2)	+
Chemstry				
COD	mgL^{-1}	115.12	10(1)	-
DO	mgL^{-1}	6.44	≥ 6(1)	+
pH		7.45	6-9(1) 6.5-8.5(2)	+
Salinity	$^0/_{00}$	0.03	Freshwater	
Fe	mgL^{-1}	0.034	0.3(1)	+

Parameter	Units	Value	Water Quality Standard	Gap Analysis
			1(2)	
Mn	mgL^{-1}	< MDL	0.4 0.5(2)	+
Cd	mgL^{-1}	0.033	0.01 0.005(2)	-
Ni	mgL^{-1}	0.099	0.05	-
Chloride	mgL^{-1}	17.25	300(1)	+
Nitrate	mgL^{-1}	1.269	10(1)	+
Nitrite	mgL^{-1}	0.012	0.06(1) 1(2)	+
Sulfate	mgL^{-1}	11.278	300(1) 400(2)	+
Microbiology				
Fecal coliform	MPN/100mL	920	100(1) 50(2)	-

Note: + = achieve the criteria; - = did not achieve the criteria ; MDL (*Method Detection Limited*) of Mn = 0.03 mgL^{-1}; (1)Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management (Class I – for drinking water); (2)Minister of Health Regulation No. 32 of 2017 (Sanitation Hygiene).

DISCUSSION

The species of riparian trees found in the Teunbaun spring consisted of 16 species belonging to 12 families. The number of species and families obtained was slightly higher than research by Semiun et al. (2023) which found 15 species from 11 families, Mamulak & Semiun (2021) found 12 species from 9 families, and Bano et al. (2023) found 16 species from 10 families. The family included Anacardiaceae, Annonaceae, Arecaceae, Bombacaceae, Euphorbiaceae, Fabaceae, Lauraceae, Malvaceae, Moraceae, Myrtaceae, Verbenaceae, and Thymelaeaceae. The most commonly found family was Arecaceae (palms). The existence of Arecaceae was spread across tropical and subtropical climates and was very diverse with approximately 2600 species and 181 genera (Rambey, et al., 2021). Arecaceae trees found in springs were community-cultivated plants, which were used for household utensils, construction, and food.

Arecaceae had been shown to have the ability to remove various heavy metals. In the springs, the most commonly found tree species was *A. catechu* (*pinang*). Semiun et al. (2023) conducted similar research but the location was in the springs of Niukbaun village, West Amarasi subdistrict. The results of the research were not much different, namely that *A. catechu* trees were the most common. *Areca catechu* is a typical plant of the Timorese people so it is often cultivated. In Timorese culture, *pinang (*with *sirih)* is used as a mandatory treat to welcome guests, apart from being used as a building construction material. Besides, the presence of this tree can be used as a phytoremediation of good water quality. As a phytoremediation, *A. catechu* has the ability to remediate pollutants. This tree can absorb Pb and remove fluoride of Fe_2O_3 (Hoang et al., 2022).

The diversity of plant species in riparian ecosystems was analyzed using Shannon-Wiener diversity index. This index has a diversity index range from the most damaged community to the most stable community, which is 1.5 – 3.5. The average diversity index of riparian trees found in springs was moderate with a value of H' = 2.19. The diversity of these springs was moderate. This is because the distribution proportion of tree species abundance was quite even. Several species were very abundant, namely *Areca catechu, Cocos nucifera*, *Gmelina arborea*. A good level of diversity can occur because the distribution of the abundance of the number of individuals in each family was evenly distributed (Semiun et al., 2023)

The species richness index analysis was calculated using the Margalef index (Dmg). The species richness index determined the number of species (species) in a community. The more the number of species found in a community, the higher the species richness index (Wahyuningsih et al., 2019). Species richness depends on climatic, edaphic and biotic factors such as riparian trees (Leishangthem & Singh, 2018). The result of the species richness index of riparian trees in the spring was 3.42. This value was classified as moderate (2.5>Dmg>4.0). This showed that from a conservation perspective, the condition of the riparian trees was still in the good category. This was possible because of the efforts of the community to maintain and preserve the plants around the spring.

Chemical parameters that did not meet water quality standards were COD, Cd, and Ni. According to Gupta et al. (2022) the presence of high COD indicated the high presence of organic and inorganic compounds that were easily oxidized chemically. However, the DO value. had met quality standards. This showed that the spring had self-purification capabilities. Self-purification was the ability of a water body to remove organic and inorganic pollutants through the biological activities that lived within it (Zubaidah et al., 2019; Nugraha et al., 2020).

The cadmium (Cd) level found was 0.033 mgL^{-1} higher than recommended. This can produce carcinogenic risks, nausea, vomiting, difficulty breathing, cramps, and decreased consciousness (Choque-Quispe et al., 2021). In addition, Cd toxicity could affect the male and female reproductive systems i.e. reducing the quality of spermatogenesis and semen, disrupting hormonal balance, and affecting the menstrual cycle (Raza et al., 2020).

The nickel (Ni) level was 0.099 mgL^{-1} (>0.05 mgL^{-1}). Nickel is a heavy metal that is difficult to decompose, and at low concentrations in water could pose a health risk to humans (Thani et al., 2020). Nickel is an element that has low toxicity, but if the amount of Ni is higher than the threshold it can affect water quality (Aris et al., 2021). The presence of nickel and cadmium in water was considered to be closely related to high levels of community activity so the impact on waste entering water springs is also high.

Coliform bacteria are microbial indicators in monitoring water quality (Abubaker et al., 2019). The presence of this bacteria can risk human health because it is toxigenic. The presence of coliform bacteria also indicates that the water has been contaminated with human or livestock feces, and there might be other pathogenic bacteria. Therefore, the water in the spring did not meet the quality standards for drinking water, but can be used for bathing and washing activities. If people want to consume it, the water must be boiled.

CONCLUSION

There were 16 species of riparian trees from 12 families found in the spring of Teunbaun. The families were Anacardiaceae, Annonaceae, Arecaceae, Bombacaceae, Euphorbiaceae, Fabaceae, Lauraceae, Malvaceae, Moraceae, Myrtaceae, Verbenaceae, and Thymelaeaceae. The most frequently found family was Arecaceae (*Arecha catechu*). The diversity and richness of riparian tree species was classified as moderate. COD, Cd, Ni and fecal coliform concentration has exceeded the quality standard, while DO and others is not.

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