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Assessment of water quality based on biological indices of macrobenthos: a river under pressure from tourism activities

Asep Sahidin[1,2,*], Zahidah[1], Herman Hamdani[1], Heti Herawati[1], Mochamad Candra Wirawan Arief[1], M. Suhaemi Syawal[3], Aiman Ibrahim[3], Roni Sewiko[4], Chitra Octavina[5,6]

[1] *Department of Fisheries, Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran, Bandung, Indonesia.*
[2] *Laboratory of Aquatic resources, Faculty of Fisheries and Marine Science, Universitas Padjadjaran, Bandung, Indonesia.*
[3] *Research Center for Limnology, National Research and Innovation Agency, Bogor, Indonesia.*
[4] *Marine Engineering Department, Karawang Marine and Fisheries Polytechnic, Karawang, Indonesia.*
[5] *Department of Marine Science, Faculty of Fisheries and Marine Science, Universitas Syiah Kuala, Indonesia.*
[6] *Marine and Fisheries Research Center, Universitas Syiah Kuala, Indonesia.*

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ABSTRACT

Cijulang River is one of the leading ecotourism objects in Pangandaran, West Java Province, Indonesia. However, the river has a variety of activities that can increase the water pollution in the river such as Green Canyon cliffs tourism, ecotourism of mangrove conservation, housing, and industrial siting. Macrobenthos is one of the bio-indicators that can assess the rate of water pollution in rivers, especially their organic pollutants. Therefore, this research aims to determine water pollution status in Cijulang River Tourism by comparing various biotic indices. The study was conducted at four site sampling locations from upstream to downstream in the rainy season period and dry season period using different methods namely, line transect model, water quality assessment by biological indexing (diversity, species dominant, and family biotic), species deficit, and organic measurement. The research showed 5873 macrobenthos and divided into 27 species with an average abundance of 167 ind.m^{-2} and are mainly dominated by gastropod species *Faunus ater* (40%). They are extreme species that can live in high organic pollution and water salinity. This divided the research of quality water assessment of Cijulang River into three categories as follows: slightly polluted (score 36-46) at Green Canyon site, moderately polluted (score 50-60) at Boat Shelter and Muara Cijulang location, and highly polluted (score 66) at Nusawiru site.

Introduction

The river is one of the terrestrial aquatic ecosystems that are very important to live in. It provides water that supports the sustainability of human activities in the aspects of fisheries, agriculture, industry, household, and as an object of ecotourism. Therefore, various uses of rivers might reduce their water quality. The river has the inherent ability to accept waste input from the outside and as well as clean up (self-purification) from the waste. However, when the debris exceeds the carrying capacity of the river, it stops accepting and leads to a decrease in water quality (Setiawan and Zulkifli, 2011).

The change in the physical and chemical compounds of the river from anthropogenic activity impacts aquatic organisms (Dumbrva-Dodoaca and Petrovici, 2010; Riyadi *et al*., 2012; Sharma *et al*., 2018; Sahidin *et al*., 2018), especially macrobenthos (Wardiatno *et al*., 2017; Sahidin *et al*., 2018). This is one of the organisms that live on the surface or in water-sediment such as mud, sand, gravel, stone, or organic waste (Alipoor *et al*., 2011; Sahidin *et al*., 2014; Wibowo *et al*., 2017). It is important to group organism in the aquatic ecosystem since it is the key biota in the food web (Iwakuma *et al*., 2008; Indra *et al*., 2019), nutrient cycle (Tabatabaie and Amari, 2011; Hale *et al*., 2016; Griffiths *et al*., 2017), pollution

* Corresponding author.
Email address: asep.sahidin@unpad.ac.id

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metabolism (van Loon *et al*., 2015; Wardiatno *et al*., 2017; Sahidin *et al*., 2018; Mearns *et al*., 2019) and secondary productivity (Kroncke and Reiss, 2010; Bissoli and Bernardino, 2018).

Therefore, macrobenthos is an organism that is difficult to escape from environmental disturbance (Pawhestri, 2015; Krisanti, 2020). It metabolizes water pollutants, especially organic compounds. Furthermore, it is a bio-indicator that describes changes in environmental conditions that occur in certain water (Alipoor *et al*., 2011; Sundaravarman *et al*., 2012; Wardiatno *et al*., 2017). Macrobenthos has criteria suitable for bio-indicators, since they are easily identified (taxonomically), living permanently in water, easily investigated, specifically and closely related to certain habitats, species, and other taxa groups that determine water quality (Setiawan and Zulkifli, 2011; van Loon *et al*., 2015; Wibowo *et al*., 2017; Wardiatno *et al*., 2017).

The assessment of water conditions can be conducted with two approaches as follows, using biota response to environmental pressure, and determining the water quality using environmental conditions as a bio-indicator (Prato *et al*., 2009; Ritter *et al*., 2009; Sundaravaman *et al*., 2012; Trishala *et al*., 2016; Stancheva and Sheath 2016; Sahidin *et al*., 2018; Manickavasagam *et al*., 2019). Assessing water conditions with a biological method is better than the physical-chemical methods, which describes conditions in short-terms (Junshum *et al*., 2008; Bhateria and Jain, 2016). However, the biological method describes with long-terms, due to its efficiency in analyzing biota even in pressurized water (Carretero and Dauvin, 2010; George *et al*., 2010; Sahidin *et al*., 2018). This makes macrobenthos more suitable as bio-indicator for river research (Setiawan and Zulkifli 2011), ecological status (Wardiatno *et al*., 2017; Sahidin *et al*., 2018), the abundance of biomass (Pawhestri *et al*., 2014), heavy metal (Lismaryanti *et al*., 2019), and biological index (Carter *et al*., 2017).

Cijulang River is a river in Pangandaran Regency, West Java, Indonesia. It flows 15 km from upstream in Cidawu village to downstream in Bojong Salawe estuary with a width of 40 m (Prananda *et. al*., 2017). It is one of the leading ecotourism objects in Pangandaran since it possesses Green Canyon cliffs, mangrove conservation ecotourism, and rivers that cross-industrial areas, namely the Nata De Coco, Coconut, and Sugar industries (Indra *et al*., 2019). From the overview of Cijulang River potential, appropriate management is needed, to avoid a decrease in water quality and pollution. The research on the status of river pollution is necessary for efficient water management since it is the basis for decision making. The determination of water pollution status uses a reference from biological components, mainly macrobenthos. The Knowledge of the pollution status in Cijulang River needs to be known as a reference in river management. This study aims to determine the level of pollution in the Cijulang River by comparing the values of biotic indices.

Materials and Methods

Location and time of research

This study was conducted in the rainy season from January - March 2018 and dry season from August - October 2018 in the Cijulang River, Pangandaran district, West Java Province, Indonesia. There were four site samples, which were determined based on purposive sampling method, using their differences in pollution as follows 1) Green Canyon site (7°43`41.6``S and 108°25`42.4``E) was in the tourist attraction center with fresh water and a bit of pollution source, 2) Boat Shelter site (7°44`07.6``S and 108°27`23.4``E) was closed to the fishing boatyard, with pollutant from tourism activity and boat wash oil, 3) Nusawiru site (7°43`53.6``S and 108°29`23.4``E) was in the mangrove area of ecotourism, and 4) Muara Cijulang site (7°43`11.6``S and 108°29`55.4``E) was in the river's estuary, which was a mixture of Cijulang and Bojong Salawe river (Figure 1).

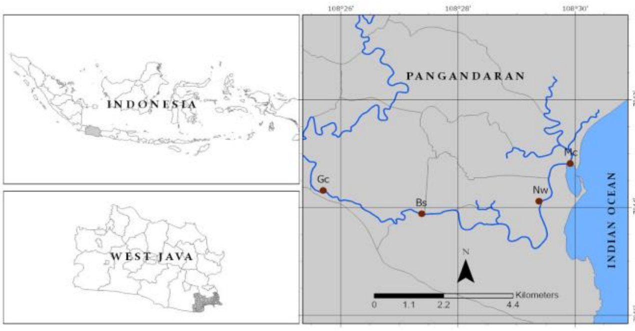

Figure 1. Map of Site Sampling (Gc= Green Canyon, Bs= Boat Shelter, Nw= Nusawiru, Mc= Muara Cijulang).

Sampling and identification

Macrobenthos samples were taken from the site: using quadrant transect and Surber mesh with a measurement of 1 m x 1 m, and swipe method. All samples were preserved with formaldehyde solution with a concentration of 10% and placed in a sample box. Macrobenthos identification was performed by comparing the morphology of samples with the standard mollusk identification book in Indonesia, such as Mollusc (Dharma, 2005), Polychaeta (Al-Omari, 2011; Sahidin *et al*., 2016), and Crustacea

(Beleem *et al*., 2016) with the nomenclature written by Mollusca Base (*https://www.molluscabase.org/).* These comparisons identified all macrobenthos specimens at the Aquatic Resources Laboratory, Universitas Padjadjaran. Observations and measurements of water samples such as temperature, DO, pH, and salinity were carried out at the river sites, at the same time observing and measuring the BOD (Jouanneau *et al*., 2013), macrobenthos and substrate characteristics including texture fraction, organic content (i.e., Carbon and Nitrogen) (Buchanan, 1984), and C/N ratio were carried out in the laboratory. The texture fraction measured using the hydrometer method. The determined organic carbon content by using Walkley and Black method, meanwhile nitrogen content was determined by using Kjeldahl method.

Data analysis

Macrobenthos was analyzed according to the difference of biotic indices namely the Shannon-Wiener index (*H'*) (Lee *et al*., 1978), Simpson dominant index (*SDI*) (Simpson, 1949), species deficit (*SD*) (Carter *et al*., 2017), and family biotic index (*FBI*) (Carter *et al*., 2017). Their formulas varied as follows:

Diversity Index Shannon-Wiener (H')

$$H' = \sum(pi\, Log_2\, pi),\ pi = \frac{ni}{N}$$

description: H' = Diversity index, ni = number of individual species and N = number of individuals in the community.

Simpson Dominant Index (SDI)

$$SDI = \sum \frac{ni^2}{N}$$

description: SDI = Species dominant Simpson index, ni = number of individuals in one type, N= total number of individuals in all type.

Species Deficit (SD)

$$SD = \frac{|Su - Sd|}{Sd}$$

description: SD = species deficit, Su = amount of macrobenthos genus upstream, Sd =number of macrobenthos in downstream.

Family Biotic Index (FBI)

$$FBI = \frac{\sum xi\, ti}{\sum xi}$$

description: FBI = family biotic index, xi= number of individual family groups i, ti= tolerance value of family group i.

The comparison and scoring analysis were used in the determination of water pollution status with a theoretical consideration of results. Pollution status analysis was modified from each biological index and organic matter, based on the five criteria, namely unpolluted, slightly, and moderately polluted, polluted, and heavily polluted (Table 1).

Results

Water quality and substrate

The water quality and sediment parameters (Table 1) were as follows: temperature, pH, DO C-organic, N-total, N/C ratio and texture, and their similar features in each site sample. The BOD concentration in the Cijulang River ranged from 0.72 - 6.81 mg/L. According to Lee et al. (1978), unpolluted water had a BOD value <3.0 mg/L. This showed that in the research process, there were differences in water quality, such as the polluted portions and the unpolluted areas. The stations that had not been contaminated were at Green Canyon site (0.72 - 1.55 mg/L), lightly polluted stations at Boat Shelter site (3.33 - 4.54 mg/L) and Muara Cijulang site (3.40 - 4.53 mg/L), as well as the moderately polluted sites at Nusawiru (5.94 - 7.30 mg/L). The classification was based on the organic disturbance in the river bodies.

The salinity concentration in Cijulang River showed a high changeable range from 4 to 35 ppm. The lowest salinity was observed at the Green Canyon site, while the highest was found at the Muara Cijulang site. Therefore, its concentration increased from the upstream to downstream, due to the mixture of seawater and river water causing the river to be brackish. The substrate layer that dominated the Green Canyon, Boat Shelter, and Muara Cijulang was sand with varied values that ranged from 43% - 87% and for Nusawiru it was clay particles (50%). The C-Organic content in each site sampling area was low and ranged from 0.97% to 1.56%.

Composition and abundance of macrobenthos

There was 5873 macrobenthos found on four site sampling location in Cijulang River, Pangandaran, West Java Province, Indonesia. They were classified into 27 species belonging to 11 families, and 4 classes (Figure 2 and Table 3). The highest number of species composition found in each gastropod class was 74% (20 species), followed by Bivalvia 11% (3 species), Crustacea 11% (3 species), and Polychaeta 4% (1 species) (Figure 2 and Table 2). The composition of macrobenthos based on the total taxa obtained was 45% (36 taxa) in the rainy season and 55% (44 taxa) in the dry season. In contrast, the composition of macrobenthos based on the total abundance in the rainy and dry seasons was 55% (819 ind.m^{-2}) and 45% (668 ind.m^{-2}), respectively. The most dominating macrobenthos species found in the Cijulang River was *Faunus ater* with an abundance of

1-176 ind.m^{-2}, and the remaining were *Tarebia* sp., *Melanoides pilcara*, *Saccostrea cucullata*, and *Cerithium kobelti*. However, the species found only in one site location were namely *Balanocochlis* sp., *Thiara winteri*, *Septaria pareceliana*, *Trochus* sp., *Suneta tuncatta*, and *Penaeus* sp. The difference in community structure was caused by differences in water quality, especially in the content of their salinity, organic matter, and substrate.

Table 1. Pollution criteria based on biological indices

Criteria	H'	SDI	SD (%)	FBI	BOD	Score
Heavily polluted	<0.5	-	75-100	7.4-10.0	100 or more	81-100
Polluted	0.5-1.0	0.75<SDI≤1.0	51-75	6.5-7.3	6-9.	61-80
Moderately polluted	1.0-1.5	0.5<SDI≤ 0.75	26-50	5.8-6.5	3-5.	41-60
Lightly polluted	1.6-2.0	0<SDI<0.5	0-25	5.0-5.8	1-2.	21-40
Unpolluted	> 2.0	0	0	0.0-5.0	0	1-20
Ref.	Lee *et al.,* (1978)	Odum (1971)	Carter *et al.,* (2017)	Carter *et al.,* (2017)	Baird and Bridgewater (2017)	-

Table 2. Water quality and substrate parameters

Water and Substrate Parameter	Site Sampling			
	Green Canyon	Boat Shelter	Nusawiru	Muara Cijulang
Water quality				
Temperature (^{0}C)	27.3 – 29.0	25.3 – 31.0	28.4 – 29.0	29.8 – 34.0
DO (mg/L)	6.2 – 9.2	6.1 – 9.1	6.7 – 8.9	7.1 – 8.8
BOD (mg/L)	0.72 – 1.55	3.33 – 4.54	5.84 – 6.81	3.40 – 4.53
pH	6.72 – 7.69	6.34 – 7.87	5.94 – 8.05	5.96 – 8.00
Salinity (ppm)	4 – 13	7 – 21	12 – 27	20 – 35
Substrate parameter				
C-organic (%)	0.97	1.09	1.56	0.51
N-Total (%)	0.08	0.1	0.13	0.04
C/N ratio	12	11	12	14
Texture	stone, clay	muddy	muddy	muddy, sandy

Table 3. List of species recorded in the Tourism of Cijulang River.

Classes	Family	Species*	Gc	Bs	Nw	Mc	Habitat
Gastropod	Thiaridae	*Thiara concellata* Roding 1789	+	+			st,gv
		Thiara winteri Busch 1842	+				st,gv
		Tarebia granifera Lamarck 1822	++	+	+++		st,md,mg
		Balanocochlis glans Busch 1842	+				st,gv
		Melanoides maculata Bruguiere 1789	+		+		sn
		Melanoides pilcara Born 1780		+			sn,st
	Neritidae	*Clithon bicolor* Recluz 1847	+	+			st
		Clithon corona Linnaeus 1758	+	+	+		st
		Clithon coronata Leach 1815	+	+			st,sn
		Clithon ovalaniensis Lesson 1831		+	+	++	st
		Clithon faba Sowerby 1836		+	+	+	st
		Clithon diadema Récluz 1841		+			st
		Clithon squarrosus Recluz 1843		+		+	st,sn
		Septaria porcellana Linnaeus 1758		+			st
	Pachychilidae	*Faunus ater* (innaeus 1758	+	++	+++	+++	md
	Trochidae	*Trochus calcaratus* Souverbie & Montrouzier 1875			+		mg
	Terebralia	*Tarebralia sulcata* Born 1778				+	md,mg

Classes	Family	Species*	Gc	Bs	Nw	Mc	Habitat
	Cheritiidae	*Cerithium salebrosum* Sowerby 1855		+			md
		Cerithium alveolum Humbron 1848				+	md
		Cerithium kobelti Dunker 1877				+++	md,mg
Bivalve	Ostreidae	*Saccostrea cucullata* Born 1778			++	+++	mg
		Suneta tuncatta Deshayes 1853			+		md
	Mytilidae	*Perna viridis* Linnaeus 1758				+	md
	Crustacea						
		Uca sp.	+			+	md,sn
	Paguridae	*Pagurus acadianus* Benedict 1901			+	+	md, S
	Penaeidae	*Penaeus* sp.	+				sn,md,st
Polychaete	Nereididae	*Nereis* sp.				+	md

Site Sampling (Gc= Green Canyon, Bs= Boat Shelter, Nw= Nusawiru, Mc= Muara Cijulang); Habitat (st= stone, gv= gravel, sn= sand, md= muddy, mg= mangrove); species recorded (+ = low recorded, ++ = medium recorded, +++ = high recorded); *identification by Dharma (2005).

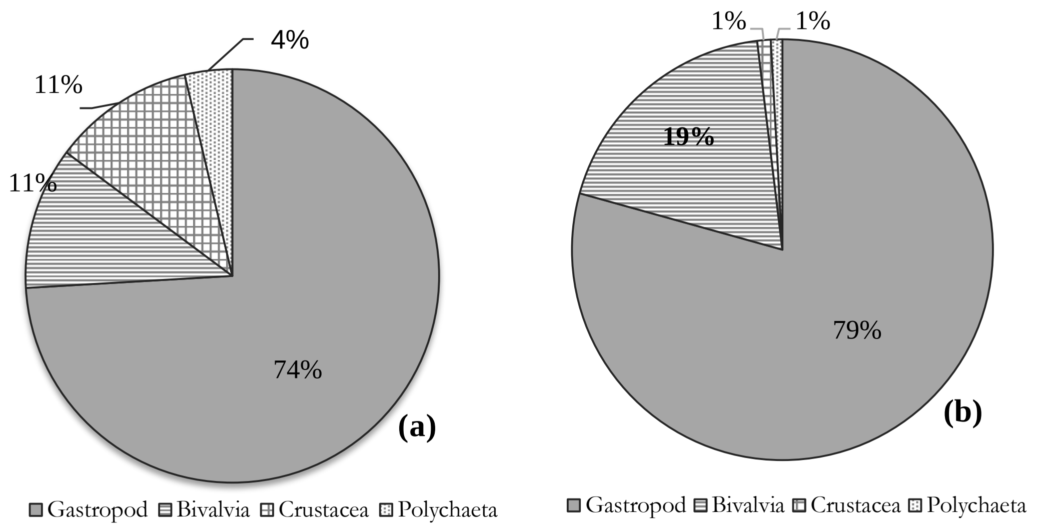

Figure 2. Composition of Macrobenthos on tourism Cijulang River, Pangandaran, West Java, Indonesia. (a) percentage of total taxa, (b) percentage of total abundance.

Macrobenthos tolerant group found in Boat Shelter, Nusawiru, and Muara Cijulang sites included *Faunus ater*, *Tarebia granifera*, *Cerithium kobelti*, and *Saccostrea cucullata*, while those found in the Green Canyon site were intolerant. The highest macrobenthos density found at Muara Cijulang was 339 ± 30 ind.m^{-2} and dominated by *Faunus ater* species (87 – 148 ind.m^{-2}), *Saccostrea cucullata* (61 – 134 ind.m^{-2}), and *Cerithium kobelti* (27 – 125 ind.m^{-2}). The lowest density found at the Green Canyon site was equal to 46 ± 5 ind.m^{-2} and dominated by *Tarebia* sp. (9 – 41 ind.m^{-2}).

Biological indices of macrobenthos and organic analysis

The biological indices used for the assessment of water quality were as follows, the diversity index (H'), Simpson dominant index (SDI), macrobenthos deficit of species (SD), and the average family biotic index (FBI), while those used for organic matter analysis were, the biochemical oxygen demand (BOD) from water bodies, and the C-organic analysis from sediment. The average macrobenthos diversity index at each research station ranged from 1.56 - 2.56, and the highest was found at the Boat Shelter site in the rainy season and Muara Cijulang in the dry season. While the dominant index ranged from 0.40-0.73, both dry and rainy seasons showed a high index in the Nusawiru site (Figure 4a, 4b).

Water quality assessment by family biotic index (FBI) showed 4.56-8.57, while the highest was found at Nusawiru in the rainy season and Boat Shelter in the dry season (Figure 4c). Both stations were in the middle area of the Tourism center and obtain direct influence from freshwater and marine water. FBI value showed different levels of water conditions, which were relatively good in the Green Canyon site, slightly bad at Nusawiru site, and bad in Boat Shelter and Muara Cijulang site. Species deficit analysis showed the same trend between the dry and rainy seasons (Figure 4d). The macrobenthos deficit species ranged from 11.4% - 55.2%, with the highest found in the river flowing from Green Canyon and Boat shelter site to Muara Cijulang, while the lowest were found in the river flowing from

Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Volume 10, Number 3, Page 267-276

Green Canyon to Boat Shelter, Boat Shelter to Nusawiru and Nusawiru to Muara Cijulang. The high species deficit showed the loss of a large number of macrobenthos species in the area.

Water quality assessment using their organic matter content showed the same trend between dry and rainy seasons both with the BOD analysis in water bodies and C-organic analysis in the sediment (Figure 4e, 4f). The BOD analysis showed 1.14-8.74 mgL^{-1} with the highest value at Nusawiru site 6.33 mgL^{-1} in the dry period and 8.74 mgL^{-1} in the rainy season, and lower in Green Canyon site with 1.14 mgL^{-1} in the dry period, and 2.51 mgL^{-1} in the rainy season. While C-organic sediment parameters showed 0.97% - 2.46% with the highest in Nusawiru site 1.55% in the dry period and 2.46% in the rainy season and lowest in the Muara Cijulang site with 0.51% in the dry period and 0.64% in the rainy season.

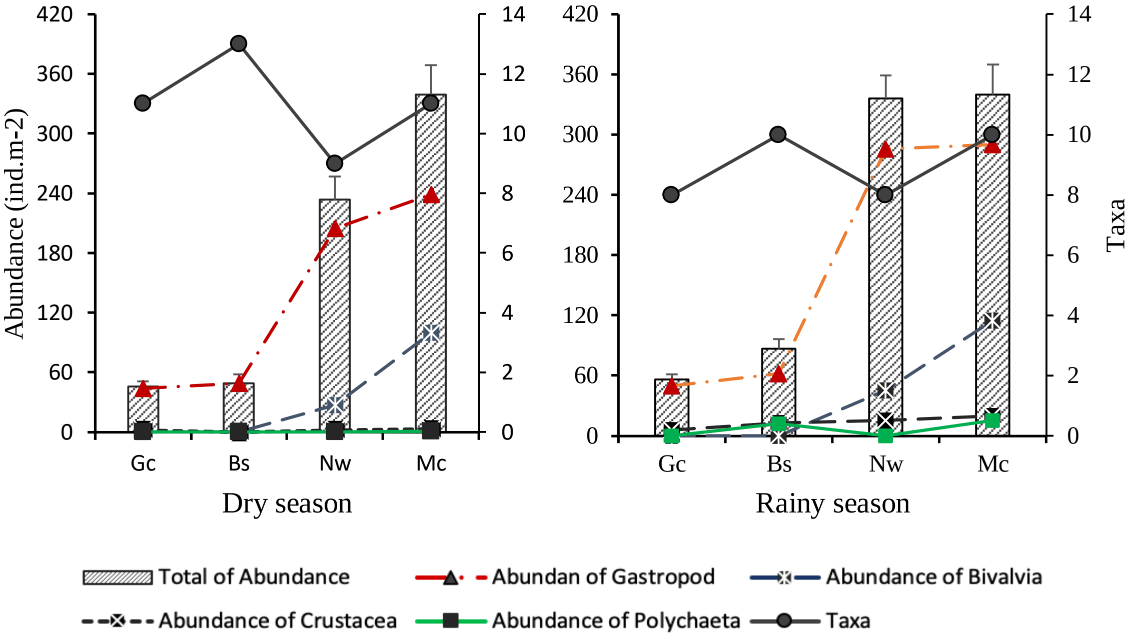

Figure 3. Distribution of macrobenthos abundance in Tourism Cijulang River, Pangandaran, Indonesia.

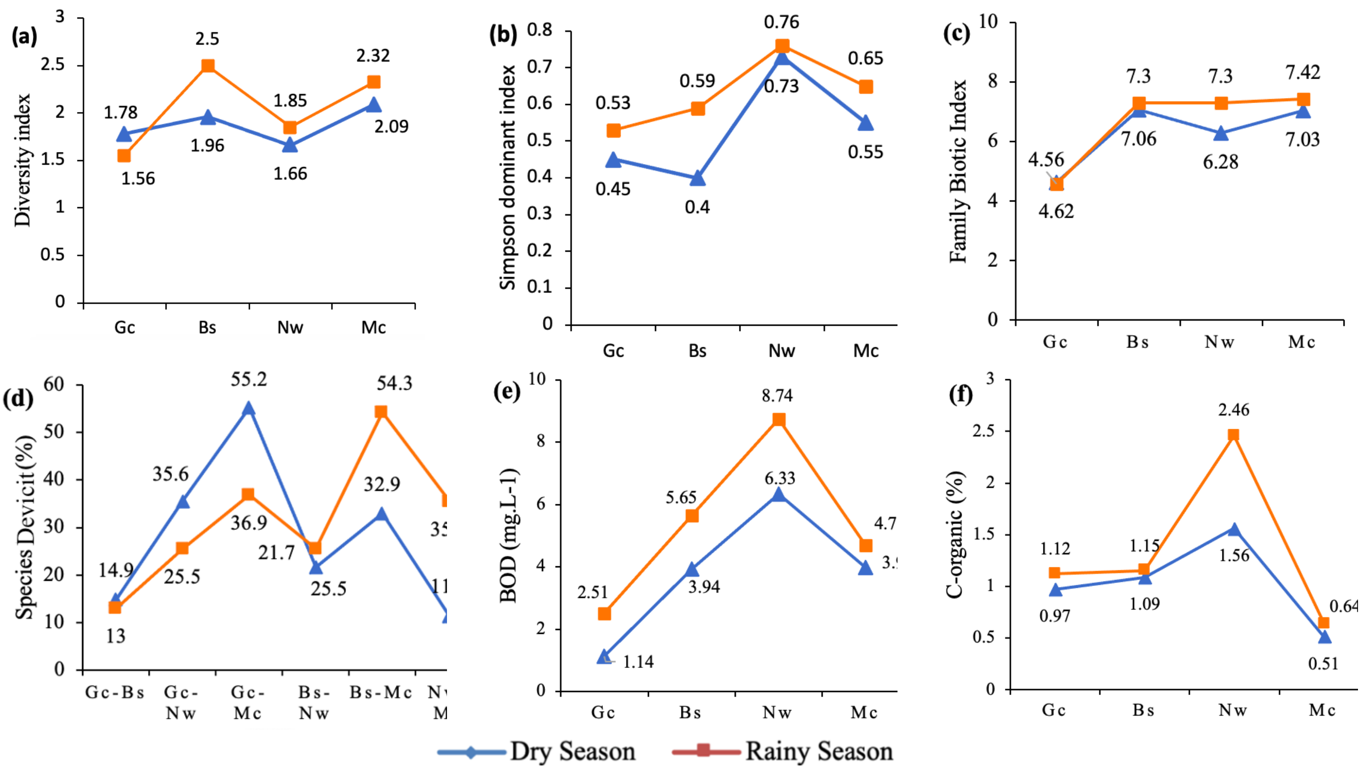

Figure 4. Water quality assessment with biological indices and organic matter, (a) diversity Sannon-Wiener index, (b) Simpson dominant index, (c) family biotic index, (d) species deficit, (e) BOD analysis, (f) C-organic analysis. Site sampling (Gc= Green Canyon, Bs= Boat Shelter, Nw= Nusawiru, Mc= Muara Cijulang).

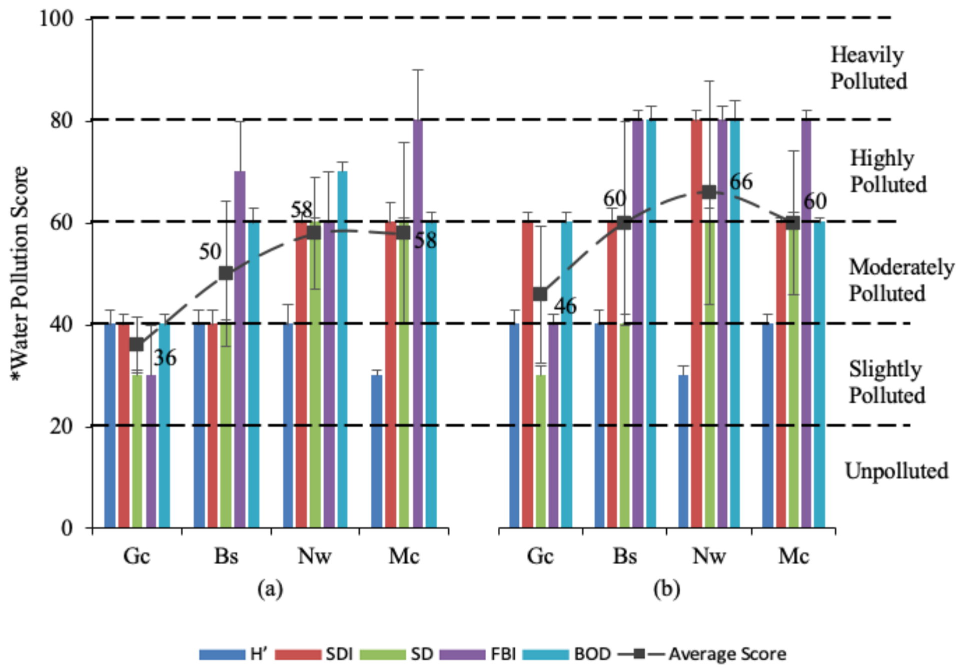

Figure 5. Water pollution status with Scoring analysis in the Tourism of Cijulang river using the comparison between biotic indices and organic analysis, (a) dry season and (b) rainy season. *Water pollution score (Table 1), H'= index of diversity (Figure 4a), SDI=Simpson dominant index (Figure 4b), FBI= family biotic index (Figure 4c), SD= species deficit (Figure 4d), and BOD=biochemical oxygen demand (Figure 4e).

Discussion

Cijulang River is one of the leading ecotourism objects in Pangandaran, West Java Province, Indonesia. There were Green Canyon cliffs and mangrove ecotourism, therefore it was known as a tourism river. The Cijulang River also crossed the path of housing and industrial areas (Indra *et al.*, 2019; Sahidin *et al.*, 2019), and gave rise to water pollution, especially the excess organic matter. The measurements of water quality in the Cijulang River (Table 1), with the parameters of DO and pH, showed suitable level for macrobenthos (Davis, 1975; Berezina, 2001). These parameters were important for the growth rate and survival of macrobenthos (Pamuji *et al.*, 2015; Krisanti, 2020) since they directly affected the community structure of benthic organisms. Macrobenthos with high tolerance level for salinity were found to easily adapt, while those that were sensitive to change could not survive. Substrate texture and organic concentration in the substrate were important factors to macrobenthos (Sahidin et al. 2014). The dominance of sand substrate fraction and the low content of organic matter in the substrate where suitable habitat for Gastropod and Bivalve survival (Manoharan *et al.*, 2011). The basic substrate of the Cijulang River Tourism was dominated by the muddy fraction (Table 1). Gastropod and Bivalvia classes were macrobenthos that could adapt and was mostly found in the muddy substrates (Manoharan *et al.*, 2011).

Faunus ater was the most commonly found gastropod in the Tourism of Cijulang River. It was found dominant in Boat Shelter, Nusawiru, and Muara Cijulang site. These stations had a muddy substrate (Table 1). *Faunus ater* had a high tolerance level to sediment conditions (Agustina *et al.*, 2018) and brackish water (Alvin *et al.*, 2011), the tolerance was optimum found in muddy sediment and high organic matter. The condition of the muddy substrate was the main cause of excess macrobenthos; however, a few were found in the sand substrate (Iwakuma *et al.*, 2008; Sahidin *et al.*, 2014; Nurfitriani *et al.*, 2019; Indra *et al.*, 2019). The organisms that adapt to a sandy substrate were macroinfauna organisms (1-10 cm), and micro meiofauna (0.1-1 mm) were those that could survive in sand grains (Hakiki *et al.*, 2017; Sharma *et al.*, 2018). Manoharan (2011) stated that the Gastropod groups were macrobenthos that adapted and commonly found on muddy and sandy substrates.

Biotic indices could determine pollution status in water bodies using the diversity index (H') (Shannon Wiener, 1949; Lee *et al.*, 1978), species dominant index (Simpson, 1949; Magurran, 1988), species deficit (Carter *et al.*, 2017), and family biotic index

(Leatemia *et al*., 2017; Carter *et al*., 2017). While the biochemical oxygen demand from the water bodies and C-organic analysis from sediment could be used for organic matter analysis. Different ecological indices were computed to derive community parameters for monitoring the pollution level (Padmanabha, 2011).

The low diversity and high SDI in Nusawiru and Muara Cijulang site was due to the dominating species namely *Faunus ater* (36-59%) and *Tarebia* sp. (21-47%), while Muara Cijulang site was dominated by *Faunus ater, Saccostrea cucullata*, and *Cerithium kobelti* in equal proportion (Figure 4a, 4b, Table 2). An increase in the SDI indicated a rise in pollution load (Padmanabha & Belagali, 2007). Some species of macrobenthos were intolerant to contamination, due to increased pollution, however, few had tolerance for adverse conditions (Basu *et al*., 2013; Signa *et al*., 2015; Tamiru, 2019). Water pollution status based on the diversity index showed that the Green Canyon, Boat Shelter, and Nusawiru were slightly polluted, while Muara Cijulang was not contaminated (Table 3). Water pollution criteria based on diversity index showed heavily polluted as <1.0, moderately polluted as 1.0 - 1.5, slightly polluted as 1.6-2.0, and uncontaminated as >2.0 (Lee *et al*., 1987). Besides the diversity, to determine the condition of rivers, it is necessary to analyze other factors, since a stable system (resistant to pollutants) could only have low or high diversity, which depended on the function of energy flow in these waters (Reshetnikova *et al*., 2017).

The higher values of species deficits showed a different macrobenthos structure at the stations. The diversity in macrobenthos structures at the Cijulang River was caused by differences in BOD and salinity values at each research area. Green Canyon site with low BOD and salinity value, had different macrobenthos structures, while Nusawiru site had a high BOD and salinity value (Table 1, Table 3). This was evidence that Nusawiru and Muara Cijulang with different BOD and salinity values, had diverse species deficits of macrobenthos. The high range of species deficit values in the Tourism of the Cijulang river was caused by differences in salinity of polluted stations. This affected the spread of organisms both vertically and horizontally (Matena *et al*., 2016; Sahidin *et al*., 2018). Indra *et al.* (2019) stated that salinity had a direct influence on the community structure of macrobenthos since each macrobenthos had a different tolerance limit for salinity depending on their ability to control the body's osmotic pressure. Therefore, salinity is a limiting factor for macrobenthos community structure in the Cijulang River.

From the FBI values, it was concluded that there are different levels of water conditions, such as the good water in Green Canyon, slightly bad in Nusawiru, and bad water in the Boat Shelter and Muara Cijulang rivers. The FBI value highly depends on the number and type of macrobenthos living in the waters. The more macrobenthos that has a high tolerance for environmental conditions, the higher the FBI value and vice versa (Mariantika and Retnaningdyah, 2014).

Green Canyon had a low FBI value, due to the little influence from anthropogenic activities which resulted in good water condition. Boat Shelter and Muara Cijulang had high FBI value since these stations had been affected by anthropogenic activities. At Boat Shelter was the location of fishing boats, settlements, and restaurants, while Muara Cijulang was the site for the meeting point of Cijulang and Bojongsalawe Rivers, which carried organic materials, then accumulate them at Muara Cijulang. At Nusawiru, there was a decrease in the level of pollution compared to Boat Shelter, due to the mangroves in this station which were pollutant traps that could absorb organic pollution waste (Cochard, 2017).

During the rainy season, there was large transport of organic matter to coastal water from the mainland through rivers and runoffs (Sahidin *et al*., 2014). Therefore, increasing organic matter on aquatic substrates will affect the condition of macrobenthos, especially in the metabolic process. While Increased metabolism caused the level of oxygen consumption to rise and resulted in decreasing oxygen content beneath the water, therefore, the bottom condition became anoxic (Sundaravarman *et al*., 2012). Besides the pollution factors (organic matter and salinity), this circumstance also affected macrobenthos. Anoxic conditions caused a decrease in species and abundance of macrobenthos. Mangrove vegetation in brackish water could be used as a buffer for water pollution, and also functions as sediment and pollutants trap, as well as special macrobenthos habitat (Nurfitriani *et al*., 2019).

Generally, the water quality status of the Cijulang River ranged from slightly to moderately polluted, with a score pollution status of 53.25 (Figure 5). The main water contaminant in the Tourism of Cijuang river were organic compounds, that originated from agriculture, housing, tourism activities, and factories.

Conclusion

The determination of water pollution status based on biological indices at the Tourism of Cijulang river were grouped into 3 major categories, namely slightly polluted groups at Green Canyon site, moderately contaminated groups at Boat Shelter and Muara Cijulang site, and highly polluted groups at Nusawiru site. *Faunus ater* is a gastropod, an extreme species that can survive in an organic polluted and salinity environment.

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