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RESEARCH ARTICLE

MACROINVERTEBRATES ANALYSIS AND ASSESMENT WATER POLLUTION OF BAUBAU RIVER, SOUTHEAST SULAWESI-INDONESIA

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ABSTRACT

Resident of Baubau City is most using potable water from river and groundwater as drinking water resources. However, rapid developments have deteriorated quality of drinking water sources in Baubau City, Indonesia. For determining water quality has been used Biotic and Polution Index to assess pollution level of Baubau River, Baubau City, Indonesia. Macro invertebrates was collected at 3 station:upper, middle, and lower river from May to September 2014 and at the same time, temperature, total dissolved solid, total suspended solid, pH, dissolved oxygen were analyzed. Pollution level was analyzed used Family Biotic Index (FBI), Belgian Biotic Index (BBI) and STORET-USEPA pollution index methods. The results analysis show that score of FBI were 6.11, 6.53, and 6.67; BBIscore: 4,4, and 3; and water pollution index score on the station 1, 2, and 3 were 2.37, 5.57, and 6.16, respectively. The macroinvertebrates was found, viz., Libelluidae, Parathelphusidae, Athyidae, Palaemonidae, Gerridae, Viviparidae, Thiaridae. Meanwhile Corbiculidae dominated by Gastropodes from Viviparidae and Thiaridae.

Conclusion: The overall water quality of the Baubau River from up to lower was moderate to heavy pollution (III-IV).Water bodies are potentially hazardous to public health and that proper sewage treatment and river quality monitoring are needed to warn against hazards to public health.

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INTRODUCTION

Impacts of urbanization on aquatic ecosystems are intensifying as urban sprawl spreads across the global land base. Significant negative relationships were revealed between road density and biological (fish and benthic macroinvertebrate) richness, diversity, and fish Index of Biotic Integrity scores. Significant positive relationships were found between road density and tolerant fish/benthic macroinvertbrates, benthos Family Biotic Index scores, mean summer stream temperature, stream flashiness, and several water quality variables in the Toronto region (Wallace, Croft-White *et al*., 2013). The urban stream syndrome (USS) identifies "symptoms" associated with urban development including changes in biotic communities, hydrology, water chemistry, and channel morphology. Direct relationships between road density (as surrogate of urbanization) and indicators of the USS were identified for streams in the Toronto region. (Wallace, Croft-White *et al*. 2013). Baubau Riverwater flow from upper to downstream through a central of Baubau City, home to some 12.028 of 150.000 people closest to the river. The Baubau River, it is intensively discharge poorly treated domestic and home industrial wastes. Poor sanitary practice of the residen some economical activity, agriculture, cattle watershed, potentially adverse effect to water quality of the river. Macro invertebrate communities are one of the most used groups in assessments of water quality, since they respond directly to the level of contamination of aquatic ecosystems. For determining the impact of land-use on the aquatic ecosystem in a river basin, was measured by means of the biological diversity, the Belgian Biotic Index and a key macroinvertebrate taxon (Adriaenssens, Goethals *et al*., 2001). The response of intolerant taxa is predominantly influenced by a nutrient-forest cover gradient. In contrast, habitat quality have a greater effect on tolerant taxa. When taxa are aggregated into a nutrient sensitive index, the response is primarily influenced by the nutrient-forest gradient (Ashton, Morgan *et al*., 2014).Macroinvertebrates correlated most strongly with dominant substrate (Lammert and Allan 1999), thus efforts to understand causes of natural variation

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between sites will produce more precise and accurate biological indicators (Lunde, Cover *et al*., 2013). This studied had combined between Family Biotic Index, Belgian Biotic Index, and Pollution Index to assess water quality of Baubau River.

Methodology

Location and Time

Study was carried out at theBaubau River, Indonesia. Sample collected for dry sesonat three station: the station 1, 2 and 3,on theposistionalcoordinate05^{o}28’,984’’LSand 112^{o}36’,121’’BT; 05^{o}27’,695’’LS and 112^{o}36’,357’’BT; and 05^{o}27’,432’’LS and 112^{o}36’,222’’BT respectively, from Mayto September 2014, consecutively (Figure 1).

Figure 1. Coordinate Posisition of the sites sample collection in the Baubau River LS (South of latitude), BT (East of logitudinal)

MATERIALS AND METHODS

Macroinvertebrate communities along the stream were sampled usingh and surber net (500µm) and a bottom kick net samplers (500 µm mesh size) had better cost/effectiveness ratios for macroinvertebrate sampling in Rapid Bioassessment Protocols (RBPs) using family level in streams (Buss and Borges, 2008). The samples were taken from an area of nearly 50 m^2 in order to include all possible microhabitats at each station. In some areas with the presence of large stones, these were first picked out and wash edin to the kick net, to remove attached macroinvertebrates. In addition, macroinvertebrate samples were separated from the sediment. All the animals collected were immediately fixed informaldehyde (4%) in the field and then transferred to 70% ethylalcohol. The macroinvertebrates were sorted, identified to theordo, family or genus. At the same time, water samples were taken monthly and analyzed for the following parameters: temperature, total dissolved solid, total suspended solid, pH, dissolved oxygen in the field by portable equipments. The pollution level of all the study area indicated could be explained by the Family Biotic Index (FBI)adapted from Hilsenhoff, Tabel 1 (Zimmerman 1993), and Belgian Biotic Index (BI), Tabel 2 and 3(Balaban and Constantinescu 2006). While, pollution index was based on STORET-USEPA Method was compared with the values stipulated by WHO, and national standard: $0 < PI < 1.0$ (normal standard water quality), $1.0 < PI < 5.0$ (weak pollution), $5.0 < PI < 10$ (moderate pollution), and $PI > 10$ (strong pollution)(MNLH 2003). Based on Family Biotic Index (FBI) analysis show that water quality on the station 1, 2 and 3 were in Fairly poor (significant organic pollution) with score: 6.11, 6.53 and 6.67 respectively. Belgian Biotic Indeks (BBI) had been in the all station were IV (heavy polluted) with score 4, 4, and 3 respectively. Meanwhile, water pollution index of the Baubau River analysis show that station 1 was in weak polluted (2.37), station 2 and 3 were moderate polluted with score: 2.37, 5.57 and 6.16 respectively.

Table 1. Water quality based on family biotic index (adapted from Hilsenhoff, 1977)

Biotic Index	Water Quality	Degree of organic pollution
0.00–3.50	Excellent	No apparent organic pollution
3.51–4.50	Very good	Possible slight organic pollution
4.51–5.50	Good	Some organic pollution
5.51–6.50	Fair	Fairly significant organic pollution
6.51–7.50	Fairly poor	Significant organic pollution
7.51–8.50	Poor	Very significant organic pollution
8.51–10.0	Very poor	Severe organic pollution

Table 2. Standard table for calculation of the belgian biotic index

Indicator group	Class frequency	Number of taxa				
		0-1	2-5	6-10	11-15	>16
Plecoptera, Heptagenidae	≥ 2	-	7	8	9	10
	1	5	6	6	8	9
Cased Trichoptera	≥ 2	-	6	7	8	9
	1	5	5	6	7	8
Ancylidae. Ephemeroptera (exc. Ecdyonuridae)	≥ 2	-	5	6	7	8
	1	3	4	5	6	7
Aphelocheirus, Odonata, Gammaridae, Mollusca (exc. Sphaeriida)	≥ 1	3	4	5	6	7
Asellidae, Hirudinea, Sphaeriidae, Hemiptera (exc. Aphelocheirus)	≥ 1	2	3	4	5	-
Tubificidae, Chironomusthummi – Plumosus	≥ 1	1	2	3	-	
Syrphidae – Eristalinae	≥ 1	0	1	1	-	-
		Biotic Index value				

Table 3. Interpretasion Biotic Index(BBI), adapted from Biotic Index Manual for Secondary School, University Gent, Belgium (1999)

Classification	BioticIndeks	Color Sign	Pollution Level
I	10 – 9	Blue	No or Lighter Pollution
II	8 – 7	Green	Light Pollution
III	6 – 5	Yellow	Moderate Pollution
IV	4 – 3	Orange	Heavy Pollution
V	2 – 1	Red	Very Heavy Pollution
VI	0	Black	Biological Death

RESULTS

Family Biotic Index, Station 1

Table 4. Ordo, Family, Frequences of macro invertebrates, and Family Biotic Index (FBI) at the stasiun 1

Ordo	Family	Frequences (n)					total	Average (xi)	Score tolerance (ti)	Xi∗ti
		1	2	3	4	5				
Odonata	*Libelluidae*	0	0	0	1	1	2	0.4	2	0.8
Decapoda	*Palaemonidae*	0	0	1	0	1	1	0.2	4	0.8
	Athyidae	2	5	3	5	5	20	4.0	6	24.0
	Parathelphusidae	1	4	2	2	1	10	2.0	6	12.0
Gastropoda	*Viviparidae*	9	12	10	11	13	55	11.0	6	66.0
	Thiaridae	2	3	4	6	10	25	5.0	7	35.0
Hemiptera	*Gerridae*	5	2	0	3	5	15	3.0	6	18.0
Bivalvia	*Corbiculidae*	0	0	0	5	2	7	1.4	6	8.4
	Total							∑n=27		∑ Xi∗ti =165
FBI										6.11

Table 5. Ordo, Family, Frequences of macro-invertebrates, and Family Biotic Index (FBI) at the station 2

Ordo	Family	Frequences (n)					Total	Average	Score tolerans(ti)	Xi∗ti
		1	2	3	4	5				
Decapoda	*Parathelphusidae*	6	4	5	7	8	30	6.0	6	36.0
Gastropoda	*Viviparidae*	3	4	5	7	6	25	5.0	6	30.0
	Thiaridae	16	10	22	10	7	65	13.0	7	91.0
Hemiptera	*Gerridae*	0	0	0	0	1	1	0.2	6	1.2
	Total							∑n= 24.2		∑Xi∗ti =158.2
FBI										6.53

Table 6. Ordo, Family, Frequences of macro-invertebrates, and Family Biotic Index (FBI) at the station 3

Ordo	Family	Frequence (n)					Total	Average	Scoretolerance (ti)	Xi∗ti
		1	2	3	4	5				
Decapoda	*parathelphusidae*	6	7	6	13	13	45	9	6	54
Gastropoda	*Thiaridae*	30	26	14	10	15	95	19	7	133
	Total							∑n= 28		∑Xi∗ti =187

Belgium Biotic Index

Table 7. Macro invertebrates and Belgian Biotic Index at the station 1

Macroinvertebrate Indicator Group	Score	Number of Taxa	Frequency	Biotic Index Value
Hemiptera	5	1	› 1	2
Gastropoda	3	2	› 1	4
Decapoda	4	3	› 1	4
Odonata	4	1	› 1	3
Bivalvia	4	1	› 1	3

Table 8. Macro invertebrates and Belgian Biotic Index at the station 2

Macroinvertebrate Indicator Group	Score	Number of Taxa	Frekuency	Biotic index Value
Hemiptera	5	1	› 1	2
Gastropoda	3	2	› 1	4
Decapoda	4	1	› 1	3

Table 9. Macroinvertebrates and Belgian Biotic Index at the station 3

MacroinvertebrateIndikator Group	Score	Number of Taxa	Frequency	Biotic Index Value
Gastropoda	3	1	› 1	3
Decapoda	4	1	› 1	3

Table 10. Score of Physical-Chemical Parameters and Pollution Index at the all Station

No	Parameters	Station			Standard Water Classificatin: I,II,III,IV
		1	2	3	
1	Temperature	25	25	25	Dev 3
2	TDS (mg/L)	330	6660	8740	1000,1000,1000,2000
3	TSS (mg/L)	140	1020	1450	50,50,400,400
4	pH	7,88	7,89	7,69	6-9;6-9;6-9;5-9
5	DO (mg/L)	11,1	11,5	11,0	6,4,3,0
	Pollution Index	2.37*	5.58**	6.15**	

Mark: * (weak polluted); ** (moderat polluted)

Table 11. Scores of FBI, BBI, Pollution Index and Water Quality (WQ) at the all Station

Station	Biotic and Pollution Index					
	FBI		BBI		Pollution Index	
	Score	WQ	Score	WQ	Score	WQ
1	6.11	Fairly poor	4	IV	2.37	weak
2	6.53	Fairly poor	4	IV	5.58	moderate
3	6.67	Fairly poor	3-4	IV	6.15	moderate

The most macroinvertebrate was found in the all station were tolerant from heavy water polluted with score were in range 6-7, viz., Athyidae, parathelphusidae, Viviparidae, Thiaridae, Gerridae, and Corbiculidae and just family was in sensitive category:Libelluidae and Palaemonidae had score 2 and 4, respectively. Eventhough, macroinvertebrate from family Ephemeroptera, Plecoptera, and Tricoptera*,* had not been available in the station, its means was in strong polluted. According to FBI, BBI and Pollution Index standard, water from Baubau River was III-IV categorized (moderate to heavy polluted).

DISCUSSION

According to (Bieger, Carvalho *et al*., 2010), aquatic macroinvertebrates were important bioindicators of the water and environmental quality of the streams of the Sinos River basin (Bieger, Carvalho *et al*., 2010). The assessment of macro-invertebrates reflected the general ecological deterioration occurring to chemical as well as toxic and genotoxic pollution (Isidori, Lavorgna *et al*., 2004). The macroinvertebrates community relying on the benthic substrate and the water layer of the downstream region of the Baubau River was still poor. Community of macroinvertebrates in the Baubau River has been most influenced by urbanization, economical activity, transportation, and residences on the watershed. Diversity of macroinvertebrates show decline trend fromupper to lower Baubau River may be related to the physical-chemical characteristic of the water, fortotal dissolved solid (TDS) and total suspended solid (TSS) of surface water show edincreasing trend from upper to lower region (Table 11). A number of land uses and stressors are probably responsible for the decline in native species Diamond, Bressler *et al*. (2002). Benthic community composition and the sediment contamination of toxic and genotoxic substances were shown to be correlated (Isidori, Lavorgna *et al*., 2004). In the Toronto region, at the most urbanized sites showed that only four fish species and a reduced number of benthic macroinvertebrate families remained at the most urbanized sites androad density was found to be a major determinant in both the fish and benthic macroinvertebrate community structure (Wallace, Croft-White *et al*., 2013). Mean wile, the results analysis of this study allows us to conclude that or do and family found resistant to heavy polluted, include Decapoda (Athyidae, Parathelphusidae), Gastropoda (Viviparidae, Thiaridae), Hemiptera (Gerridaeand) and Bivalvia (Corbiculidae). Thosemay be quit different from macroinvertebrates indicator group in distance area. However, according to (Relyea, Minshall *et al*., 2012), there were no orders or families that were solely sensitive or resistant to fine sediment. Although, among the three orders commonly regarded as indicators of high water quality, the Plecoptera (5), Trichoptera (3), and Ephemeroptera (2) contained all but one of the species or species groups classified as extremely sensitive. The results case study from Potrero de los Funes River on the use of General Quality Index (GQI) to evaluate spatial and seasonal changes in the water quality indicate that the urban activity produces a serious and negative effect on the water quality, a significant degradation of the water quality, thus constituting a sanitary risk and may have a major impact on the trophic status (Almeida, Quintar *et al*., 2007). Populatin of Baubau City has been reaches some 150.000 people, twice from about 10 years ago. Therefore, water quality of Baubau River is a result of local conditions, e.g. possibility of contamination by sewage waters, home industry, and land use in the vicinity of the Baubau River. The outlet of wastewater from the residence area with the highest impervious surface had a substantial influence on the water quality of the river. Water quality at downstream of the river was possibility quite different from the upper river, but the sediments of the downstream Baubau River was heavily polluted. Consenration of sediment in the river was strongly affected from landuses and agricultural activity in vicinity from upper to downstream. In Narmada, agricultural wastes, domestic and industrial waste water discharges and their organic load caused main variation in water quality of river (Anjana, Kumar *et al*., 2014). In the Volturno River in South Italy, the physico-chemical characterization of the surface waters showed a declining trend from up-river to down-river for dissolved oxygen and conductivity. Also, chemical variables showed a worsening along the river axis showing an increase in ammonium, phosphates, sulfates, and heavy metal (Isidori, Lavorgna *et al*., 2004). Concentrations of heavy metals in the Kizilirmak and Delice Rivers are higher compared with other heavy metal studies in the other main rivers and lakes in

Turkey. The accumulation pattern of heavy metals in the water, sediment, and fish tissue follows the sequence: Si>Fe>Al> Mn>As>Ni> Se>Cd, Fe>Al>Mn>Ni>As>Se>Cd, and Fe>Al> Mn>As>Ni> Si>Cd (Akbulut and Tuncer 2011). These possibility characteristics will assist in the water management of Baubau River for varied future demands including human consumption, irrigation, industrial and river conservation. Increased education and supervision of public, as well as sanitary practice and personal hygiene, are critical to reducing on-water contamination and the health risks associated with water pollution.

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