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AQUATIC INSECT LARVAE AS AN INDICATOR OF ECOLOGICAL INTEGRITY OF PANASEN UPSTREAM, TONDANO WATERSHED, NORTH SULAWESI

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ABSTRACT

The upstream ecological integrity facing anthropogenic pressures has been assessed linked to the community of aquatic insect larvae inhabiting. This paper evaluate the ecological integrity of the Panasen Stream by determining the distribution and environmental parameters affecting the community of aquatic insect's larvae in the Tondano Watershed. Physical and chemical parameters such as temperature, velocity, pH, Dissolved Oxygen, Conductivity, Turbidity, Hardness, Total Suspended Solids, Ammonia and Total Phosphate Water were collected. PCA analysis showed that current velocity, depth and width of the stream greatly affected the distribution and abundance of aquatic insect larvae, precipitation and substrate. Land use and active volcanic results in unsustainable anthropogenic activities have contributed to lowering the water quality, low species richness and weak ecological integrity of the Panasen Stream.

Keywords: aquatic insect larvae; ecological integrity; panasen stream.

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1. INTRODUCTION

Aquatic insects' larvae are key actors that play a significant role in the freshwater benthic food chain, through its ability to process organic matter. Their roles are mainly in nutrient cycles, primary productivity, decomposition and material translocation [1-3]. The rate of usage and circulation of nutrients in streams is important; as nutrient, turnover is an ecosystem service [4]. The activity of the insect larvae can alter the water quality and affect the energy flow patterns at different trophic levels. Their biological interactions have had a significant impact on the structure of communities. With a short life cycle, they respond rapidly to environmental changes so that their diversity, distribution and enumeration are assessed as indicators for assessing the ecological integrity of streams [5-6].

Various studies on aquatic insect larvae include Trichoptera larvae as a bioindicator of aquatic ecosystems [7-8]; Mayflies analysis of the Ephemeroptera Order [9-10]; Analysis of community structure and distribution of Ephemeroptera, Plecoptera and Trichoptera [11-12]; Biodiversity [13-14]; Freshwater management [15]; Analysis of aquatic insects as subjects of agricultural land impact [16]; Measurement of aquatic insects bodies based on hydraulic habitats [6] and research on artificial models and predictions of species richness [17] but research on the distribution and abundance of aquatic insect larvae in the tropics, particularly North Sulawesi associated with its ecological integrity is rare.

The stream's ecological integrity is the ability of stream ecosystems to support and maintain a balanced, integrated and adaptive biological system, having all the components and processes expected of a natural habitat in a region. An assessment of ecological integrity is essential to determine the relationship between ecosystem capability and human influence, which can provide information to environmental managers and be a first step for the development of appropriate conservation strategies including evaluating the effectiveness of ongoing legislative regulation [18-19] for transportation, recreation and sports facilities, raw drinking water sources, bathing and washing and industrial water sources, industrial and domestic waste disposal sites, fisheries, irrigation and reservoirs [20].

The Tondano's Watershed in Minahasa District is currently experiencing significant problems such as reduced forest area, declining quality and quantity of lake water, clove and coconut

plant dominance in land use, flooding, erosion, eutrophication and sedimentation in water bodies which have not been concerned with the principles of soil conservation and sustainable forest clearance. Nowadays Lake Tondano is pointed as one of 15 Indonesian lakes that prioritized for handling environmental problems (Priority I in Indonesia by Decree of Minister of Forestry No. 284 / Kpts-II / 1999) [21].

The Panasen Stream as one of Lake Tondano inlet directly contributes to the quality and quantity of lake water. However, the studies of aquatic insect larvae in this area are very rare and there is no published data. Despite, the fact that changes in the stream ecosystem are continuous and biological data can be a reference in conducting conservation measures. The aim of this study was to evaluate the condition of the Panasen Stream by determining the distribution and abundance of aquatic insect larvae based on differences in land use in the Tondano watershed; and determining environmental parameters that affect the presence of insect larvae communities.

2. RESULTS AND DISCUSSION

The distribution and abundance of the community of aquatic insect larvae depend on several environmental factors and characteristics of the locations as shown in Table 1 [25]. Alterations in the upstream will result in changes in habitats that directly alter species composition. The Tondano watershed is subject to human pressures, so this area is dominated by agricultural activities and settlements land. Changes in physical conditions occur through stream water channels that are diverted to irrigation water. Massive farming without good maintenance of water quality threatens the condition of the region itself. If this practice continues, there will be a time of decreasing water quality and quantity that directly affected the Tondano Lake.

Table 1. Characteristic of study locations

Characteristics	Location							
	P1	**P2**	**P3**	**P4**	**P5**	**Mh**	**Nh**	**Rh**
Elevation (m)	815	787	726	710	694	773	812	456
Width (m)	0,59-1,5	1-3,27	4,1-7	4-5,5	6-16	2,9-3	0,5-1,4	2-12,8
Depth (m)	0,19-0,40	0,16-0,48	0,1-0,45	0,13-0,52	0.18-1	0.18-0.26	0.25	21.7-47
Microhabitat	*Pools*	*Pools*, *riffles*	*Pools*	*Pools*	*Pools*	*Riffles*	*Riffles*	*Riffles*

The low presence of insect larvae in Ranolesi Station is assumed caused by the dominance of high coarse sand as its sedimentary structure, while the current velocity is very slow at only 0.12 m / sec. Chironomid larvae found at this site are a tolerant species because they can live in slow-moving water in sandy to muddy areas [26]. At Tonsewer station, the sedimentary structure that dominates is fine sand, and the texture of the sediment is clay. This less stable of substrate results in a low number of organisms because the organisms are not able to maintain their position where it should [27]. Wetland practices in this area are also due to increase in Phosphate (08 mg / L) which is higher than other sections.

Table 2 showed the mean values of physico-chemical parameters and sedimentary structures at Panasen Streams. The lowest number of species found in Tempang Station, partly due to the slow rate of current velocity of 0.23 m/s, consequently forming the pools zone and the high Suspended Solids (TSS). The rate of TSS of 20 mg/L in this location is the highest. TSS is closely related to soil erosion and erosion of stream channels. In addition, at this location approximately 14km^2 of paddy's fields being converted into constructed land for the development of Lahendong Geothermal Power Plant. The excavation activities accelerate the erosion and there has been a decline in the quality of stream ecosystems.

Table 2. Environmental parameters values measurements

Station	Temp. °C	DO mg/L	pH	Current velocity m/s	Turbidity SKL NTU	TSS mg/L	Conductivity µS/cm	Hardness mg/L	Ammonia mg/L	Total Phosphate mg/L
P1k	26,6-27,3	5,30-7,10	5,89-6,39	0,09-0,18	1,0-1,0	10,0-10,0	160,3-160,3	90,9-90,9	0,06-0,06	0,08-0,08
P2k	24,6-28,5	5,40-6,70	5,63-6,13	0,12-0,32	1,0-1,0	10,0-10,0	160,2-160,2	88,6-88,6	0,06-0,06	0,16-0,16
P3k	28,0-28,6	4,75-6,25	6,53-6,53	0,21-0,25	1,0-1,0	20,0-20,0	384,0-384,0	95,3-95,3	0,09-0,09	0,13-0,13
P4k	28,1-29,3	4,80-4,90	6,51-6,51	0,10-0,20	1,0-1,0	10,0-10,0	384,0-384,0	104,2-104,2	0,06-0,06	0,12-0,12
P5k	24,3-24,5	6,20-6,70	6,50-6,50	0,06-0,20	1,0-1,0	10,0-10,0	344,0-344,0	124,1-124,1	0,08-0,08	0,04-0,04
P2h	32,7-33,5	5,42-5,59	7,41-7,44	0,29-0,59	2,71-6,32	8,40-11,0	122,0-125,4	182,5-192,2	0,19-0,25	0,00-0,16
P3h	29,4-29,5	7,39-7,46	3,05-3,60	0,21-0,22	8,94-9,47	7,70-11,40	523,0-523,0	163,0-174,0	0,22-0,29	0,10-0,16
P4h	28,5-28,7	7,63-7,69	3,43-4,32	0,34-0,37	6,71-7,23	6,20-9,55	503,0-503,0	141,0-174,0	0,23-0,27	0,11-0,19
Mh	22,3-22,5	7,22-7,29	5,48-5,95	0,28-0,35	1,39-5,86	3,05-5,50	25,9-27,4	61,0-80,0	0,10-0,13	0,14-0,22
Nh	26,6-26,7	6,71-7,37	7,28-7,44	0,56-0,72	0,82-3,67	4,50-13,10	84,2-84,5	135,9-143,7	0,00-0,08	0,10-0,18
Rh	23,3-23,4	7,80-7,86	6,34-6,45	0,60-1,00	7,50-7,70	5,40-11,10	35,1-35,6	84,6-92,3	0,07-0,10	0,01-0,11

The insects found in lower number at Panasen Station. It is assumed that the most influential factor is the substrate structure of this site, which is dominated by coarse sand and sediment in the form of sandy clay also due to the slow current flow (0.20 m/s). The presence of nymphs of *Caenis* sp., reflecting this site is in a relatively muddy location. *Caenis* sp. is able to survive in stagnant waters (pools) because they have adaptable operculate gills to survive on muddy stream beds [28]. The reference sites and sedimentary structures were represented in Fig. 1.

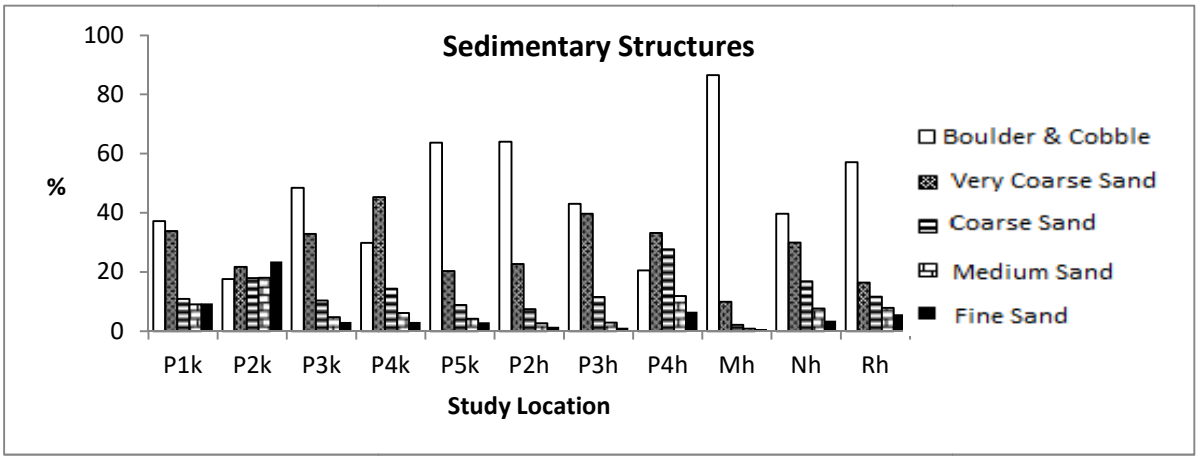

Fig. 1. Sedimentary structures

Lack of presence of insect larvae in Talikuran Station is due to slow current movement (0.13 m/s) and high hardness (124 mg/L), which increased in rate compared to the previous 4 stations (91-104 mg/L). The sedimentary structures are dominated by gravel and pebbles which suppose to be able to support the presence of insect larvae, but their dominant texture is sand, sand and sandy clay that is certainly bad for the communities. Sediment transport and deposition are natural processes in the stream environment, but increased in sediments have a negative impact on benthic communities. *Rhagovelia* sp. found in these locations is not an indicator of benthic ecosystems, as they are commonly found on the surface of the water in adult form. These organisms occupy at any habitat [28]. The Pyralidae Familia is the only member of the Lepidoptera Order living in aquatic zones. *Petrophila* sp. Larvae are able to live tolerantly on low quality water [29]. Based on this data, it showed that Panasen Stream is heavily modified and degraded.

2.1. Distribution and Abundance of Aquatic Insect Larvae

A total of 1043 individuals representing 36 species belonging to 28 families and 7 orders were recorded (Table 3). Insect larvae are found in all of the Panasen Stream Streams with the lowest number of taxa and individuals compared with the larvae found in the reference sites. In the dry season, only 7 species are found and at the beginning of the rainy season, it rises to 10 species. *Petrophila* sp., *Caenis* sp., *Chironomus* sp., *Chimarra* sp., *Cheumatopsyche* sp. and *Rhagovelia*sp were species found in both seasons. While, *Tipula* sp. and *Ischnura* sp. were found only in the dry season and *Helichuslitophilus*, *Baetis* sp., *Tricorythus*sp, *Hydropsyche*sp and *Simulium* sp. were only found at the beginning of the rainy season. Most of the species found in the Panasen Stream were tolerant of pollution.

At Ranolesi Station which is a dryland farming area, the insects consist of 3 species, *Chironomus*sp., *Rhagovelia* sp. and *Petrophila* sp. with a total of 10 individuals. At Tonsewer Station which is a combination of dry farming and paddy fields, the insects' larvae were also found 3 species only: *Petrophil*a sp., *Chimarra* sp. and *Cheumatopsyche* sp. Variations of species and number of taxa on the Panasen Stream have been changed in the early of the rainy season. At Tonsewer Station (P2h), an addition of insects species belong to *Petrophila* sp., *Chimarra* sp. and *Cheumatopsyche* sp., the emergence of *Caenis* sp., *Baetisbicaudatus*,

Tricorythus (all three of the Ephemeroptera Order), *Helichuslitophilus* (Order Coleoptera), *Hydropsyche* sp. (Order Trichoptera) and *Chironomus* sp., *Simulium* sp. (Order Diptera).

Table 3. Distribution and abundance of aquatic insects' larvae

No.	Order*	Family	Genera/Species	P1k	P2k	P3k	P4k	P5k	P2h	P3h	P4h	Mh	Nh	Rh	Total idv
1	D	Tipulidae	*Tipula* sp.			1						3		4	8
2	C	Dryopidae	*Helichuslitophilus*						3			2			5
3	C	Scirtidae	*Scirtes* sp.									1			1
4	C	Chrysomelidae	*Chrysomelidae* sp.										1		1
5	E	Heptagenidae	*Epeorus* sp.									5	2		7
6	E	Heptagenidae	*Heptagenia sp.*									2		3	5
7	T	Glossosomatidae	*Glossosoma* sp.										2	2	4
8	C	Psephenidae	*Psephenus* sp.									1	1	2	4
9	L	Pyralidae	*Petrophila* sp.	8	5	7	5	18	2				4	4	53
10	E	Prosopistomatidae	*Prosopistoma* sp.									8			8
11	E	Caenidae	*Caenis* sp.				1		31		10	22			64
12	E	Baetidae	*Baetisbicaudatus*						1			15	7	23	46
13	E	Baetidae	*Acentrellaturbida*									6		14	20
14	E	Leptophlebiidae	*Paraleptophlebia* sp.											8	8
15	D	Chironomidae	*Chironomus* sp.	1					1			1			3
16	E	Ephemerellidae	*Tricorythus* sp.						3		1	25	72	46	147
17	E	Heptagenidae	*Thalerospyrus* sp.									7		4	11
18	E	Teloganodidae	*Teloganodes* sp.									50		16	66
19	E	Baetidae	*Platybaetis*sp.									15	3	26	44
20	C	Elmidae	*Elmis* sp.										1		1
21	T	Philopotamidae	*Chimarra* sp.		4				8				72	5	89
22	T	Hydropsychidae	*Cheumatopsyche* sp.		1				72	4	19	4	105	26	231
23	T	Hydropsychidae	*Hydropsyche* sp.						40	3			40	22	105
24	D	Simuliidae	*Simulium* sp.						1			1	8	3	13

25	C	Hydrophilidae	*Berosus* sp.										26		26
26	C	Elmidae	*Dubiraphia* sp.										4	1	5
27	C	Lampyridae	*Luciolahydrophila*											5	5
28	H	Veliidae	*Rhagovelia* sp.	1				1						13	15
29	O	Coenagrionidae	*Argiallagmaminutum*									1	2		3
30	O	Cordulagasteridae	*Cordulegaster* sp.									1	1		2
31	O	Libellulidae	*Libellula* sp.									4		18	22
32	O	Libellulidae	*Macrodiplax* sp.									1		3	4
33	O	Coenagrionidae	*Ischnura* sp.				4					1		4	9
34	O	Gomphidae	*Progomphus* sp.											6	6
35	O	Chlorocyphidae	*Chlorocypha* sp.											1	1
36	D	Tabanidae	*Tabanus* sp.											1	1
			Total	10	10	8	10	19	162	7	30	176	351	260	1043

*Order: D: Diptera, E: Ephemeroptera, T: Trichoptera, C: Coleoptera, O: Odonata, H: Hemiptera

The distribution and abundance of insect larvae are summarized in Fig. 2. At the early observation of the rainy season at Panasen Station, the insect larvae found were *Caenis* sp., *Tricorythus* sp. and *Cheumatopsyche* sp. All three species have been also found in the sampling of the dry season. *Cheumatopsyche* sp. and *Caenis* sp. are tolerant species and their abundance can increase as organic pollution increases. The low presence of other aquatic insects at this location is due to high chemical content such as turbidity (6.89 SKL NTU), conductivity (503 μS/cm^2) and hardness (153 mg/L) are categorized as high. Sediments play a role in the behavioral response of insect larvae, where the larvae actively avoid substrate coated with fine sediment. Fine sediment deposition can lead to the exchange of community structures through the loss of sensitive species, especially those requiring coarse substrates to stick or eat. The trapped mud deposits can reduce the ability of photosynthesis for algae and periphyton due to reduced light penetration. Some studies have shown that abundance is generally associated with sediments [27, 30].

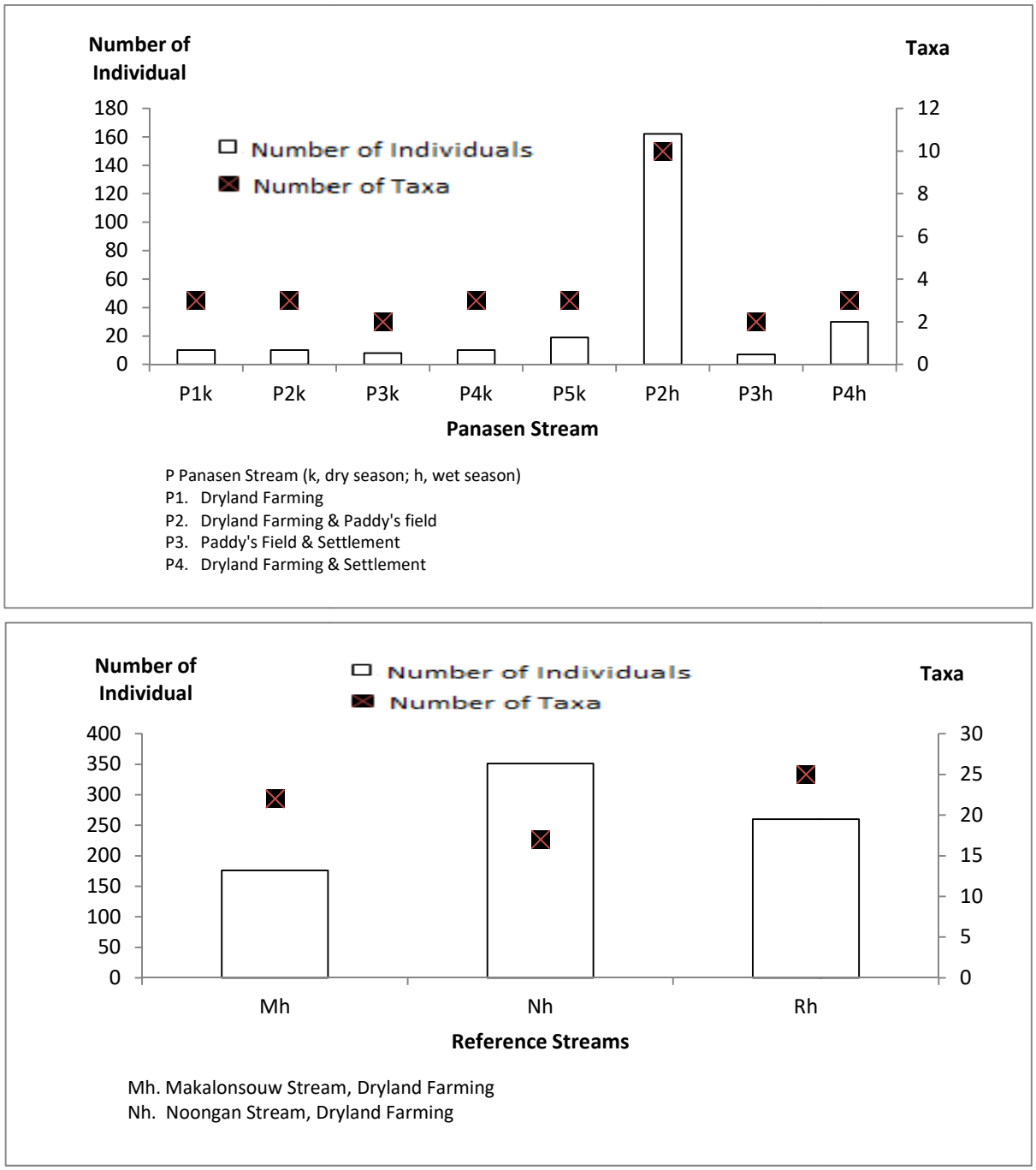

Fig.2. Comparison of number of individual and number of taxa

The three reference streams, namely Makalonsouw, Noongan and Ranoyapo are dryland farming areas. They have similarities in sedimentary structures dominated by boulder, gravel and pebbles (30-90%), and very low in fine sand. With such substrate, the current velocity at this location is relatively high 0.3-1 m/s. Unlike the Panasen Stream, species composition, as well as the number of individuals in the reference streams, are more variable and abundant (Fig. 3). The species found at Panasen Stream belong in the category of tolerant species, however in

the reference streams belong to sensitive species. The sensitive majority species are members of the Order of Ephemeroptera and Trichoptera. These two Orders coupled with Plecoptera (EPT) are often subjected to the assessment of the quality of stream habitats due to their sensitivity to environmental changes and are found in clean, cold water conditions and may contain dissolved oxygen [31].

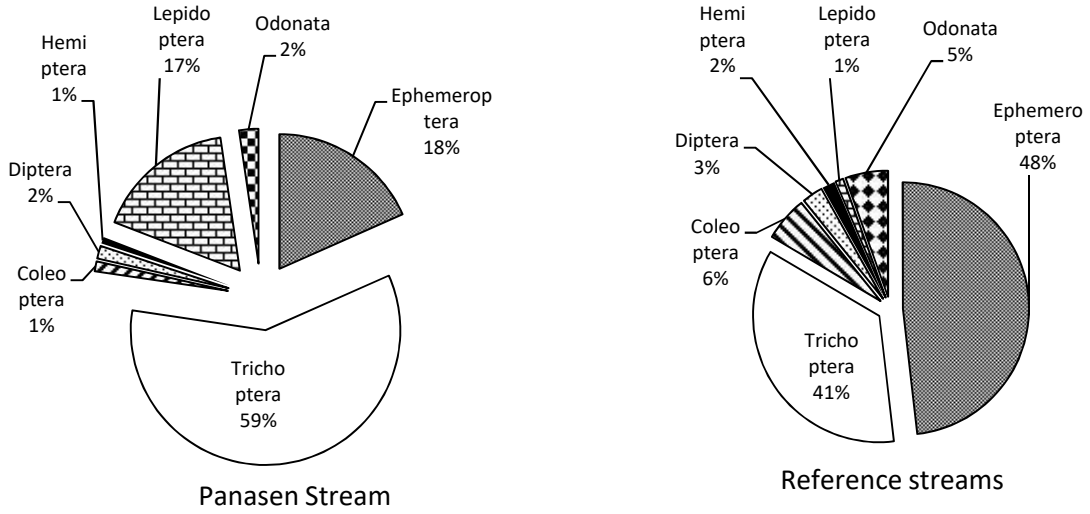

Fig.3. Proportion of aquatic insect's orders

The Order Ephemeroptera has the highest taxa richness, composed of Familia Baetidae, Caenidae, Ephemerillidae/Tricorythidae, Heptagenidae, Leptophlebiidae, Prosopistomatidae and Teloganodidae. Nympha *Tricorythus* sp. member of the Tricorythidae Family is the most numerous species of individuals (n = 143, 37.3%), followed by *Teloganodes* sp. (N = 66, 17.4%) of the total individuals of the Ephemeroptera Order. Other species found are *Acentrellaturbida*, *Platybaetis* sp, *Epeorus* sp, *Heptagenia* sp., *Thalerospyrus* sp., *Paraleptophlebia* sp, *Prosopistoma* sp. and *Teloganodes* sp. The presence of these species generally reflects the quality of healthy streams. As with *Prosopistoma* sp often called beetle-like mayfly larvae that normally occupy a shallow area is fast-fast gravel and cobble substrate [32]. While, the behavior of stream species is closely related to current velocity since fast currents may carry more nutrients over a period of time [33].

The presence of insect larvae is depended on substrate abundance where substrate selection is also closely related to the high concentration of dissolved oxygen. Trichoptera's order on the stream of reference is represented by 3 families, namely Glossosomatidae, Philopotamidae and Hydropsychidae. *Cheumatopsyche* sp. (Hydropsychidae) has the highest individual

wealth (n = 135, 48.6%). Generally, this species lives in the riffles zone. According to [33], the selection of habitats at one of the first substrate is determined by its habits of oviposition later distribution through passive drift or drift passively. This passive drift that causes *Cheumatopsyche* sp. also be found in the Panasen Stream. The Order Odonata in the reference sites is Familia Chloropcyphidae, Coenagrionidae, Cordulagateridae, Gomphidae and Libellulidae. It consists of *Ischnura* sp., *Argiallagmaminutum*, *Cordulagaster* sp., *Libellula* sp. and *Macrodiplax* sp. Only *Ischnura* sp. could be found in the Panasen Stream. The presence of these species reflects the quality of the clean and healthy stream. Order Coleoptera found in reference sites represented by Familia Chrysomelidae, Dryopidae, Elmidae, Hydrophilidae, Lampyridae, Psephenidae and Scirtidae, with species constituent that are *Chrysomelidae* sp., *Helichuslitophilus*, *Elmis* sp., *Dubiraphia* sp., *Berosus* sp., *Luciolahydrophila*, *Psephenus* sp. and *Scirtes* sp. Only *Helichuslitophilus* can be found on the Stream Panasen.

Insect larvae are abundance in reference sites that are 22, 17 and 25 species respectively on the Makalonsouw, Noongan and Ranoyapo Streams. Totally different compared to Panasen Stream. The species found on the Panasen Stream belonging to the category of tolerant species, while on the reference streams there are species included in the category sensitive to pollution. The substrate on these three streams is mostly composed of gravel and pebble and some boulders. Boulders are very important as a place to live for the larvae to shelter and get food. They play a role in capturing organic material in the form of litter that falls from terrestrial or from the canopy, also serves as a place of attachment. In addition to rock substrates, the chemical parameters of water in the reference stream indicate normal levels. These three streams have low conductivity compared to test streams, i.e. below 100 µS / cm^2. Similarly, the ammonia content of 0.11 mg / L; 0.03 mg / L and 0.08 mg / L respectively for Makalonsouw, Noongan and Ranoyapo were lower than the test stream.

The most significant factor affecting the distribution and abundance of insect's larvae is the substrate. Although there are variations on other Panasen segments but generally dominated by coarse sand, which is a bad habitat for organisms. This is not solely due to land change, but because it is connected to Soputan Mountain. The sand substrate comes from Mount Soputan through volcanic processes because the mountain is still active and even erupted during the

observation period. At the same time, the ongoing process of developing geothermal power plants contributes to the downstream sediment.

The samples were analyzed using the Principal Component Analysis, which is used to develop a set of components that can infer relationships between variables, in this case, the linkage between physical, chemical and biological factors. Insect populations on five Panasen Stream sections and three reference sites were analyzed coupled with environmental parameters (Fig. 4).

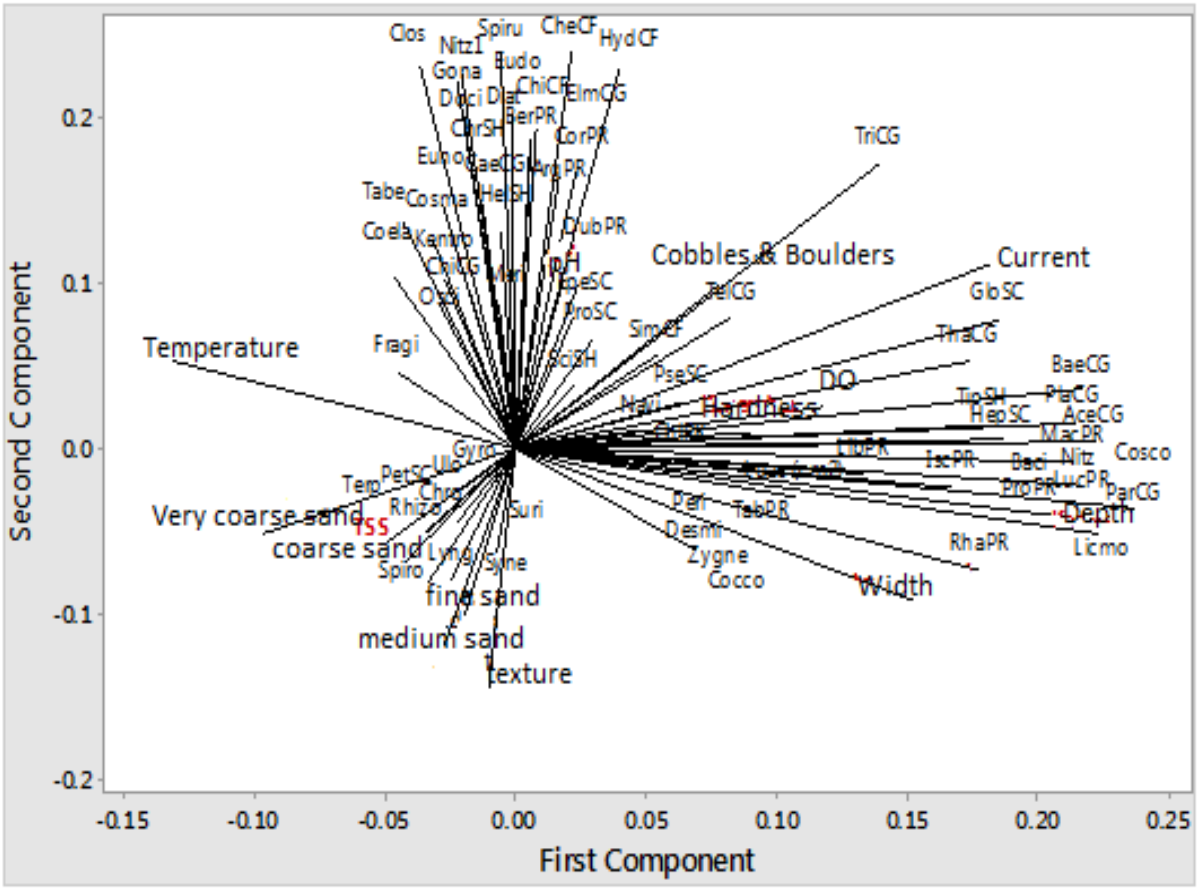

Fig.4. Principal component analysis result

The PCA results showed that stream depth and current velocity have the greatest influence on the location. Other influencing factors are conductivity, TSS, hardness and turbidity. These parameters also determine the distribution of spatial distribution of insect larvae. Other factors such as temperature, pH and dissolved oxygen and ammonia, are not limiting factors. From observations, the insect larvae community responds to environmental changes in the catchment area. Distribution and abundance in referral streams are more varied and dominated by species from the Ephemeroptera Orders which tend to be sensitive to pollution.

Land use alterations is also a major cause of biodiversity loss of stream species. Similarly, land use differences produce a variety of taxa at each level. In addition, the construction of settlements in the catchment areas decreases the spread and increases the tolerant species. The agricultural activities are strongly associated with benthic composition resulting in low species richness and poor biological integrity. All these anthropogenic pressures resulting from this catchment coupled with volcano activities result in poor water quality and weak ecological integrity.

3. METHODOLOGY

The study was conducted in 5 segments of Panasen Streamin different altitude from Soputan Mountain headwater to the mouth of Tondano Lake (Fig. 5, Table 4), as a part of Tondano watershed. The five segments are comprisedby agricultural land (Station Ranolesi namely P1), farming dry land and paddy fields (Station Tonsewer, P2): paddy fields and undeveloped land (Station Tempang, P3): dry-land agriculture/combination farms (Station Panasen, P4) and paddy fields (Stasions Talikuran, P5). Especially at stations Ranolesi and Talikuran, sampling be done only in dry season because at the beginning of the rainy season the stream water diverted into the fields for irrigations; and at Stasions Talikuran the water height was reached more than 1 meter and was not eligible for sampling site. Furthermore, observations were also conducted on three other streams namely the Makalonsow Stream, Noongan Stream and Ranoyapo Stream as reference sites. The Tondano's sub-watershed is dominated by dryland farming, mixed gardens, rice fields, and secondary forests [22]. Changes in land cover within twenty years from 1990 to 2011 were dominated by changes in forest and bush areas, each of which decreased by 44% and 28%, changes in residential and land field areas increased by approximately 12% and 33% respectively [23-24].

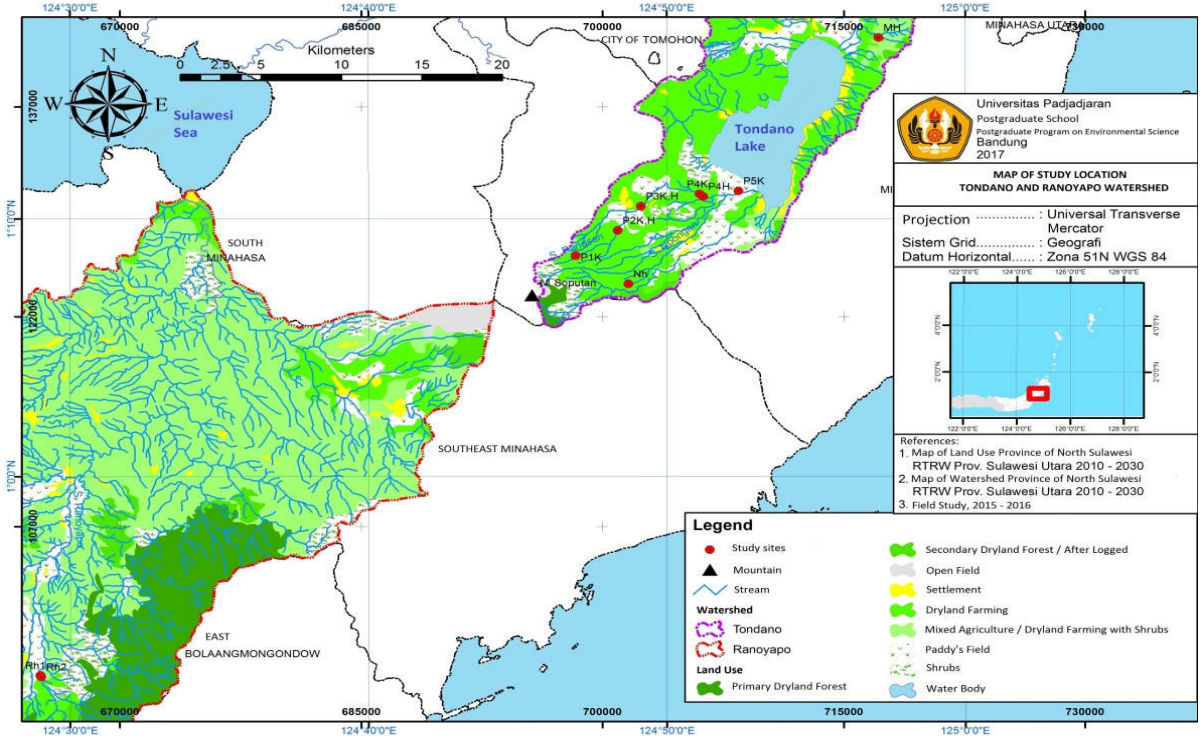

Fig.5. Map of study location

Table 4. Coordinate points of sampling locations

No.	Code	Location	Coordinate
1.	P1k	Ranolesi	01°08'34.014" LU, 124°46'56.304" BT
2.	P2k, P2h	Tonsewer	01° 09'32.923" LU, 124° 48'21.297" BT
3.	P3k, P3h	Tempang	01° 10'28.240" LU, 124° 49'6.994" BT
4.	P4k, P4h	Panasen	01° 10'57.233" LU, 124° 51'6.127" BT
5.	P5k	Talikuran	01° 11'4.247" LU, 124° 52'23.968" BT
6.	Nh	Noongan	01° 7'28.105" LU, 124° 48'42.583" BT
7.	Mh	Makalonsouw	01° 17'1.138" LU, 124° 57'6.224" BT
8.	Rh	Ranoyapo	01° 52'13.081" LU, 124°28' 59.850" BT

An aquatic insect larvae population survey was conducted in September 2015-May 2016, representative of the dry season and the rainy season. The Panasen Stream is divided into 5 stations based on land use from upstream to downstream. Each location is subdivided into 5 points with intervals of 100 meters. At each point, sampling was carried out on the left, center and right bank of the stream every 5 times. Rainfall data was taken from North Sulawesi BMKG Office (Table 5) and it showed an El-Nino phenomenon. In general, the rainy nature

of North Sulawesi Province is categorized as Below Normal (BN). In the sub-watershed Noongan BP3k Tompaso station, the intensity of rainfall in September to October 2015 was 0.

Table 5. Rainfall data (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stasiun BPK3 Tompaso												
2015	323	157	200	235	180	118	31	2	-	-	333	134
2016	240	93	55	466	293	238	241	120	304	292	287	147
Stasiun BP3k Ranoyapo												
2015	250	234	156	226	147	162	36	-	-	13	288	255
2016	335	89	102	155	540	277	165	173	513	340	223	184

Monthly rainfall criteria:

(-): no rain

0-100 mm: low

101-300 mm: medium

301-400 mm: high

> 400 mm: very high

Aquatic insect larvae were collected by using Surber Sampler (30x30 cm^2; mesh width 200 µm). The insects are searched on all possible substrates to be collected from bedrock substrates, boulders, crusts, falling leaves and dead wood. Samples collected in the net were then taken and inserted into a plastic container for inspection in the laboratory. Samples were preserved in 70% alcohol and separated each zone and each group to be further identified to the species level.

The following variables were measured in situ: width (m), depth (m) and water current velocity (m/s); whereas water temperature, pH and DO were measured by using Aquaread® AP-700 and AP-800 portable water checkers; TSS, Conductivity, Turbidity, NH_3N and Total P were analyzed based on PP RI. No. 82/2001 Class II Water Quality Standard and tested at the Laboratory of Balai Teknik Kesehatan Manado. Sediment samples of ± 1 kg were included in the ziplock plastic to determine their texture and structure in the Ecology Laboratory of Faculty of Mathematics and Natural Sciences Unsrat Manado.

4. CONCLUSION

The Panasen Stream, Tondano's watershed has long been under anthropogenic pressure and most of the sections in this upstream are degraded. Aquatic insect larvae are useful in detecting the emerging environmental gradients in this stream. Environmental factors affecting the distribution and abundance of aquatic insect larvae are a substrate, current velocity, TSS, conductivity, hardness, turbidity resulting from agricultural activities and development of geothermal power plant. However, another thing that affects the integrity of the Stream is the volcanic eruption that happens almost every year to the present day. This causes the integrity of the Panasen Stream is poor.

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