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Aufwuch Community on Association to Aquatic Plant in Lake Tempe, South Sulawesi

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Abstract. Lake Tempe was mostly covered by water hyacinth (*Eichhorniacrassipes*). Aufwuch community which live surround the aquatic plant has an important role in the food chain, as intermediate component between primary producerand higher secondary producer. This study was conducted in Lake Tempe, in order to analyse the association of aufwuch community towards aquatic plants and water quality. Sampling was carried out at five observation stations with three inundation zones. There were found 38 genera of from five classes, Cyanophyceae (5), Chlorophyceae (11), Bacillarophyceae (8), Euglenophyceae (2), and Chrysophyceae (1) as microphyto-aufwuch with density ranged from 16 544 840-203139505 ind/m^3; 33 genera from four groups, Crustacea (10), Protozoa (8), Rotifer (14), Insect (1) of microzoo-aufwuch with density ranged from 138 969-351 834 ind/m^3; and 15 genera from four groups, Gastropod (4), Insect (5), Crustacea (5), Larvae (1) as microzoo-aufwuch. The temperature of waters was ranged as 30,4-36 ℃, depth 40-145 cm, Secchi depth 15.0-60.7 cm, pH 5.2-9.2, DO 2.9-16.9 mg/L, ammonium 0.005-0.013 mg/L, ammonia 0.0002-0.2912 mg/L, nitrate 0.5828-0.9113 mg/L, nitrite 0.004-0.0127 mg/L, and orthophosphate 0.0429-0.1325 mg/L.There were three groups of aufwuch in Lake Tempe, the microphyto-aufwuch, microzoo-aufwuch, and macrozoo-aufwuch, with appropriate water quality conditions for aufwuch life.

1. Introduction

Lake Tempe in Wajo District, South Sulawesi is a flood plain, that fluctuates from around 1000 ha in dry season to more than 30 000 ha in rainy season with the depth of 1.0-5.5 m. Nearly 45% of its surface is covered by aquatic plants such as water hyacinth (*Eichhorniacrassipes*), water spinach (*Ipomoea aquatica*), and *Cyperus* sp.

People use the aquatic plant for specific fish rearing in the lake, the *bunkatoddo*. The *bunkatoddo* is operated in moderate high level of water, in about three month yearly, and people will get harvest after this period. Unfortunately, people do not dispatch the aquatic plant out of lake water. As consequence, Lake Tempe is mostly covered by water hyacinth.

On the other hand, there are other wild aquatic plants that also live in the lake, both the floating and the submerged type. The submerged part of aquatic plants provide specific environment for aquatic organisms, especially the small organisms living surround it, the aufwuch. Aufwuch leads from bare areas (e.g, newly submersed natural or artificial substrates or plant surfaces) to more or less dense covers of bacteria, protists, small plants, and animals [2]. Aufwuch can be primary producer (autotroph) or heterotroph. Aufwuch, plankton, and benthos are part of aquatic ecosystem component and have important role in aquatic productivity [1].

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There are limitted information about aufwuch community as resources support for the upper trophic level. Moreover, the information about relationship between this community and the environment, especially the habitat they are living in. Therefore this research was aimed to study the association of aufwuch community toward aquatic plant and lake water quality.

2. Material and Methods

The aufwuch samples were taken from water surround submerged part of aquatic plants with vertical towing technique using plankton net. The samples were analysed for identification and counting of microphyto-aufwuch, microzoo-aufwuch, and macrozoo-aufwuch. There were also water quality parameters analysis. Samples were taken from five locations (Station 1 to 5) (Figure 1).

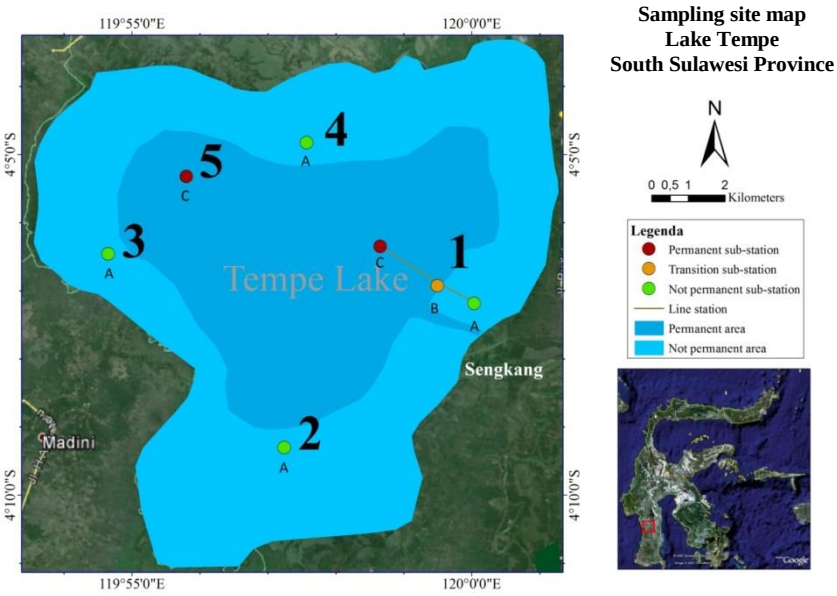

Figure 1. Aufwuch sampling site on Lake Tempe.

Microphyto-aufwuch and microzoo-aufwuch wasidentified and counted under compound microscope using plankton identification book [3]. Macrozoo-aufwuchwas observed using stereo microscope and identified based on invertebrates identification book [4,5]. Physical and chemical water quality parameters consists of temperature, depth, transparency, pH, dissolved oxygen, nitrate, nitrite, ammonia, and orthophosphate was measured and analysed based on APHA[6].

Data analysis for Shannon-Wiener diversity index, Evenness index, and Dominance index was conducted according to [7]. Cluster analysis for biological parameters was conducted using Bray-Curtis index [8], and physical and chemical parameters (including ammonium) were conducted using on Canberra index. Multiple regressions were conducted to determine relationship among biological, physical, and chemical parameters.

3. Results

3.1. Water quality

Water quality of Lake Tempe tends to vary on each station. The measurements of physical parameters and aquatic chemistry in Lake Tempe are presented in Table 1.

Table 1. Average values of physical and chemical parameters at each station

Parameters	Unit	Station				
		1	2	3	4	5
Temperature	℃	32.4	30.4	36.0	30.4	31.0
Depth	cm	93.3	90.0	40.0	40.0	145.0
Transparency	cm	60.7	38.0	15.0	33.0	49.0
pH	-	8.1	7.5	9.2	7.8	5.2
DO	mg/L	8.5	2.9	9.7[a]	3.0	7.8
Ammonium	mg/L	0.0131	0.0050	0.0100	0.0050	0.0050
Ammonia	mg/L	0.0015	0.0018	0.0002	0.0010	0.2912
Nitrate	mg/L	0.5828	0.8585	0.9113	0.7366	0.6404
Nitrite	mg/L	0.0078	0.0073	0.0047	0.0127	0.0040
Orthophosphate	mg/L	0.0429	0.0452	0.0588	0.0559	0.1325

[a]The value presented is 100% saturation

3.2. Aufwuch composition

3.2.1. Microphyto-aufwuch

The results showed that microphyto-aufwuch in Lake Tempe consisted of five families with the highest number of taxa was found in Chlorophyceae (Figure 2a). The composition of microphyto-aufwuch were Cyanophyceae (5 genera), Chlorophyceae (11 genera), Bacillarophyceae (8 genera), Euglenophyceae (2 genera), and Chrysophyceae (1 genus). The microphyto-aufwuch composition based on abundance (Figure 2b) was dominated by class Bacillariophyceae of 399 355 994 cell/m^3, while Euglenophyceae and Chrysophyceae had the lowest abundance. The dominant species found was *Melosira* sp.

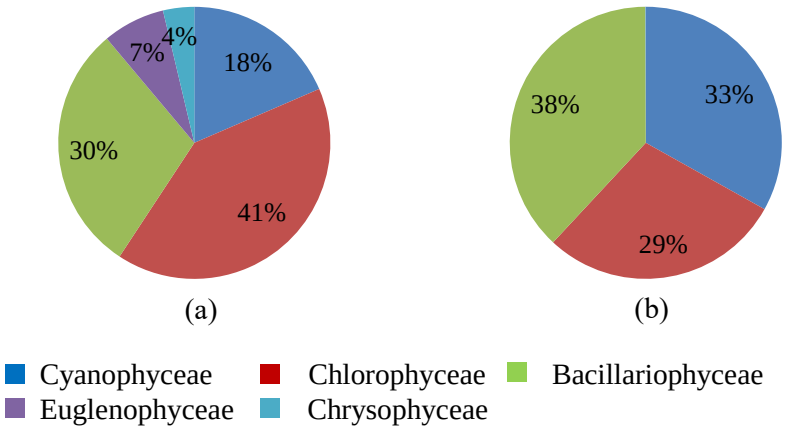

Figure 2. Composition of microphyto-aufwuch groups based on (a) number of species; (b) total abundance (cell/m^3).

The abundance of microphyto-aufwuch at each station during observations ranged from 7.04 x 10^7-3.07 x 10^8 cell/m^3. The lowest abundance was found at Station 4 and the highest abundance was found at Station 3. Table 2 showed microphyto-aufwuch composition based on the number of species and abundance at each station.

Table 2. Abundance of microphyto-aufwuch (ind/m^3) at each station.

Station	Number of species	Abundance (cell/m^3)
1	16	2.20x 10^8
2	19	7.51 x 10^7
3	15	3.07x 10^8
4	15	7.04x 10^7
5	13	2.80 x 10^8

The index value of diversity, uniformity, and dominance (Table 3) can be used to assess the stability of aquatic community. On the whole, value of diversity index (H') in Lake Tempe was ranged from 0.58 to 1.77 and the uniformity index value (E) ranged from 0.23-0.65. The highest value of dominance (C) index was obtained at Station 5 of 0.72.

Table 3. Diversity index (H'), uniformity index (E), and dominance index (C) value of microphyto-aufwuch.

Station	Diversity	Uniformity	Dominance
1	1.49	0.54	0.28
2	1.74	0.59	0.25
3	1.14	0.42	0.39
4	1.77	0.65	0.21
5	0.58	0.23	0.72

3.2.2. Microzoo-aufwuch

Microzoo-aufwuch composition based on the number of species consisted of four groups (Figure 3a). Those were Crustacea (10 genera), Protozoa (8 genera), Rotifer (14 genera), and Insect (1 genus). Figure 3b showed microzoo-aufwuch composition based on abundance that was dominated by Rotiferof 1 571 511 ind/m^3. *Vorticella* sp. was found as dominant species.

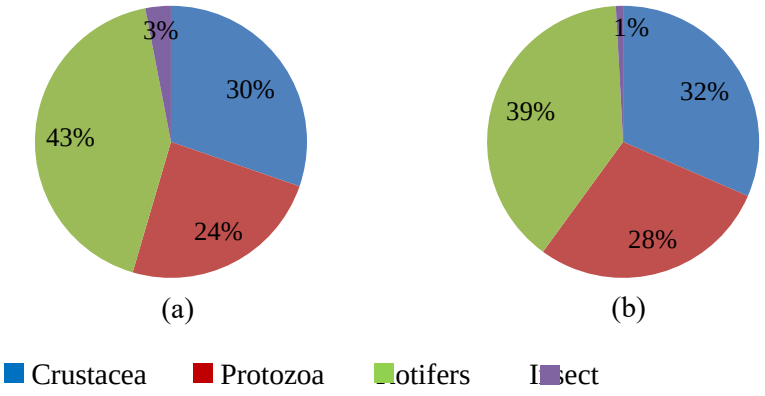

Figure 3. Composition of microzoo-aufwuch groups based on (i) number of species; (ii) total abundance (cell/m^3).

The abundance of microzoo-aufwuch during observation at each station was ranged from 4.17 x 10^5-1.06 x 10^6ind/m^3 (Table 4). The lowest abundance was found at Station 5 and the highest was found at Station 3. The highest number of taxa of microzoo-aufwuch was found at Station 1.

Table 4. Abundance of microzoo-aufwuch (ind/m^3) at each station.

Station	Number of species	Abundance (ind/m^3)
1	25	9.40 x 10^5
2	16	8.71 x 10^5
3	13	1.06 x 10^6
4	12	7.33 x 10^5
5	16	4.17 x 10^5

The value of diversity, uniformity, and dominance index was shown in Table 5. The overall value of diversity index (H') in Lake Tempe was ranged from 1.70 to 2.33 and uniformity index value (E) ranged from 0.61-0.77. The highest index value of dominance (C) is obtained at Station 2 of 0.32.

Table 5. Diversity index (H'), uniformity index (E), and dominance index (C) value of microzoo-aufwuch.

Station	Diversity	Uniformity	Dominance
1	2.33	0.72	0.15
2	1.70	0.61	0.32
3	1.79	0.70	0.22
4	1.91	0.77	0.21
5	1.94	0.70	0.23

3.2.3. Macrozoo-aufwuch

The macrozoo-aufwuch community consisted of various types of macrozoo-aufwuch populations. The results showed that macrozoo-aufwuch composition based on the number of species in Lake Tempe consisted of four groups (Figure 4a and 4b). Those were Gastropod (4 genera), Insect (5 genera), Crustacea (5 genera), and larvae (1 genus). Based on the abundance, Crustacea group has the highest abundance of 2 446 ind/m^3. Crustacea that dominated the population was *Palaemonetes* sp.

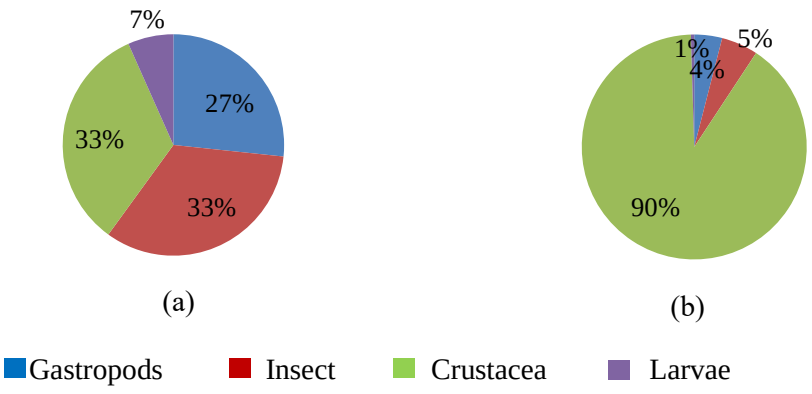

Figure 4. Composition of macrozoo-aufwuch groups based on (i) number of species; (ii) total abundance (cell/m^3).

The abundance of macrozoo-aufwuchat each station was ranged from 195-970 ind/m^3(Table 6). The lowest abundance was found in Station 2 and the highest abundance was found at Station 3. The highest number of taxa was found at Station 3. The abundance of macrozoo-aufwuch at Station 3 is allegedly related to environmental factors that support the existence of macrozoo-aufwuch.

Table 6. Abundance of macrozoo-aufwuch (ind/m^3) at each station.

Station	Number of species	Abundance (ind/m^3)
1	11	492
2	9	195
3	12	970
4	9	531
5	7	524

The value of diversity, uniformity, and dominance index was shown in Table 7. As a whole, diversity index (H') was ranged from 1.34 to 2.03 and uniformity index (E) was ranged from 0.63 to 0.93. The highest value of dominance index (C) was obtained at Station 5 of 0.35.

Table 7. Diversity index (H'), uniformity index (E), and dominance index (C) value of macrozoo-aufwuch.

Station	Diversity	Uniformity	Dominance
1	1.75	0.73	0.23
2	2.03	0.93	0.14
3	1.56	0.63	0.27
4	1.49	0.68	0.26
5	1.34	0.69	0.35

3.3. Aufwuchspatial distribution

The aufwuch spatial distribution (microphyto-aufwuch, microzoo-aufwuch, and macrozoo-aufwuch) is illustrated through dendrogram. Dendrogram of station grouping based on aufwuch abundance and water quality are presented in Figure 5. Based on the dendrogram, it is known that aufwuch communities were distributed in two location groups; location 1 (Station 1, 3, 4) and location 2 (Station 2, 5). Spatial distribution of water quality is also illustrated in figure 6. Based on the dendrogram, it is known that water quality parameters was distributed in two location groups; location 1 (Station 1, 2, 4, 5) and location 2 (Station 3).

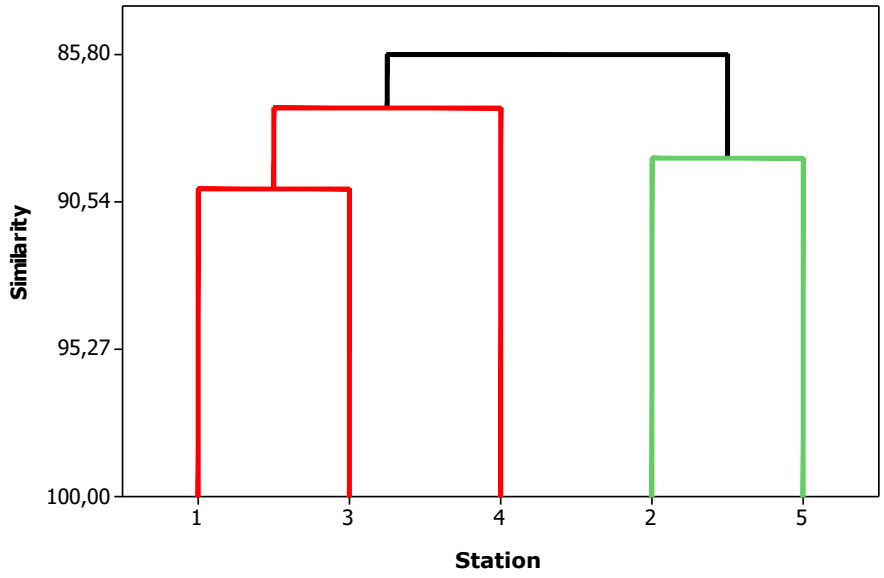

Figure 5. Dendrogram of station grouping based on aufwuch abundance.

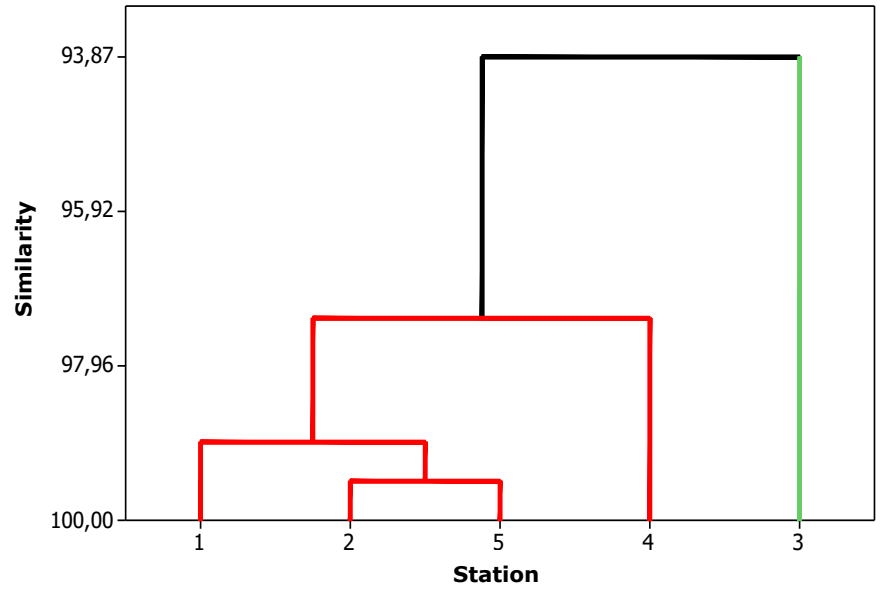

Figure 6. Dendrogram of station grouping based on water quality parameter.

The results of multiple regressions are used to see the effect of physical, chemical, and biological parameters on the abundance of microphyto-aufwuch (Y1) and microzoo-aufwuch (Y2), as well as macrozoo-aufwuch (Y3) abundance. The aufwuch abundance regression equation uses several independent variables comprise of temperature (X1), pH (X2), dissolved oxygen (X3), ammonia (X4), orthophosphate (X5), inorganic nitrogen (X6), microphyto-aufwuch (X7), and microzoo-aufwuch (X8). The formula is as follows.

$$\text{Ln } Y1 = -26.5086 + 18.93364 \text{ Ln } X1 - 9.80352 \text{ Ln } X2 - 24.4547 \text{ Ln } X5 + 7.216279 \text{ Ln } X6; (p < 0.2). \quad (1)$$

$$\text{Ln } Y2 = 23.344 - 0.56585 \text{ Ln } X7; (p < 0.2). \quad (2)$$

$$\text{Ln } Y3 = -93.4846 + 34.05507 \text{ Ln } X2 - 4.48863 \text{ Ln } X3 + 45.44704 \text{ Ln } X4 + 0.376848 \text{ Ln } X8 + 1.505424 \text{ Ln } X7; (p < 0.05). \quad (3)$$

4. Discussion

Lake Tempe is a shallow lake with depth ranging from 40-145 cm. One of serious problem in Lake Tempe is the severe sedimentation. The transparency of was only 15-60.7 cm. Low transparency is presumed due to rainwater inputs that bring agricultural runoff and soil erosion, as well as the current waves that occur in the lake itself. Agricultural runoff will bring organic material that can increase the abundance of phytoplankton [9].

Lake Tempe temperature was ranged from 30.4-36 °C. Temperatures at Lake Tempe was tend to high because Lake Tempe is located at the equator latitude, so that the heat intensity obtained is higher than other locations. The lowest temperature was found in Station 2 and 4. This is allegedly because of the existence of dense aquatic plants that shade water from light penetration. The amount of DO was varied, ranging from 2.9-16.9 mg/L. The pH values obtained was ranged from 5.2 to 9.2.

In general, the condition of water quality based on nutrient concentration in Lake Tempe is in a good condition for biota (table 1). Ammonium content was varied between 0.005-0.013 mg/L. Ammonium is ammonia in ionized form which is nontoxic. However, in an alkaline atmosphere (high pH) more ammonia is found in unionized form that is toxic. This unionized ammonia is more easily absorbed into the body of aquatic organisms than ammonium [10]. Ammonia, nitrate, and nitrite concentration was varied between 0.0002-0.2912 mg/L, 0.58-0.91 mg/L, and 0.004-0.012 mg/L. The limit of nitrite concentration in the waters exceeds 0.02 mg/L. Orthophosphates was ranged from 0.0429-0.1325 mg/L. Orthophosphate is a form of phosphorus that can be utilized directly by aquatic plants and phytoplankton, phyto-periphyton, and microphyto-aufwuch.

Chlorophyceae group dominates over the other group of microphyto-aufwuch (figure 2a). *Melosira* sp. from Bacillariophyceae class was the most common species found. The high abundance of Bacillariophyceae (figure 2b) is allegedly due to appropriate environmental factors such as pH and temperature. The average pH of the waters was 7.6 and the temperature was about 30 °C. According to [11], Bacillarophyceae can grow well in neutral pH and optimum temperatures ranging from 18-30 °C. In addition, Bacillariophyceae is also found in many layers of surface waters. Since aufwuch sampling was also carried out on the water surface, more Bacillariophyceae was found. In addition, microphyto-aufwuchspecies i.e. *Merismopedia* sp. and *Oscillatoria* sp. from Cyanophyceae class were found in high abundance. According to [12], the existence of *Merismopedia* sp. and *Oscillatoria* sp. shows a eutrophic water condition.

Microphyto-aufwuch itself has a function as the organizer of organic materials and the largest oxygen producer in the waters through photosynthesis process of 90-95% [13]. These organisms are able to thrive in relatively tranquil waters such as reservoirs, lakes, and ponds [14]. As the first feeding chain micro aufwuch greatly supports the life of biota in waters [15]. If the balance of micro aufwuch community structure in waters is disturbed, it will result in a decrease of fertility rates for these waters; in this case greatly affect the survival of the organisms in it.

The abundance of micro aufwuch illustrates the general characteristics of a reservoir and lake waters [16]. Micro aufwuch is a natural food for aquatic organisms' larvae, which microphyto-aufwuch acts as major producer, while those acting as consumer organisms are microzoo-aufwuch, larvae, fish, shrimp, crab, and other higher trophic level organisms. Information on the presence of microphto-aufwuchand nutrients can be used as a guide to determine trophic state of waters.

Microzoo-aufwuch in aquatic ecosystem is an important link for the aquatic food web. Rotifera was dominating others (figure 3a). The highest abundance in microzoo-aufwuch is in the genus *Vorticella* sp. from the Protozoa group (figure 3b). *Vorticella* sp. is an organism of the Ciliates group. The predominance of Ciliates is suspected to have something to do with organic matter in water. As [17]

stated, that Ciliates grows well in waters that contain lots of organic matter. *Vorticella* sp. is an indicator, that in the waters of the decomposition of organic matter.

The macrozoo-aufwuch composition of the Insects and Crustacea groups dominates over the other group (figure 4a and 4b). The genus of Crustacea that was commonly encountered is *Palaemonetes*sp. The number of Crustacea allegedly occurred because of the abundance of food for the Crustacea so it can flourish. As is known in Lake Tempe, the aufwuch micro productivity is very high, so it is good for food webs in other trophic levels.

As part of the freshwater ecosystem, freshwater prawns play a role in maintaining the balance of ecosystems by functioning in the aquatic food chain [18]. According to [19], the large number of species and individuals acquired in a habitat indicates that environmental conditions and nutrients support the life of the shrimp species. In addition, on sampling macrozoo-aufwuch, there are many types of insects taken, such as *Chironomus*, *Buenoa*, *Helichus*, and water spiders. Allegedly this happens because insect type organisms also utilize biological resources in the waters for food ingredients, such as microaufwuch. According to [13], some insects in natural ecosystems are microphyto-aufwuch eaters, while others are unknown.

In general, the diversity index value of each aufwuch group tends to vary on each station (table 3, 5, and 7). The value of uniformity index showed that microphyto-aufwuch groups tend to vary on each station. Microphyto-aufwuch at Station 1, 2, 4 tends to be uniform, which can be seen from the index value of uniformity higher than the dominance, while Station 3 and 5 had lower uniformity index. It shows there is dominancy at Station 3 and 5. The dominance of certain types of microalgae is related to the structure of the body and the pattern of its life. Based on the results, microphyto-aufwuch of Lake Tempe is dominated by diatoms or Bacillariophyceae class. The dominancy ofBacillariophyceae compared to some other phytoplankton groups is common in the waters that are mixed and the tidal changes continuously.

Based on the uniformity index values, the microzoo-aufwuch and macrozoo-aufwuch groups tend to be uniform at each station, so there no dominance of the speciesoccurred. It can be seen from the index value of uniformity greater than the value of dominance index on each station.

The result of determination of observation site equality index based on aufwuch abundance showed two groups at 86% equality. The first group consisted of station 1, 3, and 4, while the second group consisted of Station 2 and 5. The result of similarity index based on physical parameter, and water chemistry showed two groups at 95% equality. The first group consists of station 1, 2, 4, and 5 whereas the second group consists only of Station 3. The similarity of stations obtained, illustrates that the stations in each group have the same characteristics. In general, the grouping based on aufwuch abundance as well as on the physics-chemical parameters of Station 2 waters has a characteristic similarity with Station 5, and Station 1, 3, and 4 are also relatively similar in characteristic to the grouping based on aufwuch abundance as well as by aquatic physics-chemical parameters.

Based on the results of multiple regressions, there are functional relationships and aquatic biology. There is a clear connection between microphyto-aufwuch abundance and the physics-chemical parameters of waters such as temperature, pH, orthophosphate, and inorganic nitrogen (a combination of nitrates, nitrites, and ammonium). Furthermore, there is a relationship between microzoo-aufwuch abundance with microphyto-aufwuch parameters. Next, the macrozoo-aufwuch abundance is related to parameters such as pH, DO, ammonia, microphyto-aufwuch and microzoo-aufwuch.

The distribution of aufwuch is related to the physical and chemical parameters of Lake Tempe. Physical and chemical parameters of waters are abiotic factors in the ecosystem that contribute to the survival of aquatic organisms. According to [9], factors such as season, period of sunlight, wind patterns, lake depth, temperature, pH, turbidity, dissolved oxygen, and nutrient enrichment, such as dissolved chloride, phosphate, and organic carbon affect the presence of microphyto-aufwuch in freshwater lake. It also features watershed, land use, and biogeochemical features, soil, or sediments also affect the ecology of microphyto-aufwuch. The micro and macro-zooaufwuch abundance is closely related to the abundance of microphyto-aufwuch.

5. Conclusion

There are three aufwuch communities associated with aquatic plants (water hyacinth, water spinach, and grass) in Lake Tempe; microphyto-aufwuch, microzoo-aufwuch, and macrozoo-aufwuch. The microphyto-aufwuchwas dominated by Bacilariophyceae. The microzoo-aufwuchwas dominated by Protozoa. The macrozoo-aufwuchwas dominated byCrustaceae. Physical, chemical, and biological parameters affect the abundance of aufwuch communities in Lake Tempe.

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