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# The Thermal Water Waste Pollution from Electricity Industry of PLTU - Tello and its Effects on Fishes and Macrozoobenthos Organism in Tallo Estuary, Makassar

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**Abstract:** ***Study on thermal water waste pollution from electricity industry of PLTU - TELLO and its effects on fishes and macrozoobenthos in Tallo Estuary, Makassar has been conducted from March to May 2010. The result revealed that hot water caused increase temperature around the outlet of the factory. Direct observation demonstrated that difference temperature (Δt) occurred along the river from outlet to the estuary. From the fifteen samples, it was observed that the mean of difference temperature (Δt) in outlet were $5^{O}$ C in the morning and $5.17^{O}$ C in the day. In the Estuary the delta t (Δt) were $4.7^{O}$ C in the morning and $5.07^{O}$ C in the day. It was also observed that the farther the distance from the outlet the cooler of the temperature was occurred. The mean of the delta t were $5.21^{O}$C in the morning and $5.20^{O}$ C in the day. The increase of temperatures were followed by the decrease of dissolved oxygen, whereas the salinity increase by increasing the temperature. Fishes that caught in the study were 598. If the number converted to catch per unit trip per month, then the number was very small compared to the catching effort of the artisanal fisheries along the river bank of Tallo. Based on the macrozoobenthos data, the closer to the outlet, the fewer the number and the diversity of macrozoobenthos were found.***

**Keywords:** Tallo estuary, the thermal water pollution, diversity index, fishes andmacrozoobenthos

## 1. Introduction

The thermal water waste is the waste of cooling water from industrial or company machines, which, because it is no longer used after receiving heat or because it is excess after producing steam energy, is then channeled into the sewer. Likewise, the Tello Steam Power Plant (PLTU) in Makassar City has for a long time transferred energy as a steam power plant and disposed of the excess hot water into a drain which ultimately transfers to the Tallo River. In fact, until now the Tallo River is still a natural water (river) whose stretch is very strategic dividing the East and North areas of Makassar City, where most of the city's people still hope for it as land infrastructure to find a source of livelihood. The thermal water waste that is wasted and enters the river body will cause changes in temperature to increase from the normal average temperature of the river waters. This change in temperature is known as "thermal pollution", and if this situation continues, it will certainly affect the living environment of the aquatic biota in it.

In general, most of the aquatic biota (especially eurythermal ones) choose warm waters for metabolism such as feeding and reproduction activities, even though the warmth of the medium has approached the temperature of its lethal point. Starting from this view, it is interesting to examine the waters of the Tello River Estuary, which is suspected to have been contaminated with hot water waste for a long time, which is likely to increase the instability of the abundance of aquatic biota or even kill it.

This research aims to determine the extent of the influence of hot water waste from the Makassar City PLTU - Tello company on fish biota and macrozoobenthos in the waters of the Makassar Tallo River estuary. It is hoped that the results of this research will provide information in making policies to improve water environmental management, especially waste management for industries that produce hot water waste.

## 2. Research Methods

### 2.1 Time and Location

This research was conducted from March to May 2023 in the estuary of the Tallo River, Tallo District, Makassar.

#### 2.1.1. Research Station

There are 5 observation stations determined based on the separation of designation categories, namely; 1) part of the river where PLTU water is sucked in, 2) part of the river where it is spilled, 3) part of the upper estuary (near the spillway), 4) part of the lower estuary (around the coastline), and 5) coastal waters around 100 m from the mouth of the estuary (as comparison or control station). Except for stations I and V, the other three stations (II, III, and IV) are each divided into 3 sub - stations as sampling points and at the same time as repeat observations (Fig.1).

#### 2.1.2 Measurement of Environmental Parameters Physics

Physical factors include temperature, measurements are made at observation stations using a stem thermometer, both on the surface and at certain depths, and the results are expressed in degrees Celsius.

Brightness is measured with a Secchi disk, where the depth obtained is expressed in cm or percent (%).

The direction and speed of the current are measured with an Ekman current meter. The current speed is expressed in cm/second and the direction in degrees ($0^O$ N and $90^O$ T).

The slope of the topography towards the river mouth or sea is known based on the degree of slope of the bottom for every 100 m horizontal distance from the start of the waste disposal. And the average depth is calculated based on the length of the weighted rope that sinks to the bottom at every 100 m distance traveled (JICA, 2005).

**Chemistry**
Chemical analysis of the sample water taken with the Nansen bottle at the same depth as the temperature measurement, then brought to the water quality laboratory, Department of Fisheries, Faculty of Marine Sciences and Fisheries Unhas to determine its dissolved $O_2$ content (mg/l) using the Winkler method. Salt content (salinity) is expressed in permil (‰) with a hand - refractosalinometer. The acidity (pH) of water is determined based on the pH Universal Indicator color standard.

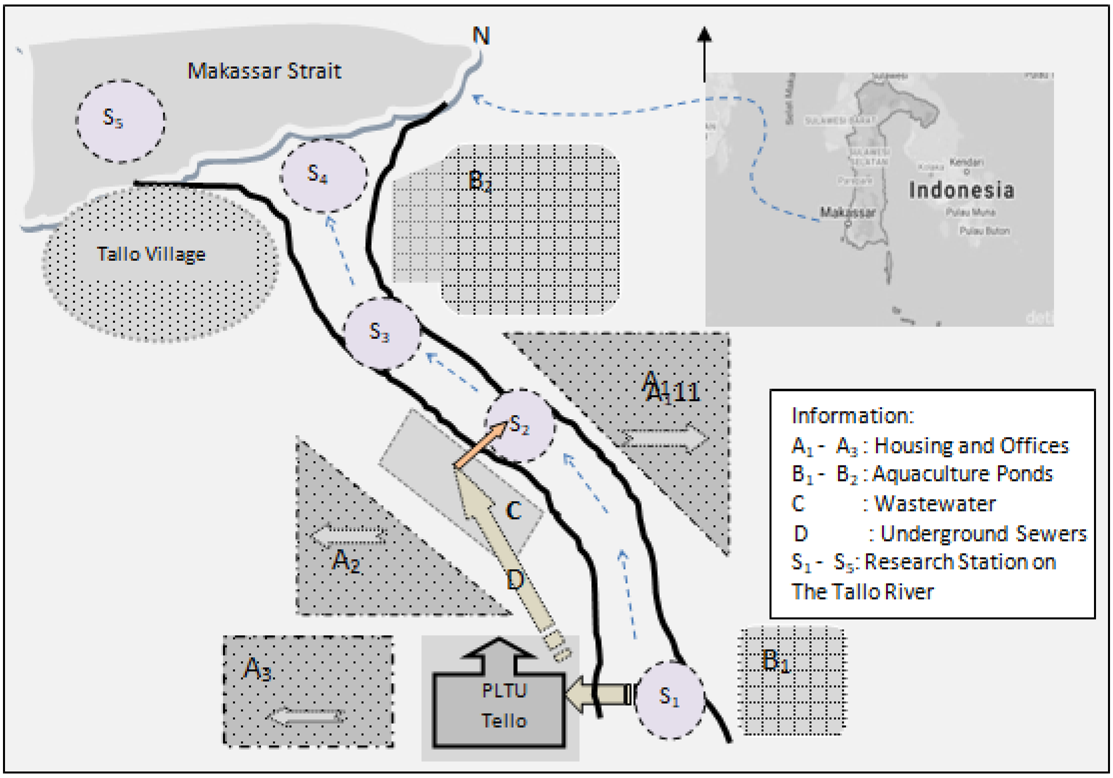


**Figure 1:** Location plan and research stations in the waters of the Muara and Tallo Rivers, Makassar

### 2.1.3 Aquatic biota

The aquatic biota that are the objects of observation in this research are fish and basic organisms (macrozoobenthos). Fish are obtained using drag nets and gill nets which are operated using the same method at each station on a scheduled basis. Samples of caught fish were preserved in 10% formalin and then taken to the laboratory of the Department of Fisheries, Unhas and the fish specimen laboratory of the Paotere Makassar Fisheries and Marine Service to be matched to the type or species.

Relative density is determined based on a scoring system according to the number of individuals and the weight of each type per week. All types are ranked in order of value according to the density of individuals. The species that occupy level I have the highest relative density, whereas the species that occupy the lowest level have the lowest relative density. Total density is the number of individuals and the amount of weight caught from each type of fish during the study.

Benthic organisms (macrozoobenthos) were obtained at each research station using an "Ekman Dredge" with an opening capacity of 16x14 cm2 in the bottom water material. The removal was carried out 3 times and with a filtering capacity of 0.5 mm. Furthermore, the samples were preserved in 0.70 alcohol solution for analysis and identification in the laboratory. The diversity index for both fish biota and macrozoobenthos is calculated based on the Shannon and Weaver index (Odum, 1971).

$H = - \sum (ni / N) \ln (ni / N)$

Where; H = diversity index; ni = number of individuals or specific gravity of I, and N = Total number of all individuals or total weight.

## 3. Results and Discussion

### 3.1 Environmental Physico - Chemical Factors

#### 3.1.1 Temperature

The water temperature at each station can be seen in Table 1. The temperature between the suction/take channel (station I) and the disposal/disposal (station II) shows an average difference (Δt) of $5^oC$ in the morning and $5.17^oC$ in the afternoon, while between the waste and the upper estuary near the waste and estuary the bottom around the coastline respectively the difference in the morning is $1.50^oC$, in the afternoon is $0.98^oC$, and towards station IV is $4.70^oC$ in the



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morning and 5.07°C in the afternoon. And towards the sea (± 100 m from the mouth of the estuary) the temperature decreases with an average difference (Δt) of 6.21°C in the morning and 6.57°C in the afternoon from the waste station. This shows a trend of increasing temperature towards the waste or disposal station, and decreasing towards the sea.

The highest average temperature in the morning and afternoon was obtained at station II (extraction), namely 33°C and 34.37°C, then the lowest in the morning and afternoon at station I (suction), namely 28°C and 29.20°C, and station V (control) with respectively - each morning and afternoon 26.79°C and 27.80°C. The temperature range in the river body (stations I - IV) is 28.0 - 34.50°C, which is still higher than the temperature range in the surrounding coastal waters, namely 26.79 - 27.80°C, this indicates that heat waste pollution has influenced changes in increasing natural temperature of river waters, especially around waste disposal and river mouths. This affects the dominance of labyrinth fish and accelerates metabolism in the process of hatching eggs and cysts which can cause blooming algae and eutrophication in the waters. The dominance of the chanidae and claridae families raises predation problems for other economically important fish seeds that are the target of community food consumption, such as Barbonymussp, Cyprinussp, Tilapianilotica, shrimp and crabs.

Ecologically, increasing temperature affects the acceleration of macro metabolism and microorganisms (especially the decomposer group) which require a lot of oxygen, causing the oxygen to decrease. If oxygen is reduced below the optimal limit for life, then usually what happens is an - aerobic oxidation processes which give rise to many unpleasant chemical gases such as NH3, H2S, and other toxic acids. And this is usually indicated by a decrease in pH which makes the waters more acidic (Kinne, 1994).

**Table 1:** Average Water Temperature of the Tallo River and Estuary at 5 Observation Stations during Research

| Station | Average | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|
| Suction/Extraction water intake (St. I) | | | | |
| • Morning | 28, 00 | 0, 58 | 27, 00 | 29, 00 |
| • Afternoon | 29, 20 | 1, 23 | 27, 30 | 31, 00 |
| Sewer/Bureau wishful thinking (St. II) | | | | |
| • Morning | 33, 00 | 1, 11 | 31, 30 | 34, 50 |
| • Afternoon | 34, 37 | 0, 57 | 32, 00 | 34, 74 |
| Upper estuary (±500m from drainage) (st. III) | | | | |
| • Morning | 32, 50 | 1, 10 | 30, 00 | 33, 47 |
| • Afternoon | 33, 39 | 1, 15 | 31, 17 | 33, 59 |
| Lower estuary (around the coastline) (St. IV) | | | | |
| • Morning | 28, 30 | 1, 17 | 26, 50 | 30, 37 |
| • Afternoon | 29, 30 | 1, 22 | 27, 30 | 31, 50 |
| Coastal waters (± 100 m from Muara towards sea) | | | | |
| • Morning | 26, 79 | 0, 67 | 26, 50 | 27, 70 |
| • Afternoon | 27, 80 | 9, 97 | 27, 50 | 29, 30 |

### 3.1.2 Brightness (Transparency)

The brightness at each observation station can be seen in Table 2. The highest average brightness was obtained at station V (about 100 m from the mouth of the estuary to the sea) which was 1.30 m, followed by stations IV, III, I, and II, with respective averages of 1.10 m, 0.85 m, 0.65 m, and the lowest 0.47 m. The lowest brightness obtained around the desludging station and waste disposal is caused by the activity of ponds and disposal of domestic waste and the rapid eroding of currents in the shallowest parts, especially around the waste.

### 3.1.3 River current speed

The current velocity at each station can be seen in Table 2. The highest average current velocity was observed around the desludging station towards the waste disposal site, which was 20 cm/sec., with a direction of 347o North Latitude. Whereas at the sewage station towards the upper estuary, the current speed is 18.15 cm/sec., with a direction of 3250 North Latitude following the river channel. The lowest current speed was obtained at station IV, namely 11.60 cm/sec., with a direction of 335o north latitude. Current speed at station IV is often dominated by backflow from the sea upstream with relatively the same speed of 11.25 cm/sec., and this upstream backflow relatively maintains a permanent high temperature, especially at station III (upper estuary). near sewage).

### 3.1.4 Salinity

Salinity at each observation station can be seen in Table 2. The highest mean salinity was obtained sequentially from stations V, III, IV, II and I, namely 29.37 ‰, 27.30 ‰, 27.10 ‰, 23.0 ‰ and 15.30 ‰. The relationship between temperature and salinity at each observation station can be seen in Figure 2.

The trend of temperature with salinity in nature is generally consistent, but this does not apply at station III where the permanent high temperature from station II (sewer) affects the salinity which continues to increase at station III even though the temperature has dropped at that station. The high salinity obtained at station III (upper estuary near the ditch) is not only due to the influence of the innate temperature of the ditch, but also due to the influence of backflow from the coast which has high salinity.

### 3.1.5 Dissolved oxygen

Dissolved oxygen at each observation station can be seen in Table 2, where the lowest average $O_2$ concentration was obtained at station II followed by station III respectively 1.17 mg/l and 2.15 mg/l. The highest solution concentration was obtained at station V, followed by stations I and IV respectively at 4.10 mg/l, 2.98 mg/l and 2.47 mg/l. This average tends to be inconsistent with increasing temperature, where at station II with the highest temperature of 34.37 °C, the solubility of $O_2$ is the lowest among the other observation stations.

The low level of $O_2$ at the waste station is likely due to its effective use in the metabolic processes of organisms, as well as the occurrence of direct evavoration in areas with high temperatures.

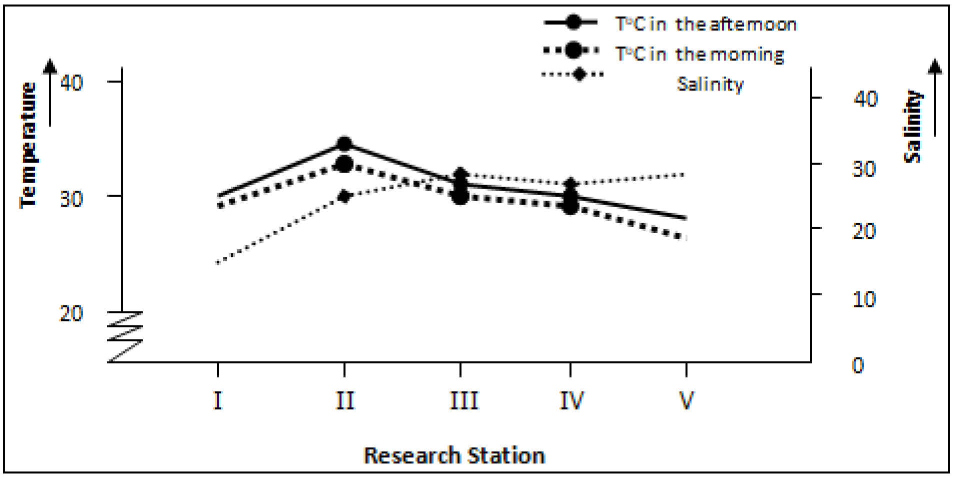


**Figure 2:** Graph of the relationship between average temperature in the morning and afternoon with salinity at each research station during March - May 2023

**Table 2:** Average data for measuring environmental parameters at each observation station during the study

| Environmental Parameters | Research Station | | | | |
|---|---|---|---|---|---|
| | I | II | III | IV | V |
| Temperature (o C) | | | | | |
| • Morning | 28, 00 | 33, 00 | 29, 50 | 28, 30 | 26, 79 |
| • Afternoon | 30, 20 | 34, 37 | 30, 33 | 29, 30 | 28, 80 |
| Salinity (‰) | 15, 30 | 23, 00 | 27, 30 | 27, 10 | 29, 37 |
| Oxygen (mg/l) | 2, 98 | 1, 17 | 2, 15 | 2, 47 | 2, 10 |
| Acidity (pH) | 6, 75 | 5, 87 | 6, 07 | 7, 05 | 8, 35 |
| Brightness (m) | 0, 65 | 0, 47 | 0, 85 | 1, 10 | 1, 30 |
| Current velocity (cm/det.) | 20, 00 | 18, 15 | 17, 79 | 11, 60 | - |
| Topographic slope (O) | 3, 50 | 7, 75 | 9, 45 | 9, 90 | 10, 75 |
| Depth | 1, 75 | 2, 25 | 2, 90 | 3, 15 | 3, 60 |

### 3.1.6 Degree of acidity (pH)

The acidity of the waters at each observation station can be seen in Table 2. In general, the average range of acidity of river bodies other than coastal waters (St. V) is 5.87 – 8.35 indicating a value that can normally be tolerated by river organisms, but the lower limit of the pH range is considered close to critical for fish biota, especially in waste area and its surroundings.

The relationship between the solubility of oxygen and the degree of acidity at each observation station can be seen in Fig.3. In this graph, the decrease in oxygen solubility accompanied by a decrease in pH indicates a direct effect of waste heat on the pattern of changes in temperature, oxygen solubility and pH in waters, especially in station drainage and upper river estuaries which are directly connected to the drainage.

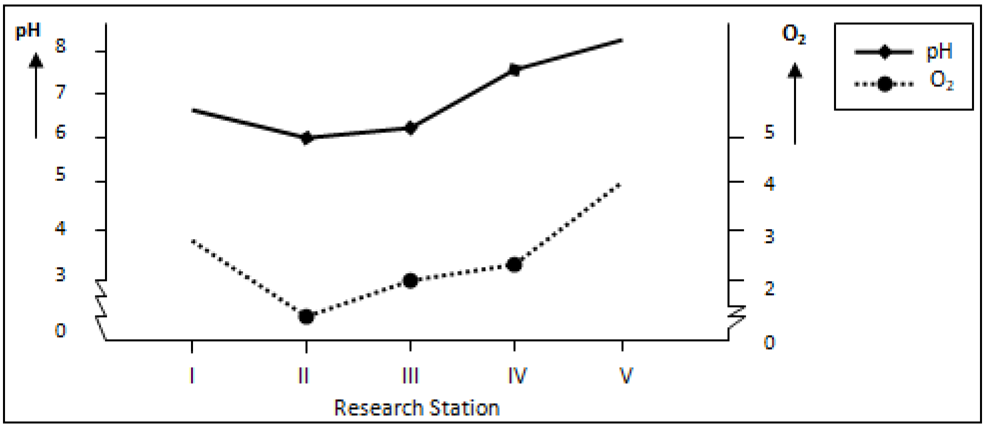


**Figure 3:** Graph of the Average Degree of Acidity and Solubility of $O_2$ at Each Research Station during March - May 2023

## 3.2 Environmental Biological Factors

### 3.2.1 Fish organisms

Data on fish catches obtained in river bodies, especially in spillways to river mouths during March - May 2023 can be seen in Appendix Table 1. The total number of individuals obtained during the research was 598 individuals with 26 ranks. From this number, there were 14 families with 28 species of fish dominated by the first 5 largest ranks (1 - 5) each sequentially *Ambassisgymnocephalus* (72 ind.), *Chanastriata* (56 ind.), *Mugilcephalus* (45 ind.), *Tricogasterpectoralis* (16ind.), and *Leiognathussplendens* (38 ind.). However, based on the station's habitat, ranks 1 and 5 were not found at station II, possibly this was due to 2 things, first; *A. gymnocephalus* and *L. splendens* are both native marine fish that have recently entered and adapted to river estuaries, secondly; both of them have not been able to penetrate the high temperature waters (33 - 34.37$^{O}$C) at station II (sewage). Ranked 26th with the lowest number of densities were *Lutjanusfulviflamma* and *Scomberomoruslinealatus* with only 2 individuals each.

Based on the observation station, the highest density was obtained at station IV (354ind.) and the lowest at station II (15 ind.). This difference may also be caused by 2 things as described above and the joining of marine fish species into the estuary where the IV station is far from the hot waste disposal. Likewise, at station III, which is a transition between the sewer and the estuary, the density of fish is not much different from the density at the waste, where at station III the water is warm (32.50 - 33.37$^{O}$C) as a direct result of heat transfer above it. still limiting the migration of marine and brackish fish to come to it. Except for river - dwelling freshwater fish that are both eurythermal and euryhaline such as *C striata* and *T. pectoralis*, as well as a small number of marine fish from the Mugilidae group, these fish almost occupy the entire station even though they are still dominated by other groups of marine fish at the station. IV (river mouth).

The relative and total density of each individual based on rank order along with the diversity index can be seen in Table 3. In order, the highest diversity was shown at station IV, then station III, and the lowest at station II. The low diversity at station II is thought to be due to the high water temperature as a result of waste heat from PLTU - Tello wastewater. Only freshwater fish from the Ophiocephalidae, Anabantidaegroups dominate the area, in addition to small amounts of marine fish such as Mugilcephalus and Mugil sp. All of these fish are considered to be tolerant of high temperatures and salinity. Whereas in the estuary area around the coastline it shows a high diversity index (0, 955) meaning that almost all fish caught (especially marine fish) during the study were around station IV, this was due to temperature, oxygen content and salinity factors. which is relatively normal, river estuaries are also still areas where we can get a lot of food.

There are two sides to the fish distribution pattern in the river estuary; firstly, the distribution pattern of marine fish from the families Leiognathidae to Anabantidae (Table 3) which tends to penetrate the waters from the estuary towards the drainage, but because gradually every movement towards the drainage is also accompanied by changes in increasing temperature so it tends to limit the density of these fish., although the salinity is still relatively high, equal to sea water salinity of 23 - 27‰ (Attachment Table 2).

**Table 3:** Fish Abundance, Biodiversity and EquitabilityDuring Research in the Waters of the TalloRiver Estuary, Makassar

| Fish Families and Species | May | | | June | | | July | | | Amount |
|---|---|---|---|---|---|---|---|---|---|---|
| | St. II | St. III | St. IV | St. II | St. III | St. IV | St. II | St. III | St. IV | Individual |
| ***Leiognathidae*** | | | | | | | | | | |
| *1. Leiognathus equulus* | - | 1 | 3 | - | 2 | 5 | - | 1 | 3 | 15 |
| *2. L. splendens* | - | 3 | 11 | - | 5 | 9 | - | 3 | 7 | 38 |
| ***Ammbassidae*** | | | | | | | | | | |
| *1. Ambassis gymnoce - phalus* | - | 3 | 15 | - | 7 | 23 | - | 5 | 19 | 72 |
| ***Serranidae*** | | | | | | | | | | |
| *1. Epinephelus amphi - cephalus* | - | 1 | 3 | - | - | 2 | - | - | 2 | 8 |
| *2. E. tauvina* | - | - | 3 | - | 1 | 5 | - | 1 | 1 | 11 |
| ***Mugilidae*** | | | | | | | | | | |
| *1. Mugil cephalus* | 2 | 3 | 11 | 3 | 9 | 7 | - | 3 | 7 | 45 |
| *2. Mugil sp.* | 3 | 5 | 7 | 1 | 3 | 3 | 1 | 1 | 11 | 35 |
| ***Clupeidae*** | | | | | | | | | | |
| *1. Sardinella brachysoma* | - | - | 1 | - | - | 3 | - | - | 5 | 9 |
| *2. S. perforata* | - | - | 7 | - | - | 13 | - | - | 9 | 29 |
| *3. Sardinella sp.* | - | - | 3 | - | - | 3 | - | - | 17 | 23 |
| ***Lutjanidae*** | | | | | | | | | | |
| *1. Lutjanus russelli* | - | - | 1 | - | - | 11 | - | - | 13 | 25 |
| *2. Lutjanus sp.* | - | - | 7 | - | - | 9 | - | - | 3 | 19 |
| *3. L. fulviflamma* | - | - | - | - | - | 1 | - | - | 1 | 2 |
| ***Cyprinidae*** | | | | | | | | | | |
| *1. Puntius javanicus* | - | - | 3 | - | - | 11 | - | - | 7 | 21 |
| *2. Osteochilus hasselti* | - | - | - | - | - | 7 | - | - | 3 | 10 |
| ***Ophiocephalidae*** | | | | | | | | | | |
| *1. Chana striata* | - | 5 | 9 | 5 | 7 | 11 | - | 7 | 12 | 56 |
| *2. O. micropeltes* | - | - | - | - | - | - | - | - | 3 | 3 |
| ***Anabantidae*** | | | | | | | | | | |
| *1. Trichogaster pectoralis* | - | - | 4 | - | - | 5 | - | - | 7 | 16 |
| *2. Anabas testudineus* | - | - | 1 | - | - | 4 | - | - | 3 | 8 |
| J u m l a h | 5 | 21 | 89 | 9 | 34 | 132 | 1 | 21 | 133 | 445 |
| **H': Biodiversity** | 0.667 | | | 0.879 | | | 0.955 | | | **H'< 1** |
| **E': Equitability** | 0.137 | | | 0.358 | | | 0.473 | | | **E'< 1** |

The Second, the opposite occurs where river fish from the families Cyprinidae, Ophiocephalidae, to Anabantidae, show a distribution pattern with population density that tends to decrease from the direction of drainage to the river mouth. It is possible that this distribution pattern is closely related to the chain effect of rising temperature which tends to be followed by increasing salinity, decreasing $O_2$, and lowering pH, especially in waste areas.

### 3.2.2 Macrozoobenthos

From the analysis of the basic organisms of the macrozoobenthos group obtained at three main research stations (II, III, and IV), 24 genera from 19 families were found which were divided into 6 classes namely; Gastropods with 7 families 10 genera, Pelecypoda (Bivalvia) 7families 8 genera, Asteroidea 2 families 2 genera, Polychaeta 1 family 2 genera, Echinoidea and Nudae each 1 family 1 genera (Table 4).

**Table 4:** Total and Relative Density and Diversity of Macrozoobenthos at the 3 Main Stations of the Tallo River Estuary during the Research

| No. | Types of benthic organisms | | Research Station | | | |
|---|---|---|---|---|---|---|
| | | | II | III | IV | Jumlah |
| | | | n n/$N_{II}$ | n n/$N_{III}$ | n n/$N_{IV}$ | |
| **A.** | **GASTROPODA** | | | | | |
| 1 | Neritidae | - *clithon* | *89 0, 7607* | *47 0, 1407* | *21 0, 0325* | *157* |
| | | - *Rhinoclavis* | - - | *37 0, 1108* | *49 0, 0758* | *86* |
| | | - *Clypeomorus* | *31 0, 1751* | *29 0, 0868* | - - | *60* |
| 2 | Potamididae | - *Littorina* | - - | *19 0, 0569* | *59 0, 0913* | *78* |
| 3 | Naticidae | - *Natica* | - - | - | *22 0, 0341* | *22* |
| 4 | Achitectonicidae | - *Heliacus* | - - | *21 0, 0629* | *33 0, 0511* | *54* |
| 5 | Ceritidae | - *Ceritina* | *13 0, 0734* | *27 0, 0808* | *47 0, 0728* | *87* |
| 6 | Buccinidae | - *Babylonia* | *7 0, 0395* | *9 0, 0269* | *26 0, 0402* | *42* |
| | | - *Engina* | *11 0, 0621* | *19 0, 0569* | *21 0, 0325* | *51* |
| 7 | Turridae | - *Pleurotoma* | - - | - | *19 0, 0294* | *19* |
| **B.** | **PELECYPODA** | | | | | |
| 8 | Verenidae | - *Tapes* | - - | - | *35 0, 0542* | *35* |
| | | - *Macoma* | - - | - | *56 0, 0867* | *56* |
| 9 | Limopsidae | - *Limopsis* | - - | - | *28 0, 0433* | *28* |
| 10 | Tellinidae | - *Tellina* | - - | *11 0, 0329* | *23 0, 0356* | *34* |
| 11 | Donacidae | - *Donax* | - - | *31 0, 0928* | *38 0, 0588* | *69* |
| 12 | Arcidae | - *Anadara* | - - | - | *29 0, 0449* | *29* |
| 13 | Pectinidae | - *Placuna* | - - | *3 0, 0100* | *16 0, 0248* | *19* |
| 14 | Corbulidae | - *corbula* | - - | - - | *13 0, 0201* | *13* |
| **C.** | **ASTEROIDEA** | | | | | |
| 15 | Asteroidae | - *Astropecten* | - - | - - | *3 0, 0046* | *3* |
| 16 | Archasteridae | - *Archaster* | - - | - - | *19 0, 0294* | *19* |
| **D.** | **ECHINOIDEA** | | | | | |
| 17 | Laganidae | - *Laganum* | - - | *3 0, 0100* | *23 0, 0356* | *26* |
| **E.** | **POLYCHAETA** | | | | | |
| 18 | Nereidae | - *Nereis* | *12 0, 0678* | *32 0, 0958* | *27 0, 0418* | *71* |
| | | - *Nephthys* | *9 0, 0508* | *29 0, 0868* | *21 0, 0325* | *59* |
| F. | **CTENOPHORA** | | | | | |
| 19 | Nudae | - *Nuda* | *5 0, 0282* | *17 0, 0509* | *18 0, 0279* | *40* |
| **T o t a l ($N_{st\ i}$)** | | | *177* | *334* | *646* | ***1157*** |
| **Biodiversity Index** | | | *0, 7958* | *1, 5461* | *2, 1237* | |

The total and relative density as well as the Macrozoobenthos Diversity Index obtained at the 3 main observation stations during the study (Table 4) provide an indication of the distribution of the number and composition of different types of organisms. Among the 3 observation stations, station IV shows high macrozoobenthos diversity with an index of 2.1237 and the number of individual species is more abundant than the other stations. Low species diversity is shown at the waste station with an index of 0.7958. And this value gives an indication of changes in the quality of the waters around the wastewater which is caused by water pollution, namely the entry of hot water waste into the area.

Based on the observation station for the existence of class groups from macrozoobenthos, it shows that at St. IV all existing classes were found. Meanwhile at station II only 3 classes were obtained, namely gastropods, polychaeta and ctenophora. Of these 3 classes, the gastropods with the genera clithon and clypeomorus show the highest total density compared to the other classes, so that the gastropods with these genera can be considered dominant and ecological indicators of waters affected by hot water waste. This is also evidenced by the distribution pattern of the two genera (clithon and clypeomorus) of the gastropods where the farther they are shifted away from the sewage station, the density of the two types of gastropods decreases. Compared to other genera, the opposite occurs in that the farther you move to the station below (St. III and St. IV), generally the greater the density of the macrozoobenthos.

### 3.2.3 Topographical slope

The topographic slope of the river waters from the drainage direction to the river mouth in coastal waters is presented in

Table 2. In general, this slope shows an average slope angle of 8.27$^{O}$. This slope is still below the slope of the current acceleration medium for the estuary and pond ecosystem, which means that the retention of standing water for the needs of the estuary and pond ecosystem lasts relatively long (Connel and Miller, 2005). However, the problem is that the impact of waste heat and other pollution can also last a long time with the inundation, as happened in the B1 and B2 pond areas around St. I and St. IV (Fig.1).

### 3.2.4 River depth

The depth of the river from station I to station V ranges from 1.75 – 3.60 m with an average of 2.73 m (Table 2). Based on this depth, the Tallo River is a shallow river type compared to the world's large rivers, so that zonal stratification can only be guessed by photic zones which alternate with turbidity zones based on seasonal changes, although they tend to be dominated by permanent turbidity characteristics which cause low water productivity (Perkins, 1997).

## 4. Conclusion and Suggestion

### 4.1 Conclusion

Based on the results of research on PLTU - Tello thermal water waste and its impact on fish biota and macrozoobenthos in the estuary of the Tallo River, Makassar, the following conclusions can be drawn:

1) There is a difference in the average temperature between each observation station. The average temperature at the hot water waste disposal station (St. I/sewerage) is higher than the other stations. The relatively high temperature at the drainage station limits the movement of eurythermal estuarine fish upstream where the salinity is still relatively brackish. On the other hand, the relatively high temperature at this station means that eurythermal and euryhaline freshwater fish from the family Ophiocephalidae or Chanidae and Anabantidae are quite persistent and abundant in the area, but towards stations III and IV (estuary) the density has decreased and fish have dominated sea.
2) Warm temperatures around hot springs limit the biodiversity of food fish and other benthic organisms, so that food availability becomes limited and this has an impact on the dominance of small, slow - growing fish such as those from the Ciprinidae, Borbonymus and Claridae families.
3) A higher diversity of river biota, both fish and macrozoobenthos, was found at the estuary station (St. IV) with ecological dominance Ambassisgymnocephalus from the fish group and Littorina class Gastropoda from the macrozoobenthos group. And this diversity was lower at the sewage station (St. II) which was dominated by Trichogasterpectoralis from the fish group and Clithon from the Gastropoda class from the macrozoobenthos group.
4) The Tello Steam Powered Electricity Industry (PLTU) has an impact on the fish biota community and benthic organisms as indicated by the low biodiversity index and even distribution in the waters of the Tallo River, especially at stations near to the electricity industry.

### 4.2 Suggestion

This research needs to be continued on other aspects of chemical waste such as Pb, Cu, Ag, Hg, Zn, and others, considering that the Tallo River is prone to waste discharge and infiltration from various industries near to the PLTU - Tello electricity industry, Makassar.

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