JPPIPA 9(11) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Meiobenthos Community as a Description of Environmental Changes at Losari Beach, Makassar

Ahmad Hasyim[1], Muh. Sri Yusal[1], Syamsuri[2], Hasria Alang[3]*

[1] Biology Education, Faculty of Teacher Training and Education, Patompo University, Makassar, Indonesia
[2] Economic Education, Faculty of Teacher Training and Education, Tanjungpura University, Pontianak, Indonesia
[3] Biotechnology Study Program, West Kalimantan Muhammadiyah Institute of Technology and Health, Pontianak, Indonesia

Received: May 2, 2013
Revised: September 15, 2023
Accepted: November 25, 2023
Published: November 30, 2023

Corresponding Author:
Hasria Alang
hasriaalangbio@gmail.com

DOI: 10.29303/jppipa.v9i11.3773

Abstract: This research aims to describe the ecological values of meiobenthos as a bioindicator of water quality at Losari Beach, Makassar. The sampling method used was the purposive sampling method. The determination of the research location was also based on previous research which described the coastal location of Losari Beach as being polluted by chemicals and dangerous metals. The research data were then analyzed statistically to calculate meiobenthos density, diversity index, and uniformity index. The research results showed that the abundance of meiobenthos found during the research was 66946 indv/m2, consisting of 12 phyla and 91 species/genus. The stations at the mouth of the Tallo River, Jeneberang River, and Tanjung Merdeka are research stations that have high abundance. The phylum oligochaeta, ostracoda, tunicata, and ciliophora are phyla with high abundance compared to other phyla. Based on the research results, it was concluded that this phylum has a high level of adaptation to the entry of various pollutants into water bodies. The diversity and uniformity index shows that the meiobenthos types in Losari are classified as having a high and even diversity index. The dominance index also shows that no single meiobenthos type is dominant, except for those in the reclamation project area. Temperature, current speed, depth, brightness, salinity, pH, DO, seawater nitrate, and seawater phosphate have a correlation or relationship with the abundance of meiobenthos on Losari Beach, Makassar.

Keywords: Anthropogenic; Bioindicators; Losari beach; Meiobenthos; Water Quality

Introduction

Coastal areas and coasts are the result of the integration of several interconnected, dynamic, and productive ecosystems whose sustainability needs to be maintained because they hold sources of biodiversity. The resources in these waters are one of the natural riches that are most widely used by society, but along with their use without paying attention to their sustainability, this environment has experienced a decline in function and quality. The types of pollutants entering coastal areas directly or indirectly threaten the life of all biota, including threats to the degradation of natural resources in coastal ecosystems such as mangroves, seagrasses, coral reefs, and marine benthic animals. (Dahuri et al., 2008; Yusal, 2012; Dailami et al., 2020; Duhita *et al.*, 2020; Handayani et al., 2021; Adrianto et al., 2021; Darmayani et al., 2021a; Darmayani et al., 2021b).

One area that has enormous potential for coastal and marine resources is the Losari Beach Zone. This zone is located in South Sulawesi. However, there is an increase in human activity and development around the area, such as industrial activities, densely populated housing, construction of hotels, restaurants, cafes, tourist activities, hospitals, home industries, gold craftsmen and fisheries, and agricultural activities in the upper reaches of the river. is a series of activities that are

How to Cite:
Hasyim, A., Yusal, M. S. ., Syamsuri, S., & Alang, H. (2023). Meiobenthos Community as a Description of Environmental Changes at Losari Beach, Makassar. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 10308–10316. https://doi.org/10.29303/jppipa.v9i11.3773

the main cause of the entry of pollutants into waters. This condition will certainly affect the quality of the surrounding waters and threaten the existence of organisms that live on the surface and at the bottom of the waters (Yusal, 2017; Yusal *et al.*, 2019c, 2019d; Yusal *et al.*, 2019a, 2019b; Yusal, 2020b, 2020a; Yusal, 2021; Handayani et al., 2021; Adrianto et al., 2021; Darmayani et al., 2021a; Darmayani et al., 2021b)

These activities have caused the condition of the region to be on the verge of worrying depletion of resources and ecosystems. Several environmental parameters such as physical and chemical are slowly changing towards the negative category. Apart from that, the dissolved metal content has also passed the quality standard threshold to be categorized as contaminated. Several studies around the Losari Beach area show that the heavy metal content of Lead (Pb), Copper (Cu) and Cadmium (Cd) has exceeded the water quality standard threshold(Yusal, 2012, 2020; Yusal & Hasyim, 2014; Yusal *et al.*, 2019a, 2019b; Yusal *et al.*, 2019c, 2019d; Yusal et al., 2019e; Yusal and Hasyim, 2022).

Apart from physical and chemical parameters, pollution or quality indicators in an environment can also use biological parameters (Nangin et al., 2015; Zaghloul et al., 2020). Benthos is one of the aquatic biota that can be used as an indicator of water quality. Benthos is a group of invertebrates. This type of organism lives and remains for a long time in the bottom water environment. Apart from that, this organism is easier to identify because it is microscopic to macroscopic in size. The use of benthic animals in measuring water quality is more effective and efficient and is useful as comparative data for physical and chemical measurements of the aquatic environment (Campbell et al., 2019; Yusal *et al.*, 2019; Handayani et al., 2021; Yusal & Toni, 2021; Darmayani et al., 2021; Yunus et al., 2022; Yusal and Hasyim, 2022).

One type of benthic animal that is effectively used as an indicator for water pollution is meiobenthos. Meiobenthos can also be termed meiofauna so it is defined as a collection of organisms that are larger than microfauna, but smaller than macrofauna. This organism can pass through a 1 mm sieve with a size range between 63–1000 µm, but cannot pass through a 45 µm sieve (Dahuri et al., 2008; Yusal, 2012; Yusal *et al.*, 2019a; Yusal *et al.*, 2019b; Handayani et al., 2021; Yusal and Hasyim, 2022). Meiobenthos is a biological component that can be used as an indicator of changes in water quality. Several advantages of meiobenthos as a bioindicator of water quality: 1). Have different sensitivities to various types of pollutants and provide fast reactions to changes in waters; 2). Has low mobility so is easily influenced by the surrounding environmental conditions; and 3). Easy to catch and identify (Yusal & Hasyim, 2014; Yusal *et al.*, 2019a; Yusal *et al.*, 2019b, 2019c; Yusal et al., 2019d; Yusal, 2020b; Yusal, 2021). Research on the meiobenthos community as an indicator of environmental change around Losari Beach has never been carried out. This is the background for this research to be carried out. The research aims to describe the ecological values of meiobenthos as a bioindicator of water quality at Losari Beach, Makassar. It is hoped that the implications of this research can become a policy determinant in formulating the sustainability of human activities around the area..

Method

Time and location of research

The research was carried out in July-September 2021 at Losari Beach which is located in the north-to-south area of Makassar City, South Sulawesi. The research location illustrates the high level of human activity and development in the surrounding environment. The sampling locations consisted of 9 research stations and were located around tourism, hotels, coastal reclamation projects, aquaculture, upstream agricultural locations, hospitals, ports, industrial areas, home industries, and densely populated housing. The research location can be seen in Figure 1.

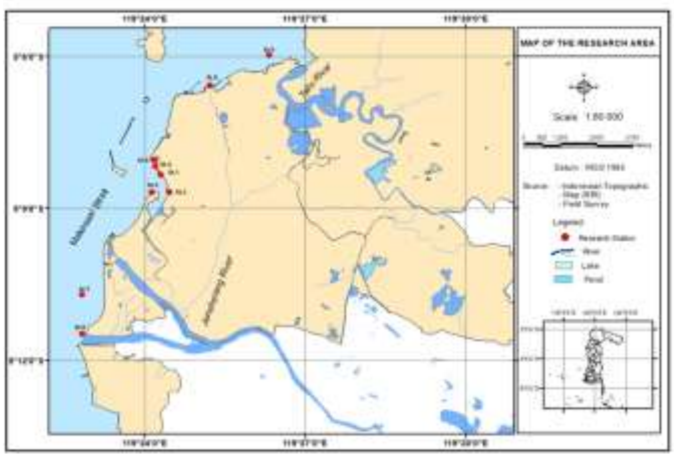

Figure 1. Map of research location

Sampling Method

The sampling method in this research is to use a purposive sampling method, namely selective sampling based on certain objectives carried out on aquatic substrates such as meiobenthos habitat. The determination of the research location was also based on previous research which described the coastal location of Losari Beach as being polluted by chemicals and dangerous metals.

Statistical Analysis

The density of meiobenthos on the coast of Losari Beach was analyzed using the Equation 1. The diversity index is a mathematical depiction of the composition, abundance, and number of individuals or species in a particular community. The diversity index can also be interpreted as an ecological index that describes the level of diversity of species that inhabit an area or habitat. The Diversity Index in a community can be calculated based on the Shannon-Wiener inde (Odum, 1994), as follows on Equation 2. The diversity index is used as a guide to see the level of pollution in waters. The basis for assessing water quality can be seen in Table 1. The dominance index is an index that mathematically describes the level of dominance of a species in a community. The dominance index is measured using the Simpson-Simpson Index of Dominance formula, as follows on Equation 4 (Krebs, 1989).

$$K = (10000x\ a)/b \tag{1}$$

$$H = -\sum_{i=1}^{s}(pi \ln pi) \tag{2}$$

$$Pi = \frac{ni}{N} \tag{3}$$

$$D = \frac{\sum ni(ni-1)}{N(N-1)} \tag{4}$$

$$E = \frac{H}{\ln S} \tag{5}$$

Description:

K	:	Density of meiobenthos (individuals/m2)
A	:	Number of meiobenthos (individuals)
b	:	Ekman Grab opening area (22.5 cm x 22.5 cm)
10.000	:	conversion from cm2 to m2 (Krebs, 1989)
H	:	Diversity index
N	:	total number of individuals of all species
Ni	:	number of individuals of each type
D	:	Simpson's dominance index
E	:	uniformity index
H	:	diversity index
S	:	number of species or types

The uniformity index is an ecological index that mathematically describes the evenness of an individual or species in a community that inhabits a particular habitat. Uniformity can indicate balance in the distribution of the number of individuals of each type. The uniformity index is calculated using the Hilis Evenness Index formula on Equation 5 (Krebs, 1989). The uniformity value of a population will range between 0 - 1 with the following criteria, which are High uniformity (E > 0.6); Moderate uniformity (0.4 < E < 0.6); and Low uniformity (E < 0.4).

Table 1. Water quality criteria based on the Shannon-Wiener diversity index (Odum, 1994)

Value	Water Quality Index
>2,0	High Diversity
1.6-2.0	Medium Diversity
1.0-1.59	Low Diversity
<1,0	Very Low Diversity

One-way ANOVA analysis was used to see real differences in the variance of meiobenthos abundance in the study area (Odum, 1994; M. S. Yusal, Marfai, Hadisusanto, & Khakim, 2019). Principal component analysis to examine physical and chemical parameters that have a significant effect on meiobenthos abundance.

Result and Discussion

Abundance and composition of meiobenthos on the coast of Losari Beach

The total abundance of meiobenthos found during the study was 66946 indv/m2, consisting of 12 phyla and 91 species and genera. Station I consists of 3209 indv/m2, station II consists of 3185 indv/m2, station III consists of 4746 indv/m2, station IV consists of 5100 indv/m2, station V consists of 2415 indv/m2, station VI consists of 16239 indv/m2, station VII consists of 10909 indv/m2, station VIII consists of 10118 indv/m2, and station IX consists of 10870 indv/m2 (Table 2). The details are based on phylum meiobenthos, namely phylum aelosomatidae (40 indv/m2), phylum ciliophora (1902 indv/m2), phylum gastrotricha (600 indv/m2), phylum gnathostomulida (258 indv/m2), phylum nematoda (751 indv/m2), phylum nemertina (456 indv/m2), phylum oligochaeta (25562 indv/m2), phylum ostracoda (31945 indv/m2), phylum polychaeta (1286 indv/m2), phylum sarcomastigophora (595 indv/m2), phylum tunicata (2905 indv/m2), and phylum turbellaria (646 indv/m2). In sequence, the density composition of the phylum meiobenthos is (Figure 2): ostracoda (47.828%), oligochaeta (38.272%), tunicata (4.349%), ciliophora (2.848%), polychaeta (1.925%), nematodes (1.124%), sarcomastigophora (0.891%), gastrotricha (0.831%), turbellaria (0.8309%), nemertina (0.683%), gnathostomulidae (0.386%), and aelosomatidae (0.060%).

Table 2. Abundance of meiobenthos on the coast of Losari

Phyla	Density (ind m^{-2})									
	ST.1	ST.2	ST.3	ST.4	ST.5	ST.6	ST.7	ST.8	ST.9	∑
Aelosomatidae	-	-	40	-	-	-	-	-	-	40
Ciliophora	238	297	159	20	99	119	120	692	158	1902
Gastroicha	159	0	79	0	20	79	40	0	178	600
Gnathostomulida	0	20	119	0	0	0	0	40	79	258
Nematoda	20	0	79	158	178	0	0	0	316	751
Nemertina	20	20	99	0	0	40	79	0	198	456
Oligochaeta	218	1481	1402	1936	772	5747	4523	4583	4900	25562
Ostracoda	1960	1168	1307	1840	970	9977	6007	4585	4131	31945
Polychaeta	40	79	158	99	59	79	20	178	574	1286
Sarcomastigophora	356	20	40	0	0	40	80	0	59	595
Tunicata	0	20	1284	1047	158	79	40	0	277	2905
Turbelaria	198	40	20	0	159	79	0	40	0	646
∑	3209	3185	4746	5100	2415	16239	10909	10118	10870	66946

Table 2 showed that the highest abundance was found at stations 6, 7, and 9, where the meiobenthos types found were in the phyla Ostracoda, Oligochaeta, Ciliophora, and Tunicata, while the lowest abundance was found at stations 5 and 2. The lowest phylum found was Aelosomatidae and only found at station 3. There is a significant difference in the average abundance of meiobenthos at various research stations because the F value = 7.584 with a significance probability of (ρ = 0.00 < 0.05). This shows that the abundance of each meiobenthos phylum at each station has no similarities and is very significantly different. The Tukey test also shows that three groups of meiobenthos inhabit the coast of Losari Beach (Table 3) (Yusal *et al.*, 2019a, 2019b; Yusal *et al.*, 2019c, 2019d; Yusal, 2020b; Yusal, 2021; Yusal and Hasyim, 2022). The results of the variance analysis were also supported by differences in the density levels of the meiobenthos phylum at each station.

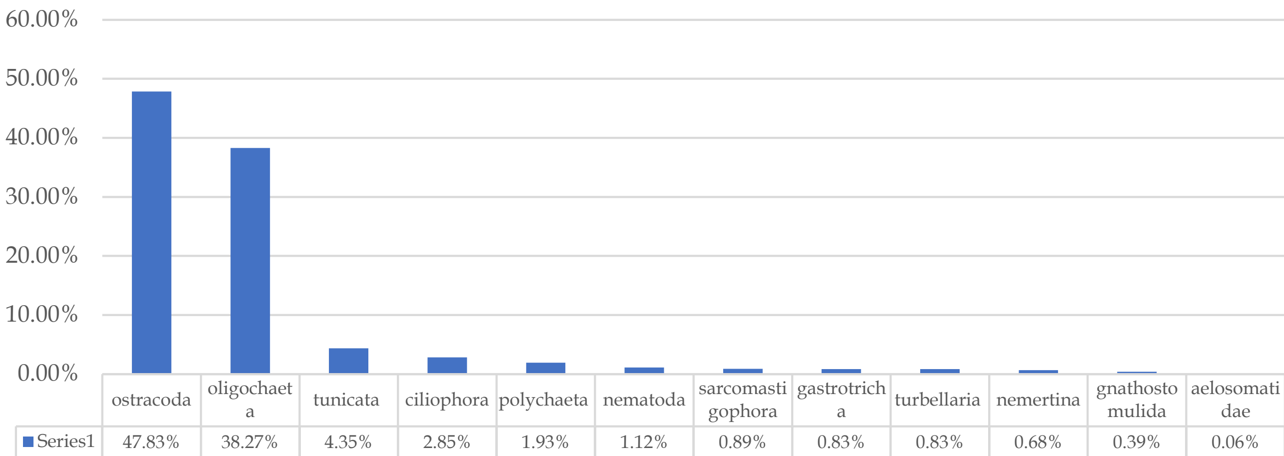

Figure 2. Composition of Phylum meiobenthos on the Losari Coast

In general, the meiobenthos that inhabits the coast of Losari Beach is a true meiofauna type, namely a type of benthic meiobenthos organism whose entire life cycle becomes meiobenthos at the bottom of the water (permanent meiobenthos). This is to research reported by (Yusal & Hasyim, 2014; Yusal *et al.*, 2019a, 2019b; 2019c, 2019d; 2019e; Yusal, 2021; Yusal and Hasyim, 2022) which states that ciliophora, Oligochaeta, ostracods, are a type of meiobenthos that has a high level of adaptation to habitats that contain pollutants or the accumulation of various organic and inorganic contents originating from land and the surrounding water environment. This type of meiobenthos can live in various habitat conditions, whether muddy, fine sand, or coarse sand.

Ciliophora have cilia on all or part of their bodies as organs that help in movement, finding food, or adapting to unfavorable environments, oligochaete are meiobenthos that can adapt to habitats that lack oxygen in polluted bottom water environments, while ostracods have tools for attaching to the substrate or in benthic plants in the form of threads attached to sand or other substrates (Yusal *et al.*, 2019a, 2019b; Yusal *et al.*, 2019c; Yusal, 2020b; Yusal, 2021)

The reproduction rate of the phylum ostracoda, oligochaete, and ciliophora is also relatively high even though environmental conditions do not allow it. This happens because this organism is hermaphroditic, bisexual, and even parthenogenetic, namely the ability to produce offspring without prior marriage between two different sexes. Ciliophora is also able to carry out binary fission, namely the direct division of its body's nucleic cells to give birth to a new generation without the help of marriage between two individuals of different sexes. This causes this organism to become dominant in the research location. Yusal *et al.*, 2019b; Yusal and Hasyim, 2022 suggest that Phylum Tunicata has adapted to an unfavorable environment by simplifying its internal organs to a very small shape and is hermaphrodite, that is, it has double-sex cells, making it possible to produce offspring in inadequate environmental conditions. The size of the gonads of the sex cells is small and is always carried along the lower side of the body until it matures and at any time develops into a new individual.

Table 3. Tukey HSD test results for the abundance of meiobenthos on the coast of Losari Beach

			Subset for alpha = 0.05		
	Phylum	N	1	2	3
Tukey HSD[a]	phylum aelosomatidae	9	2.22		
	phylum ganthostumulida	9	11.00		
	Phylum nemertina	9	13.22		
	phylum turbellaria	9	15.56		
	phylum gastroicha	9	19.89		
	phylum sarcomastigophora	9	226.22	226.22	
	phylum nematoda	9	266.33	266.33	
	phylum polychaeta	9	336.67	336.67	
	phylum ciliophora	9	393.56	393.56	
	phylum Tunicata	9	700.89	700.89	
	phylum Oligochaeta	9		1389.44	1389.44
	phylum ostracoda	9			2223.33
	Sig.		.699	.056	.433

Stations 6, 7, and 9 are stations with a high level of abundance and are located around the Jeneberang and Tallo Rivers which flow directly to the coast of Losari Beach. The high level of abundance at this station is because the Jeneberang and Tallo Rivers have brought organic pollutant materials from downstream and are carried by currents or rainwater to the river mouth or downstream. This organic contamination is a nutrient or food ingredient for meiobenthos, so this is the trigger for high meiobenthos growth in that location. Likewise, the location of Station 7 which is one of the beach tourist destinations in Makassar City, this area is busy with local tourists on holidays and weekdays. This research station, which is located on Tanjung Merdeka Beach, has begun to build several supporting facilities for tourists, such as villas, guest houses with simple to luxurious facilities, semi-permanent buildings for resting places on the beach, cafes and food stalls scattered around the area. around the beach. Development at tourism locations also plays a major role in the presence of organic waste entering the surrounding waters. These particles could be the cause of the high abundance of meiobenthos in this area (Yusal *et al.*, 2019a; Yusal *et al.*, 2019b, 2019c; Yusal, 2020b).

Station 5 is a station with a very low level of abundance. The location of the station is around the Soekarno Hatta Makassar port, which is the largest port in Eastern Indonesia. The location of the observation station is characterized by high development activity in the surrounding area, heavy port traffic, and high port renovation activity to welcome the Indonesian government's sea highway axis program. Station 2 is also classified as a station that has a low level of abundance. The location of Station 2 is in the vicinity of hotel buildings, restaurants, cafes, hospitals, home industries, handicraft industries, and gold craftsmen. This is to what has been reported (Setiawan, 2014; Yusal *et al.*, 2019a; Yusal, 2021) that several Losari areas allow the entry of inorganic waste such as dangerous metals into the surrounding waters, which has fatal consequences for the growth of meiobenthos.

Dominance index, Shannon-Weiner index (diversity index), and uniformity index

The average value of the dominance index at the research station is 0.0746 with a standard deviation of 0.0217 (Figure 3). The meiobenthos dominance index value at all research stations ranged between 0.0507-0.1178 (Figure 4). This shows that there is meiobenthos that dominates station III, while stations I, II, IV, V, VI, VII, VIII, and IX did not find the type of meiobenthos that dominates the research station because the average is still close to 0.

The average value of the diversity index is 2.8824 with a standard deviation of 0.2009 (Figure 3). The meiobenthos diversity index value at all research stations ranged between 2.2653 and 3.0992 (Figure 4). This shows that the meiobenthos that inhabit all research stations are still categorized as having high diversity (Odum, 1994). The high diversity value is due to meiobenthos being able to adapt to disturbed or polluted environments, due to the entry of polluting materials from land or the surrounding environment (Yusal *et al.*, 2019a, 2019b; Yusal, 2020b; Yusal and Hasyim, 2022). The average value of the uniformity index is 0.8673 with a standard deviation of 0.0439 (Figure 3). The meiobenthos uniformity index value at all research stations ranged from 0.7860 to 0.9459 (Figure

4). This shows that the types of meiobenthos that inhabit the seven research stations are not the same or evenly distributed and there is no dominant meiobenthos at some of the research stations because the value range almost reaches 11 (Krebs, 1989), while station III has a low uniformity value, because of the meiobenthos is dominant at this station.

Table 4. Variation of physico-chemical parameter values at several different stations

Parameter	Research Station									Max.
	St. I	St. II	St. III	St. IV	St. V	St. VI	St. VII	St. VIII	St. IX	Limit*
Salinity	25	30	29	26	26	20	27	20	25	Alami
pH	9,98	7,52	7,48	7,8	7,42	7,15	7,7	7,78	7,98	7-8,5
Temperature (°C)	30	28	31	28	32	33	30	32	33	Alami
Depth (m)	3,2	2,4	6	2	3	4	2,6	4	2	-
Current speed (m s^{-1})	0.032	0,08	0,4	0,1	0,59	0,68	0,35	0.42	0,67	-
Brightness (m)	2	2	3	1	1,5	3,5	2,5	3,4	1,5	-
DO	4	3,4	5	3,2	5	5	5	3	5	>5 mgL^{-1}
Seawater Phosphates	0,03	0,12	0,0002	0,18	0,0003	0,005	0,0004	0,64	0,0024	0,015 mgL^{-1}
Sediment Phosphates	0,02	0,025	0,019	0,015	0,018	0,017	0,013	0,023	0,023	-
Sediment Phosphates	0,0006	0,02	0,0003	0,51	0,00021	0,09	0,0002	0,78	0,00023	0,008 mgL^{-1}
Sediment Phosphates	0,0014	0,001	0,0005	0,0006	0,0012	0,001	0,0006	0,0006	0,0006	-

Max. Limit*: Based on Kep.Men.KLH.RI. No.51.Th.2004

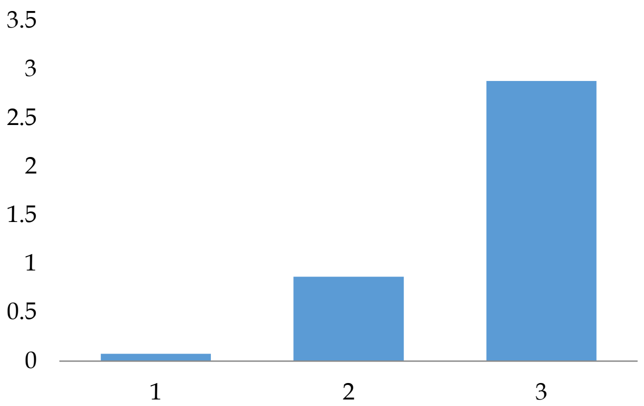

Figure 3. Mean and standard deviation of meiofauna abundance

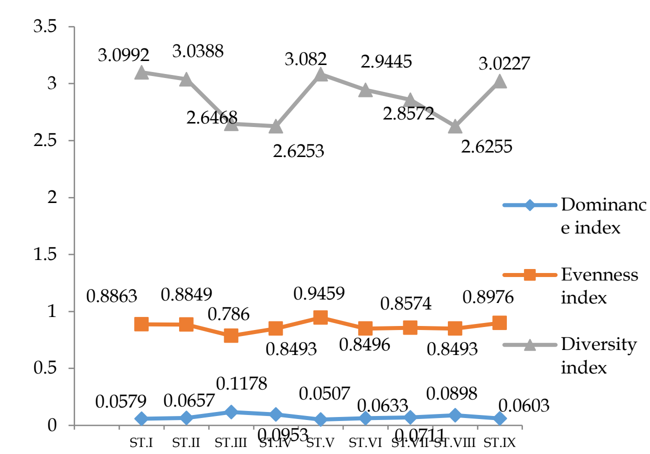

Figure 4. Ecological index of meiobenthos on the coast of Losari Beach

Relationship between Physical-Chemical parameters and meiobenthos abundance on the coast of Losari Beach

Several measurement results of physical-chemical parameters (Table 4), such as DO, phosphate, nitrate, and pH, were above or below the threshold limits determined by the Indonesian government through the Ministry of Environment Decree No. 51 of 2004. Based on Figure 5 and Table 5, show that several environmental physical and chemical factors, such as temperature, current speed, depth, brightness, salinity, pH, DO, seawater nitrate, and seawater phosphate correlate with the abundance of meiobenthos on the coast of Losari Beach, Makassar. The relationship between these variables is in the form of a positive or negative correlation with a contribution level to the variable of 0.15-11.78%. The salinity, pH, and phosphate of seawater have a positive correlation with the abundance of meiobenthos at the bottom of the waters, meaning that the higher the range of physical-chemical parameters. So the higher the abundance of meiobenthos at the bottom of the waters.

Low pH values are influenced by the entry of polluting materials into the waters. This has the potential to cause the death of aquatic organisms. Seawater phosphate is an abiotic parameter needed for the development of meiobenthos in waters, conversely, when the phosphate content decreases the abundance of these organisms also decreases (Yusal *et al.*, 2019a; Yusal *et al.*, 2019; Yusal, 2021; Yusal and Hasyim, 2022). Water salinity is an environmental parameter that greatly influences the existence of meiobenthos. Increasing salinity content will disrupt the existence of meiobenthos at the bottom of the waters.

The same thing was stated (Yusal *et al.*, 2019b; Yusal, 2021; Yusal and Hasyim, 2022) that temperature, current speed, depth, brightness, DO, and seawater nitrate have a negative correlation with the abundance of meiobenthos on the coast of Losari Beach. This means that the abundance of meiobenthos decreases along with the increase in the range of physical-chemical parameters in the coastal waters of Losari Beach. Oxygen content is an important factor for the life of organisms such as meiobenthos, dissolved oxygen is useful in the respiratory and metabolic processes of meiobenthos that live at the bottom of the waters. In general, high DO content can increase the abundance of meiobenthos at the bottom of waters, but several types of meiobenthos can live well in anaerobic conditions (M. S. Yusal, 2020b; M. S. Yusal, Marfai, Hadisusanto, & Khakhim, 2019a). Nematodes, ciliates, platyhelminthes, gnathostomulida, gastrotricha, oligochaeta, and aschelmintes are meiobenthos that can live and reproduce in unfavorable environmental conditions, such as low DO content (Yusal, 2021). Likewise, other parameters such as current speed, temperature, depth, brightness, and seawater nitrate are factors that influence the abundance of meiobenthos in waters, but several types of meiobenthos can survive in environmental conditions that are low in some of these parameters (Yusal *et al.*, 2019a, 2019c; Yusal and Hasyim, 2022).

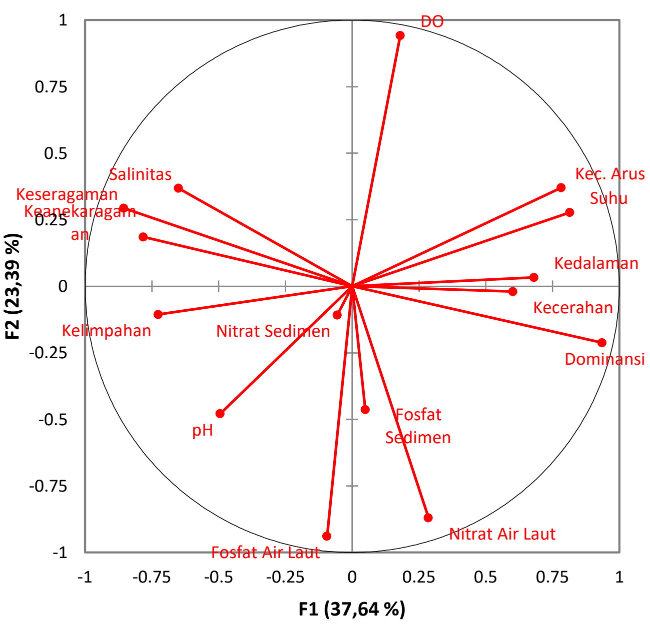

Figure 5. Diagram of PCA analysis results between several physicochemical parameters and meiobenthos abundance on the coast of Losari Beach

Table 5. Summary of PCA analysis of contribution values of physicochemical variables (%) that influence meiobenthos abundance

	F1	F2	F3	F4
Abundance	9,3351	0,3204	11,0283	0,5926
Dominance	15,5018	1,2818	0,2574	2,2129
Uniformity	12,9428	2,4495	0,7741	6,7369
Diversity	10,8347	0,9757	6,8906	6,1825
Seawater Phosphates	0,1568	25,1152	1,6087	0,2906
Sediment Phosphates	0,0429	6,1403	1,7934	12,2964
Seawater Nitrates	1,4470	21,5619	0,0239	4,6404
Sediment Nitrates	0,0551	0,3321	0,0091	58,1719
Salinity	7,4806	3,8605	11,0559	2,1631
pH	4,3253	6,5400	6,0891	0,5108
Temperature	11,7814	2,1903	6,5276	1,9727
Depth	8,2246	0,0313	25,6541	0,0261
Brightness	6,4216	0,0115	17,9144	2,8752
DO	0,5742	25,2823	0,1408	0,8765
District Current	10,8760	3,9073	10,2326	0,4512

Conclusion

The highest meiobenthos found on Losari Beach are phyla that can adapt to polluted or polluted conditions, including the phyla Ostracoda, oligochaeta, tunicata, and ciliophora. The elite stations located at the mouths of the Tallo and Jeneberang Rivers are research stations with high levels of abundance. This happens because this research area supplies several organic pollutants that are carried by currents from downstream so that they become food nutrients for the meiobenthos around the research area. Research stations located in the Paotere people's port area, Soekarno-Hatta International Port, and stations located around hotel buildings, restaurants, cafes, and hospitals are research stations with low levels of abundance, due to physical disturbance of the meiobenthos habitat or contamination dangerous metal content into water bodies or research station locations due to various anthropogenic activities in the surrounding environment. The meiobenthos species found on Losari Beach are classified as benthic organisms with a high diversity index because they are in the diversity index range >2. Likewise, the uniformity index value almost reaches 1, indicating that the types of meiobenthos in the study area are very evenly distributed. The results of the dominance index calculation also show that there is no dominant type of meiobenthos in the research area, except in the research area which is in the coastal reclamation area. The high diversity value also shows that the worrying condition of Losari's water quality is because most of it is only inhabited by meiobenthos species that inhabit the research area. After all, benthos organisms are only able to adapt to the environmental conditions of the bottom waters that have been contaminated by organic or inorganic pollutants. Temperature, current speed, depth, brightness, salinity, pH, DO, seawater nitrate, and seawater phosphate are several physical and chemical environmental parameters that have a correlation or relationship with the abundance of meiobenthos on the coast of Losari Beach, Makassar.

Acknowledgments
The authors thank all parties who supported and helped in completing this research

Author Contributions
AH and MSY discovered problems, compiled research instruments, retrieved research data, analyzed data, and built manuscripts, and also edited the language and reviewed the articles that had been compiled. S and HA reviewed and monitored the research progress and provided input on the research.. All authors have read and agreed to the published version of the manuscript.

Funding
there was no funding for this research.

Conflicts of Interest
The authors declare no conflict of interest.

References

Campbell, N.A., Jane B. Reece, Lisa A. Urry, Michael L. Cain, S. A. W. (2019). *Biologi. Edisi Kesepuluh*. Jakarta: Erlangga.

Dahuri, H.R., J. Rais, S.P. Ginting, & H. J. S. (2008). *Pengelolaan Sumber daya Wilayah Pesisirdan Lautan Secara Terpadu*. Jakarta: PT. Pradnya Paramita.

Dailami, M., Tahya, C.Y., Harahap, D.G.S., Duhita, M.R., Sutrisno, E., Hidana R., Supinganto, A., Puspita, R., Purbowati, R., Yusal, M.S., Alang, H., & Apriyanti, E. (2020). *Biologi umum*. Widina Bhakti Persada Bandung.

Handayani, Darmayani, S., Nendissa, S.J., Hasibuan, A.K.H., Dimenta, R.H., Indarjani, Hetharia, C., Duhita, M.R., Arif, A., Yusal, M.S., Sianturi, B.J., Ulinniam, & Latumahina, F. . (2021). *Fisiologi Hewan*. Bandung: Widina Bhakti Persada.

Hebert Adrianto, Ulinniam Ulinniam, Eny Wahyuning Purwanti, Muh Sri Yusal, Dyah Ayu Widyastuti, Eko Sutrisno, Kevin A Tamaela, Muhammad Dailami, Rini Purbowati, Anggi Khairina Hanum Hasibuan, Dessyre M Nendissa, Muhammad Rifqi Hariri, Sandriana Juliana Ne, L. C. (2021). *Bioteknologi*. Bandung: Widina Bhakti Persada.

Krebs, C. . (1989). *Ecological Methodology*. USA: University of British Colombia Press.

Nangin, S. R., Langoy, M. L., & Katili, D. Y. (2015). Makrozoobentos Sebagai Indikator Biologis dalam Menentukan Kualitas Air Sungai Suhuyon Sulawesi Utara. *Jurnal MIPA*, *4*(2), 165–168. https://doi.org/10.35799/JM.4.2.2015.9515

Odum, E. . (1994). *Fundamentals Of Ecology*. Gadjah Mada University Press.

Duhita, M. R., Hetharia, C., Junaedi Sianturi, B., Sri Yusal, M., Sutrisno, E., Purbowati, R., Tinta Manik, V., Octorina, P., Alang, H., & Apriyanti, E. (2020). *BIOLOGI UMUM*. Widina Bhakti Persada Bandung.

Darmayani, S., Hidana, R., Sa'diyah, A., Isrianto, P.S., Hidayati, H., Jumiarni, D., Hafsari, A.R., Latumahina, F.S., Setyowati, E., Estikomah, S.A., Kurniati, S., Syam, S., Sufiyanto, M.I., & Sri, M., V. D. N. G. (2021). *Bioteknologi Teori dan Aplikasi*. Bandung: Widina Bhakti Persada Bandung.

Darmayani, S., Hidana, R., Latumahina, F.S., Nendissa, S.J., Situmorang, M.V., Juniatmoko, R., Widarawati, R., Novita, M.Z., Swardana, A., Octorina, P., Siagian, G., Hasibuan, A.K.H., & Yusal, M.S., (2021). *Ekologi, Lingkungan Hidup dan Pembangunan*. Bandung: Widina Bhakti Persada Bandung.

Setiawan, H. (2014). Pencemaran Logam Berat Di Perairan Pesisir Kota Makassar Dan Upaya Penanggulangannya. *Eboni*, *11*(1), 1–13. https://doi.org/10.20886/buleboni.5028

Yunus, M., Yusal, M. S., & Samsi, A. N. (2022). Diversity of Land Insect in Polda Plantation South Sulawesi. *Jurnal Pembelajaran Dan Biologi Nukleus*, *8*(3), 795–806. https://doi.org/10.36987/jpbn.v8i3.3374

Yusal, M.S., Marfai, M.A., Hadisusanto, S., & Khakhim, N. (2019). Abundance and diversity of meiofauna as water quality bioindicator in Losari Coast, Makassar, Indonesia. *Ecology, Environment, & Conservation*, *25*(2), 589–598. Retrieved from http://www.envirobiotechjournals.com/article_abstract.php?aid=9616&iid=275&jid=3

Yusal, M.S., & Hasyim, A. (2014). Analisis Kualitas Perairan Berdasarkan Indeks Ekologis Meiofauna di Kab. Barru. *Jurnal Ilmiah Pena*, *5*(1), 79–87. https://doi.org/10.14710/jil.20.1.45-57

Yusal, M.S., & Hasyim, A. (2017). Pemeriksaan Kualitas Perairan Berdasarkan Analisa Biodiversitas Fitoplankton (Studi Kasus Pada Pembuangan Limbah Cair Hasil Buangan PT. Kima Makassar). *Jurnal Ilmiah Pena: Sains Dan Ilmu Pendidikan*, *7*(1), 31–41. https://doi.org/10.51336/jip.v7i1.31

Yusal, M. S. (2012). Analisis Kualitas Perairan Berdasarkan Indeks Ekologis Meiofauna Interstisial Ekosisitem Manggrove di Pantai Batu Gosok Kecamatan Komodo Kabupaten Manggarai Barat Nusa Tenggara. *Jurnal Ilmiah Pena.*, *1*(1), 1–15. Retrieved from https://journal.unhas.ac.id/index.php/jai2/article/view/10676

Yusal, M. S. (2020a). Sistem Respirasi dan Ekskresi Organisme Heterotrof. *Biologi Umum*. Bandung: Widina Bhakti Persada Bandung.

Yusal, M. S. (2020b). Studi Struktur Komunitas Meiofauna dan Kualitas Perairan Zona Pesisir Losari Makassar. *Jurnal Ilmu Alam Dan Lingkungan*, *11*(2), 63–71. https://doi.org/10.20956/jal.v11i2.10676

Yusal, M. S. (2021). Studi Potensi Eutrofikasi di Pesisir Losari Makassar. *Jurnal Enggano*, *6*(2), 348–357. https://doi.org/https://doi.org/10.31186/jenggano.6.2.348-357

Yusal, M. S. & G. T. (2021). Fern inventorization in Cunca Rami Waterfall Zone of West Manggarai, East Nusa Tenggara. *Jurnal Pembelajaran Dan Biologi Nukleus*, *7*(1), 218–234. https://doi.org/https://doi.org/10.36987/jpbn.v7i1

Yusal, M. S., & Hasyim, A. (2022). Kajian Kualitas Air Berdasarkan Keanekaragaman Meiofauna dan Parameter Fisika-Kimia di Pesisir Losari, Makassar. *Jurnal Ilmu Lingkungan*, *20*(1), 45–57. https://doi.org/10.14710/jil.20.1.45-57

Yusal, M. S., Marfai, M. A., Hadisusanto, S., & Khakhim, N. (2019a). Water Quality Study Based On Meiofauna Abundance And Pollution Index In The Coastal Zone Of Losari Beach, Makassar. *Jurnal Ilmu Lingkungan*, *17*(1), 172. https://doi.org/10.14710/jil.17.1.172-180

Yusal, M. S., Marfai, M. A., Hadisusanto, S., & Khakhim, N. (2019b). Abundance of Meiofauna and Physical-Chemical Parameters as Water Quality Indicator. *ILMU KELAUTAN: Indonesian Journal of Marine Sciences*, *24*(2), 81. https://doi.org/10.14710/ik.ijms.24.2.81-90

Yusal, M. S., Marfai, M. A., Hadisusanto, S., & Khakhim, N. (2019c). Analisis Ekologis Meiofauna Sebagai Bioindikator Di Pesisir Pantai Losari, Makassar. *Bionature*, *19*(1). https://doi.org/10.35580/bionature.v19i1.7308

Yusal, M. S., Marfai, M. A., Hadisusanto, S., & Khakim, N. (2019). The Ecological Analysis of Meiofauna as a Water Quality Bioindicator on the Coast of Losari Beach, Makassar. *IOP Conference Series: Earth and Environmental Science*, *256*, 012024. https://doi.org/10.1088/1755-1315/256/1/012024

Zaghloul, A., Saber, M., Gadow, S., & Awad, F. (2020). Biological indicators for pollution detection in terrestrial and aquatic ecosystems. *Bulletin of the National Research Centre 2020 44:1*, *44*(1), 1–11. https://doi.org/10.1186/S42269-020-00385-X