ANALYSIS OF COASTAL WATER QUALITY AT MARINE TOURISM SITES IN THE CITY OF SIBOLGA

Kelvin Sihombing[1*], R. Hamdani Harahap[1], Miswar Budi Mulya[1]

[1]Department of Natural Resources and Environment Management, School of Graduate Studies, Universitas Sumatera Utara, Medan 20155 Indonesia

*kelvinsihombing12@gmail.com

ABSTRACT

Sibolga is one of the cities in North Sumatra Province that has outstanding marine tourism destinations, some of which include Pelabuhan Lama (Anggar) Beach and Ujung Sibolga Beach. This research aims to analyze the coastal water quality of marine tourism objects in Sibolga City. This research was conducted from March to July 2023 at Pelabuhan Lama (Anggar) and Ujung Sibolga Beach. Water quality assessment is carried out using the STORET method. Pelabuhan Lama (Anggar) Beach obtained a total score of -18, and Ujung Sibolga Beach received a total score of -26. The total scores for both tourist sites fall into class C with a moderate pollution category.

Keywords: Water Quality, Marine Tourism, STORET Method.

1. INTRODUCTION

Sibolga is one of North Sumatra Province's cities with outstanding marine tourism destinations. This is because Sibolga City is on the west coast of Sumatra Island and has beautiful and exotic tourist destinations. Several marine tourist attractions exist in Sibolga City, such as Ujung Sibolga Beach, Pelabuhan Lama (Anggar) Beach, Poncan Gadang Island, and Poncan Kotak Island. In addition to being marine tourist attractions, these islands also play a role in breaking high waves coming from the Indian Ocean. This makes Sibolga safer from potential natural disasters caused by high sea waves.

Tourism is vital in generating foreign exchange in various countries, including Indonesia. This is in line with the government's efforts to develop the tourism sector in Indonesia by attracting as many foreign tourists as possible to serve as a source of foreign exchange earnings for Indonesia. One of the prominent marine tourism destinations in North Sumatra Province is Sibolga City. Sibolga is one of the tourist attractions frequently visited by both local and foreign tourists. This is because, geographically, Sibolga City has the potential for marine tourism. Apart from its beautiful beaches, the city also boasts natural beauty, mountains, islands, underwater tourism, and other tourism potentials.

The Sibolga City Government has made efforts to develop the potential of marine ecotourism by building various supporting facilities and infrastructure to attract tourists to Sibolga City. However, behind every effort made by the Sibolga City Government to develop marine tourism in the region, there are various unresolved problems, such as waste issues and a decline in water quality in several actors, such as tourism activities, households, and fishing. According to Tambunan et al.[1], tourism activities can positively impact the local economy, but on the other hand, tourism activities can also put pressure on the environment. In addition to tourism activities, hotels, restaurants, settlements, and fishermen's activities have the potential to generate waste in the coastal areas. The impacts of these activities can affect the condition of the coastal environment. Coastal vulnerability to environment.

Coastal exposure to environmental changes due to tourism activities can lead to ecological degradation[1]. If the load received by the waters exceeds their carrying capacity, it can decrease water quality. The aquatic environment becomes unsuitable according to the established quality standards, and the seas become physically, chemically, and biologically polluted. This not only affects the communities within it but also significantly impacts the people who utilize the coastal waters.

Water quality is an essential factor in the sustainability of marine tourism. Knowing the environmental quality, especially the level of water pollution is necessary for policy direction in developing monitoring and recovery programs for ecological components that have experienced a decline in quality as part of risk management[2].

2.   RESEARCH METHOD
Time and Place

This research was conducted from March to July 2023. Observation sample collection was conducted at the marine tourist destinations in Sibolga City, North Sumatera, namely Ujung Sibolga Beach and Pelabuhan Lama (Anggar) Beach. Both beaches experience a high influx of tourists weekly due to their strategic location and easy accessibility. Water sample analysis was conducted at the Balai Teknik Kesehatan Lingkungan dan Pengendalian Penyakit (BTKLPP) Medan, North Sumatera. The research location map can be seen in Figure 1.
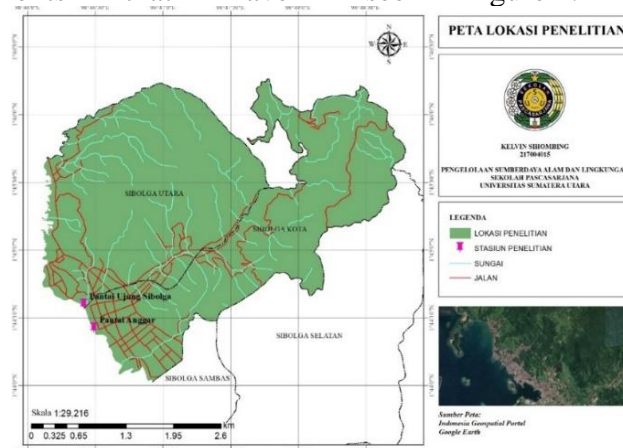

Figure 1. The research location map

Procedure
Determination of Observation Location

The determination of the observation location is carried out using a purposive sampling technique. Purposive sampling is a technique for selecting observation locations based on specific considerations that focus on the research objectives. The research locations are divided into two observation stations.

Station 1 is at Pelabuhan Lama (Anggar) Beach with coordinates $1^0$44'32,426" N and $98^0$46'25,953" E. Station 1 is directly adjacent to the hotel area. Station 2 is at Ujung Sibolga Beach with coordinates $1^0$44'34,869" N dan $98^0$46'24,711" E. This station is a tourist area adjacent to residential areas. They are located in the Kota Beringin Sub-district, Sibolga Kota District.

Measurement of Physical, Chemical, and Biological Parameters of Water

The water's physical, chemical, and biological parameters are measured in situ and ex situ. The results of the seawater quality measurements will be compared to the seawater quality standards for marine tourism activities as stipulated in Attachment VIII of the Peraturan Pemerintah Republik Indonesia Number 22 of 2021 regarding the implementation of environmental protection and management.

STORET Method

The STORET method is a method used to determine water quality status. This STORET method refers to Attachment I of Keputusan Menteri Lingkungan Hidup Number 115 of 2003 regarding guidelines for determining water quality status. Water quality status can be determined by observing whether the measured parameters meet or exceed the water quality standards. In principle, determining water quality status using the STORET method involves comparing water quality data with the relevant water quality standards. If the measurement results meet the water quality standards (measurement results are lower than the standards), a score of 0 is given. If the measurement results do not meet the water quality standards (measurement results are higher than the standards), a score is provided, as shown in Table 1. Water quality status is determined using the scoring system from the US Environmental Protection Agency (US-EPA), which classifies water quality into four classes. The classification of water quality status can be seen in Table 2

Table 1. Determination of the scoring system to determine water quality status

Quantity of observations	Score	Parameters		
		Physical	Chemical	Biological
< 10	Maximum	-1	-2	-3
	Minimum	-1	-2	-3
	Average	-3	-6	-9
> 10	Maximum	-2	-4	-6
	Minimum	-2	-4	-6
	Average	-6	-12	-18

Source: Lampiran I Keputusan Menteri Lingkungan Hidup No. 115 tahun 2003

Table 2. Classification of water quality status using the scoring system

Class	Score	Criteria
A	0	Excellent (meets water quality standards)
B	-1 s/d -10	Good (slight pollution)
C	-11 s/d -30	Moderate (moderate pollution)
D	≥-31	Poor (heavy pollution)

Source: Lampiran I Keputusan Menteri Lingkungan Hidup No. 115 tahun 2003

3. RESULT AND DISCUSSION
Physical, Chemical, and Biological Water Parameters

The analysis of coastal water quality at Pelabuhan Lama (Anggar) Beach and Ujung Sibolga Beach was conducted by observing thirteen parameters, which include total suspended solids (TSS), odor, pH, BOD5, oil and grease, mercury (Hg), hexavalent chromium (Cr(VI)), cadmium (Cd), copper (Cu), lead (Pb), zinc (Zn), and total coliforms.

The physical parameters measured in this study consisted of total suspended solids (TSS) and odor. The water quality standards used to assess seawater quality for marine tourism activities, whether for physical, chemical, or biological parameters, refer to Appendix VIII of the Republic of Indonesia Government Regulation 22 of 2021 on implementing environmental protection and management. In both Pelabuhan Lama (Anggar) Beach and Ujung Sibolga Beach, none of the total suspended solids (TSS) samples exceeded the established water quality standard of 20 mg/L. The average value obtained in Pelabuhan Lama (Anggar) Beach was 11 mg/L, while in Ujung Sibolga Beach, it was 10 mg/L. According to Andini et al.[3] (2015), knowledge of total suspended solids (TSS) distribution is essential because its presence can affect. Suppose the total

suspended solids (TSS) value is high and exceeds the established standard. In that case, it can indicate a high pollution level and hinder sunlight penetration into the water.

Regarding odor parameters, both tourist locations were generally categorized as odorless, which aligns with the criteria that water bodies designated as marine tourism objects should be odorless. The odor was measured organoleptically, using the sense of smell[1].

In addition to physical parameters, water quality analysis was also conducted for chemical parameters, including pH, BOD5, oil and grease, mercury (Hg), hexavalent chromium (Cr(VI)), cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn). Generally, the pH values at Pelabuhan Lama Beach (Anggar) and Ujung Sibolga Beach did not exceed the established standard, ranging from 7 to 8.5. Pelabuhan Lama (Anggar) Beach had an average pH value of 7.66, while Ujung Sibolga Beach had a pH value of 7.7. According to Rahmadanty et al.[4], pH is one of the parameters that must be measured when designating an area as a tourist destination because excessively acidic or alkaline waters can irritate the skin and eyes during swimming and other direct water-related activities.

Biological Oxygen Demand (BOD_5) parameters, there were differences in the results between the two observation locations. Ujung Sibolga Beach obtained a value of 16.167 mg/L, placing it in the category of exceeding the water quality standard. In contrast, Pelabuhan Lama (Anggar) Beach obtained a value below the water quality standard at 8.867 mg/L. The BOD5 standard for marine tourism activities is 10 mg/L. The high BOD_5 content at Ujung Sibolga Beach could be due to its proximity to the mouth of the Aek Doras River. This river mouth is a gathering point for organic materials carried from upstream, leading to the high BOD_5 content at Ujung Sibolga Beach. A high organic content in that water causes an increase in BOD5 content in a body of water.

Irham et al.[5] also stated that in estuarine waters, organic materials from upstream meet other organic materials downstream, increasing BOD_5 content. BOD_5 (Biological Oxygen Demand) is the amount of oxygen microorganisms require to break down organic materials in water. High BOD_5 content at Ujung Sibolga Beach indicates a low dissolved oxygen content in the water, which, if left unchecked, can lead to the death of aquatic organisms due to a lack of dissolved oxygen[6].

The oil and grease parameter has a standard of 1 mg/L. Based on the results of the water quality analysis, both observation locations had average values that exceeded the standard. Pelabuhan Lama Beach (Anggar) had an average value of 2.273 mg/L, while Ujung Sibolga Beach had a value of 2.533 mg/L. Pelabuhan Lama Beach (Anggar) is close to hotel areas and the anchorage of oil tankers and tourist ships. On the other hand, Ujung Sibolga Beach is located downstream of the Aek Doras River and near residential areas. According to Agustina et al.[7], oil and grease pollution sources can come from household activities such as washing and cooking, as well as spilled oil from port activities and fishing vessels. The impact of oil and grease pollution can hinder the movement of marine life and the supply of light to the water, disrupting the growth of microorganisms that serve as food for some fish species[8].

In contrast to the oil and grease parameter, both Pelabuhan Lama (Anggar) Beach and Ujung Sibolga Beach had average values for mercury (Hg) below the standard, with each location having values of 0.00018033 mg/L and 0.00013133 mg/L, respectively. The standard for mercury (Hg) is 0.002 mg/L. Mercury (Hg) is one of the heavy metals whose sources of pollution can come from uncontrolled industrial waste disposal, oil sludge containing high concentrations of heavy metals, and the burning of oil and coal on land that is carried into the atmosphere and then mixed with rainwater and falls into the water. Mercury

(Hg) can cause poisoning in humans, and this can occur due to contamination from seawater or contaminated foods such as shrimp, fish, and clams.

The hexavalent chromium (Cr(VI)) parameter has a standard limit of 0.002 mg/L for the marine tourism category. The analysis of seawater quality found that the average levels of hexavalent chromium (Cr(VI)) at both locations exceeded this standard. Pelabuhan Lama Beach (Anggar) had an average value of approximately 0.053 mg/L, while Ujung Sibolga Beach had an average value of about 0.045 mg/L. The erosion or weathering of mineral rocks is a factor that can lead to an increase in the content of hexavalent chromium (Cr(VI)) in both tourist locations. Additionally, the fact that Pelabuhan Lama Beach (Anggar) and Ujung Sibolga Beach serve as stopover points for ships also contributes to the elevated levels of hexavalent chromium (Cr(VI)) in both water bodies. This is in line with Andini et al.[3], which explains that hexavalent chromium (Cr(VI)) can be influenced by natural factors such as rock erosion or weathering and airborne hexavalent chromium particles carried by rainwater. Furthermore, non-natural factors, such as industrial activities around the water and dense human settlement activities, can also introduce hexavalent chromium (Cr(VI)) into the water. The intake of hexavalent chromium into the human body can lead to damage to the digestive system, resulting in abdominal pain, vomiting, and bloody diarrhea[9].

In contrast to the hexavalent chromium (Cr(VI)) parameter, the average levels of cadmium (Cd) obtained at both observation points are below the established standard of 0.002 mg/L. Pelabuhan Lama Beach (Anggar) has a value of approximately 0.000058 mg/L, while Ujung Sibolga Beach has a value of roughly 0.00006133 mg/L. It is important to know the presence of cadmium (Cd) because it is one of the non-essential heavy metals whose benefits to the human body are not yet known, and it is also categorized as a toxic

metal. According to Wardani et al.[10], excessive intake of cadmium (Cd) into the bodies of living organisms can lead to health problems, poisoning, and even death.

The copper (Cu) parameter has a standard of 0.05 mg/L for marine tourism activities and has average results below the established standard. Pelabuhan Lama Beach (Anggar) has an average value of approximately 0.000612 mg/L, while Ujung Sibolga Beach has a value of approximately 0.00072567 mg/L. Copper (Cu) is an element living organisms need in small quantities. Copper (Cu) can come from industries located around the water[11].

For the lead (Pb) parameter, Pelabuhan Lama Beach (Anggar) obtained an average value of approximately 0.000445 mg/L, while Ujung Sibolga Beach obtained an average value of approximately 0.000508 mg/L. Based on these measurement results, both observation sites still have results below the established standard of 0.005 mg/L. Lead (Pb) is considered a toxic heavy metal, and its potential benefits within living organisms are not well understood. Therefore, this parameter is important to monitor because excessive lead (Pb) levels in a water body can negatively impact affected organisms, including organ damage and health problems[12].

For the last chemical parameter, zinc (Zn), the standard for marine tourism activities is 0.095 mg/L. Both Pelabuhan Lama Beach (Anggar) and Ujung Sibolga Beach obtained average values below this standard, with Pelabuhan Lama Beach having an average value of 0.001 mg/L and Ujung Sibolga Beach having an average value of 0.0007233 mg/L. According to Komarwidjaja et al.[13], zinc (Zn) is one of the heavy metals that humans require in small amounts. Still, excessive levels of zinc (Zn) in the body can lead to health issues such as skin irritation, nausea, vomiting, and anemia.

The biological parameter measured in this study is total coliform. The limit for total coliform in marine waters for tourism activities is 1000 mg/L. Based on the

analysis of seawater quality at both tourist locations, it was found that the total coliform count in both waters is below the established standard. The total coliform count at Pelabuhan Lama Beach (Anggar) is 23.8 Jml/100 mL, while at Ujung Sibolga Beach, the total coliform count is 44.233 Jml/100 mL. The presence of total coliform bacteria in a body of water is important to monitor because an excessive presence can harm tourists visiting the area. As explained by Widyaningsih et al.[14], if the total coliform count in a water body exceeds the established standard, it can lead to increased growth of pathogenic bacteria, which can cause health issues in humans. The presence of total coliform bacteria can originate from the activities of the local community around the water body, such as the disposal of domestic waste into the water, including vegetable waste, food remnants, and feces. According to Setyati et al.[2], organic waste is a nutrient supply for coliform bacteria. The results of the water quality analysis at Pelabuhan Lama Beach (Anggar) and Ujung Sibolga Beach can be seen in Table 3.

Table 3. The results of water quality

Parameters	Unit	Quality standards	Test Results	
			Pelabuhan Lama (Anggar) Beach	Ujung Sibolga Beach
Physical				
Total suspended solid (TSS)	mg/L	20	11	10
Odor	-	Tidak berbau	Tidak berbau	Tidak berbau
Chemical				
pH	-	7-8,5	7,657	7,7
BOD_5	mg/L	10	8,867	16,167
Oil and grease	mg/L	1	2,273	2,533
Mercury (Hg)	mg/L	0,002	0,00018033	0,00013133
Hexavalent chromium (Cr(VI))	mg/L	0,002	0,053	0,045
Cadmium (Cd)	mg/L	0,002	0,000058	0,00006133
Copper (Cu)	mg/L	0,05	0,000612	0,00072567
Lead (Pb)	mg/L	0,005	0,000445	0,000508
Zinc (Zn)	mg/L	0,095	0,001	0,0007233
Biological				
Coliform (total)	Jml/100 mL	1000	23,8	44,233

Water Quality Status

Water quality status is determined using the STORET method following Appendix I of the Minister of Environment Decree No. 115 of 2003 regarding guidelines for determining water quality status. The parameters used in this study are 12 parameters consisting of chemical, physical, and biological parameters. The number of observations used is three repetitions, so according to Table 2, the value system for determining water quality status is using <10.

At Pelabuhan Lama (Anggar) Beach, no minimum values exceeded the quality standards, resulting in a total minimum value of 0. However, for the maximum values, some parameters exceeded the quality standards, namely BOD_5, oil and grease, and hexavalent chromium (Cr(VI)), each receiving a value of -2. The average values for the analyzed parameters scored -12, primarily influenced by oil and grease and hexavalent chromium (Cr(VI)), both receiving a score of -6. With these scores, Pelabuhan Lama (Anggar) Beach received a

total score of -18, categorizing it as Class C with a moderate pollution level. The water quality status at Pelabuhan Lama (Anggar) Beach can be seen in Table 4.

Table 4. Water quality status of Pelabuhan Lama (Anggar) beach

No	Parameter	Minimum	Maximum	Average
1	Total suspended solid (TSS)	0	0	0
2	Odor	0	0	0
3	pH	0	0	0
4	BOD_5	0	-2	0
5	Oil and grease	0	-2	-6
6	Mercury (Hg)	0	0	0
7	Hexavalent chromium (Cr(VI))	0	-2	-6
8	Cadmium (Cd)	0	0	0
9	Copper (Cu)	0	0	0
10	Lead (Pb)	0	0	0
11	Zinc (Zn)	0	0	0
12	Coliform (total)	0	0	0
	Sub total	0	-6	-12
	Total	-18		

Table 5. Water quality status of Ujung Sibolga beach

No	Parameter	Minimum	Maximum	Average
1	Total suspended solid (TSS)	0	0	0
2	Odor	0	0	0
3	pH	0	0	0
4	BOD_5	0	-2	-6
5	Oil and grease	-2	-2	-6
6	Mercury (Hg)	0	0	0
7	Hexavalent chromium (Cr(VI))	0	-2	-6
8	Cadmium (Cd)	0	0	0
9	Copper (Cu)	0	0	0
10	Lead (Pb)	0	0	0
11	Zinc (Zn)	0	0	0
12	Coliform (total)	0	0	0
	Subtotal	-2	-6	-18
	Total	-26		

The water quality status for Ujung Sibolga Beach is -26, categorizing it as Class C with a moderate pollution level. The total score is derived from minimum, maximum, and average scores. The minimum value has a total of -4, stemming from parameters BOD5 and oil and grease, both having values of -2. The maximum value, on the other hand, scores -6, contributed by parameters BOD_5, oil, fat, and hexavalent chromium (Cr(VI)), each with values of -2. The average score for Ujung Sibolga Beach is -18, with contributions from BOD5, oil and grease, and hexavalent chromium (Cr(VI)), all scoring -6. As for the biological parameter analyzed, coliform (total), neither Pelabuhan Lama (Anggar) Beach nor Ujung Sibolga Beach exceeded the quality standards. Therefore, the minimum, maximum, and average scores for both tourist locations are 0 (Table 5).

With these results, Pelabuhan Lama (Anggar) Beach and Ujung Sibolga Beach have experienced a decline in their function as marine tourism destinations. Therefore, the public needs to be aware of this water

quality status to serve as a reference for activities in tourist areas, ensuring that tourism can proceed smoothly without posing health risks to tourists. These research findings align with the study conducted by Damayanti[15] at Bulumanis Kidul Beach, which indicated that the beach had a moderate pollution level of water quality, necessitating public awareness and education about the water quality status. Considering the intermediate pollution status of both Pelabuhan Lama (Anggar) Beach and Ujung Sibolga Beach, it is crucial to engage in environmental severe management efforts to reduce BOD_5, oil and grease, and hexavalent chromium (Cr(VI)) levels in the waters. These coastal areas will be utilized according to their intended purpose as marine tourism destinations. According to Wijayanti et al.[16], various measures can be taken to control pollution in marine tourism destinations, such as formulating and supervising policies for coastal pollution management, conducting outreach on these policies for the community, early education on the importance of environmental conservation, increasing community involvement in preventing coastal pollution, providing waste disposal facilities, sanitation personnel, domestic wastewater disposal systems, and implementing beach cleanliness programs involving the community.

4.   CONCLUSION

The water quality at both marine tourism destinations in Sibolga yielded the following results: Pantai Pelabuhan Lama (Anggar) received a score of -18. In contrast, Pantai Ujung Sibolga received a score of -26. Both of them fall into Class C with a moderate pollution category.

REFERENCES

1. Tambunan, J.M., Anggoro, S., Purnaweni H. (2013). Kajian Kualitas Lingkungan dan Kesesuaian Wisata Pantai Tanjung Pesona Kabupaten Bangka. *Prosiding Seminar Nasional Pengelolaan Sumberdaya Alam dan Lingkungan,* 2013.
2. Setyati, W.A., Pringganies, D., Pamungkas, D.B.P., Suryono, C.A. Monitoring Bakteri Coliform pada Pasir Pantai dan Air Laut di Wisata Pantai Marina dan Pantai Baruna. *Jurnal Kelautan Tropis,* 2022; 23 (1): 113-120.
3. Andini, V. M., Mutiara, I., Witasari, Y. Studi Persebaran *Total Suspended Solid* (TSS) Menggunakan Citra Aqua Modis di Laut Senunu, Nusa Tenggara Barat. *GEOID*, 2015; 10 (2): 204-213.
4. Rahmadanty, A., Ambariyanto, S., Munasik. Analisa Kesesuaian Perairan Untuk Pengembangan Wisata Bahari di Pantai Karang Jahe, Rembang. *Journal of Marine Research,* 2022; 11 (3): 383-390.
5. Irham, M., Abrar, F., Kurnianda, V. Analisis BOD dan COD di Perairan Krueng Cut, Banda Aceh. *Depik*, 2017; 6 (3): 199-204.
6. Daroini, T.A., Arisandi, A. Analisis BOD (*Biological Oxygen Demand*) di Perairan Desa Prancak Kecamatan Sepulu, Bangkalan. *Juvenil*, 2020; 1 (4): 558-566.
7. Agustina, A., Aprinica, N.P.I. Dampak Pariwisata Terhadap Pencemaran Air Danau Batur Kabupaten Bangli. *Jurnal Ilmiah Hospitality Management*, 2022; 12 (2): 81-89.
8. Ondara, K., Dhiauddin, R., Wisha, U.J. Feasibility of Banda Aceh Sea Water Quality for Marine Organism. *Jurnal Kelautan Nasional*, 2020; 15(2): 103-112.
9. Tyas, N.M., Affandi, R. Uji Toksisitas Letal Cr^{6+} terhadap Ikan Nila (*Oreochromis Niloticus*). *Jurnal Ilmu Pertanian Indonesia (JIPI)*, 2016; 21 (2): 128-132.
10. Wardani, I., Ridlo, A., Supriyantini, E. Kandungan Kadmium (Cd) dalam Air, Sedimen dan Kerang Hijau (*Perna viridis*) di Perairan Trimulyo Semarang. *Journal of Marine Research*, 2018; 7 (2): 151-158.

11. Cahyani, M.D., Azizah, R., Yulianto, B. Studi Kandungan Logam Berat (Tembaga (Cu) pada Air, Sedimen dan Kerang Darah (*Anadara granosa*) di Perairan Sungai Sayung dan Sungai Gonjol, Kecamatan Sayung, Kabupaten Demak. *Journal of Marine Research,* 2012; 1 (2): 73-79.
12. Pratush A., Kumar, A., Hu, Z. Adverse Effect of Heavy Metals (As, Pb, Hg, and Cr) on Health and their Bioremediation Strategies: a review. *International Microbiology,* 2018; 21 (3): 97-106
13. Komarwidjaja, W., Riyadi, A., Garno, Y.S. The State of Heavy Metal Content in the Coastal Water of Aceh Utara Regency and Lhokseumawe City. *Jurnal Teknologi Lingkungan,* 2017; 18 (2): 251-258
14. Widyaningsih, W., Supriharyono., Widyorini, S. The Analysis of Total Coliform Bacteria in Kali Wiso Estuary Jepara. *Diponegoro Journal of Maquares,* 2016; 5 (3): 157-164
15. Damayanti, H.O. Sea Water Quality Status of Bulumanis Kidul Coast Pati Regency. *Jurnal Manusia dan Lingkungan,* 2013; 20 (3): 367-376.
16. Wijayanti, B.I., Chamid, C. Kajian Pengendalian Pencemaran Air Laut Berdasarkan Partisipasi Masyarakat di Kawasan Pesisir Pantai Santolo Kecamatan Cikelet Kabupaten Garut. *Journal Riset Perencanaan Wilayah dan Kota*, 2021; 1 (1): 23-29