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Distribution of Heavy Metals in Sediments in the Nambo Coastal Waters of Southeast Sulawesi Province

Distribusi Logam Berat pada Sedimen di Perairan Pantai Nambo Provinsi Sulawesi Tenggara

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Abstract

A study was conducted on the distribution of heavy metals in sediments in Nambo Beach, Southeast Sulawesi Province, on July 24, 2022. This study aims to determine the content of heavy metals such as Cu, Pb, and Cd in sediments, determine the size of sediment grains, and assess the level of pollution in sediments on Nambo Beach. Determination of station points using a purposive sampling method with 7 station points. The technique used for heavy metal analysis in sediments is the atomic absorption spectrophotometry (AAS) method. The size of sediment grains is determined using a rock comparator, while to determine the level of pollution, the Geoaccumulation Index (I_Geo), Contamination Factor (CF), and Pollution Load Index (PLI) methods are used. The results of the study obtained showed that the highest content of heavy metals was Cu at all stations with values ranging from 0,011-0,0224 mg/L with an average value of 0,014 mg/L and the highest value was at station 1, Pb Metals, with values ranging from 0,001-0,0106 mg/L with an average value of 0,0033 mg/L and Cd with a relay range of 0,001-0,0025 mg/L and an average value of 0,0017 mg/L. The sedimentary grain sizes scattered on Nambo Beach include silt, clay, fine sand, and very fine sand. For testing the level of heavy metal pollution of Cu, Pb, and Cd in sediments, the results of calculations with the category of unpolluted to lightly polluted for all stations were obtained.

Keywords: Nambo Beach, Sediment, Heavy Metal, AAS, Pollution Level.

Abstrak

Telah dilakukan penelitian mengenai distribusi logam berat pada sedimen di perairan Pantai Nambo, Provinsi Sulawesi Tenggara, pada tanggal 24 Juli 2022. Penelitian ini bertujuan untuk mengetahui kandungan logam berat seperti Cu, Pb, dan Cd pada sedimen, mengetahui ukuran butiran sedimen, dan mengetahui tingkat pencemaran pada sedimen di Pantai Nambo. Penentuan titik stasiun menggunakan metode purposive sampling dengan 7 titik stasiun. Metode yang digunakan untuk analisis logam berat pada sedimen adalah metode spektrofotometri serapan atom (AAS). Ukuran butiran sedimen ditentukan dengan menggunakan pembanding batuan, sedangkan untuk mengetahui tingkat pencemaran digunakan metode Indeks Geoakumulasi (I_Geo), Contamination Factor (CF), dan Pollution Load Index (PLI). Hasil penelitian yang diperoleh menunjukkan bahwa kandungan logam berat tertinggi adalah Cu pada semua stasiun dengan nilai berkisar antara 0,011-0,0224 mg/L dengan nilai rata-rata 0,014 mg/L dan nilai tertinggi pada stasiun 1 yaitu Logam Pb dengan nilai berkisar antara 0,001-0,0106 mg/L dengan nilai rata-rata 0,0033 mg/L dan Cd dengan kisaran 0,001-0,0025 mg/L dengan nilai rata-rata 0,0017 mg/L. Jenis ukuran butir sedimen yang tersebar di Pantai Nambo antara lain lanau, lempung, pasir halus, dan pasir sangat halus. Untuk pengujian tingkat pencemaran logam berat Cu, Pb, dan Cd pada sedimen diperoleh hasil perhitungan dengan kategori tidak tercemar hingga tercemar ringan untuk semua stasiun.

Kata kunci: Pantai Nambo, Sedimen, Logam berat, AAS, Tingkat Pencemaran

1. Introduction

Nambo Beach is one of the leading destinations in Kendari City, with a current area of 9 ha, making it the central tourist spot for the people of Kendari City and even other districts. The existence of Nambo Beach as a marine tourist destination certainly touches the lives of many people around the beach. The importance of environmental management of Nambo Beach is that it will help create a conducive environmental atmosphere for implementing tourism activities (Yusnidar, 2016). The physical condition of the Nambo coastal water environment had experienced turbidity or changes in the color of the water around it. This is due to sandwashing waste from a mining company near Nambo coastal waters.

One of the pollutants that are quite alarming that occurs is heavy metals such as Pb, Cd, Cu, and others. The presence of heavy metals in water will be difficult to degrade, and even the metal will be absorbed into the organism's body. Heavy metals such as Pb and Cu are dangerous and can enter the body through the digestive tract (Siaka et al., 2016). Heavy metals are naturally found in aquatic environments. Its presence in the water column and sediments can come from human activities on land, such as industry, transportation, mining, and settlements. Heavy metals in water can be used as an important parameter to see the pollution level of a body of water (Sari et al., 2019).

Marine sediment analysis is a beneficial method for studying environmental pollution caused by heavy metals. Heavy metals accumulate in sediments through complex chemical and physical adsorption mechanisms depending on the sediment matrix present in nature and the nature of the compounds absorbed. Sediments contaminated with heavy metals can harm the organisms living in them. Besides being harmful to aquatic organisms, heavy metals can be dangerous if they reach humans because they are toxic and can cause health problems and death (Ahmad, 2013).

Prediction of sediment enrichment by metallic elements can occur in various ways, and some common ways are by using the geoaccumulation index (I-geo), contamination factor (FC), and pollution load index (PLI). Several previous studies that have been conducted in the waters of Kendari Bay, which is also one of the tourist destinations of Kendari City by Amriarni et al. (2011) stated that heavy metal content of Pb and Zn was found in sediments, water, and shellfish in the waters of Kendari Bay. Meanwhile, Wibowo et al. (2020) found a high content of heavy metal Ni accumulated in seawater. In addition, research by Ahmad (2013) conducted in Kendari Bay and Lasolo Bay stated that heavy metal levels of Pb, Cd, Cu, Zn, and Ni in seawater in the waters of Kendari and Lasolo Bay are still relatively good for marine life and have not been polluted. Therefore, this study was conducted to determine the presence or absence of Cu, Pb, and Cd heavy metals content in sediments, determine the sediment type, and predict the pollution level on Nambo Beach due to heavy metals.

2. Material and Method

2.1. Time and Place

This research was conducted in July 2022 at Nambo Beach, located in Abeli District, Kendari City, Southeast Sulawesi, between 4^0 00' 5" S and 122^0 36' 59" E (Figure 1). Sampling was carried out at seven stations using the purposive sampling method, which is a sampling method that can represent the overall state of the research area. Sample measurements were conducted in situ, and laboratory analysis was performed in the Biology laboratory of FMIPA UHO.

2.2. Procedure

2.2.1. Preparatory Stage

Tool preparation for primary data collection in the field and determining station points (purposive sampling) to take sediment samples. Tools and materials used in this study include GPS, AAS Shimadzu AA7000, PVC pipes, ovens, plastic samples, porcelain dishes, analytical balances, hot plates, trophy cups, Aquades, rock comparators, pH meters, hand-refractometers, kite currents, HNO_3, and boats.

2.2.2. Data Retrieval

Sediment sampling was obtained from Nambo coastal waters with 7 station points. The sediment sampling process is carried out at low tide using PVC Pipe Tools as much as 500 g at each station. Environmental parameters such as pH, salinity, and current speed are measured as much as three repetitions at each station when the sea water is at high tide. Samples obtained at each station are then put into labeled sample bags and placed in ice boxes to be taken to the laboratory.

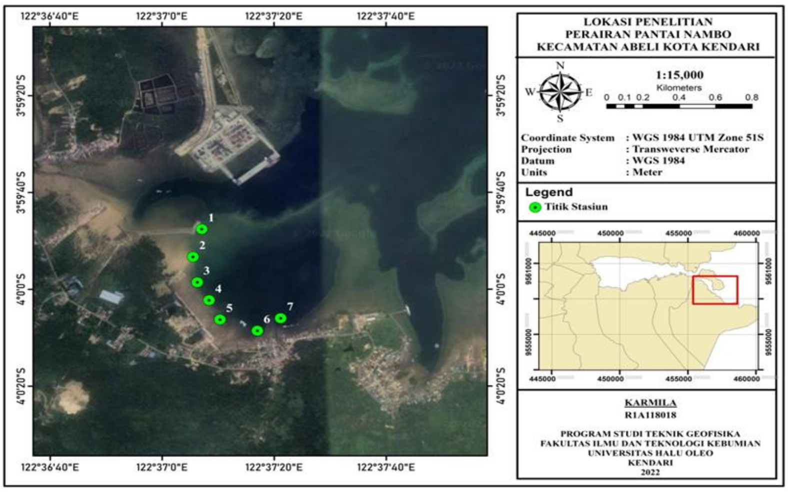

Figure 1. Sampling location

2.3. Data Analysis

The Data analysis consists of in situ analysis, namely sediment sampling and measurement of water quality parameters, including pH, salinity, and current speed directly in the field and laboratory analysis, namely determining heavy metal levels using the AAS method and then continued grain size analysis using sedimentary rock comparators. The results of the heavy metal analysis in sediments using the AAS method are then associated with the grain size of the bottom sediment waters, where the grain size has an important role in the distribution of heavy metals in sediments, while for the analysis of the level of heavy metal pollution in sediments using criteria i_geo, CF, and PLI using the following formula:

$$Igeo = \log2 (Cx/1,5\ Cb) \quad (1)$$

$$CF = Cx/Cb \quad (2)$$

$$PLI = [CF1\ X\ CF2\ x\ CF3......CFn] \quad (3)$$

3. Result and Discussion

3.1. Concentration and Distribution of Heavy Metals Copper (Cu), Lead (Pb), and Cadmium (Cd) in Sediments

The results of heavy metal analysis Cu, Pb, and Cd using the AAS method can be seen in Table 1, where the concentration obtained at each station is lower than the concentration of heavy metals in nature (Table 2). From Table 1, we can map the distribution of Cu, Pb, and Cd metals at each station to know the distribution direction.

Table 1. Heavy metal concentrations at individual stations

Station	Heavy Metals (mg/L)			Average
	Lead (Pb)	Copper (Cu)	Cadmium (Cd)	
01	0,0106	0,0224	0,0021	0,0117
02	0,004	0,0112	0,0025	0,0059
03	0,0021	0,0111	0,002	0,005067
04	0,001	0,011	0,001	0,004333
05	0,0016	0,0116	0,0011	0,004767
06	0,002	0,019	0,0019	0,007633
07	0,0021	0,014	0,0014	0,005833
Average	0,0033	0,0143	0,0017	

The distribution of Cu metal is higher at station 1, which is characterized by dark blue degradation. It is caused by the flow of the river estuary near the station, so the metal concentration is higher. In comparison, for other stations, there is less influence from the mouth of the river. Hence, the concentration is lower, characterized by the green color degradation from stations 2-5. Stations 6-7 also have a high concentration marked by dark blue to light blue degradation because stations 6-7 are near the houses of residents living around the beach.

Pb (Lead) metal, when viewed from Figure 3, has the highest concentration at stations 1-2, characterized by dark blue to light blue degradation, while stations 3-7 have low concentration values. The low concentration of metal at the station is thought to be because it is far from the mouth of the river, so the concentration is low. For the Cd distribution (Figure 4), the highest metal concentration is at stations 1,3 and 6, marked with dark blue degradation, while the 4,5,7 metal concentration is lower, indicated by green degradation. The high and low concentration of heavy metals at each station is thought to be due to the estuary of the river that flows directly into Nambo Beach (stations 1-2). In addition, activities such as tourist activities (Stations 3-5) and activities of residents living around the beach (Stations 6-7) also significantly affect the concentration of heavy metals. From the overall concentration of heavy metals, it can be concluded that the highest concentration is at station 1, with the type of Cu (Copper) metal dominating the most.

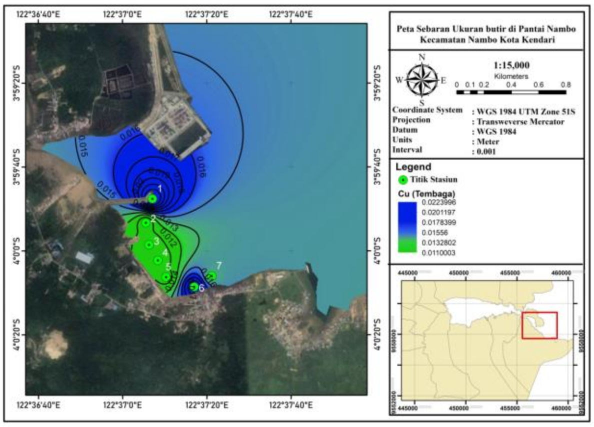

Figure 2. Cu (Copper) metal distribution

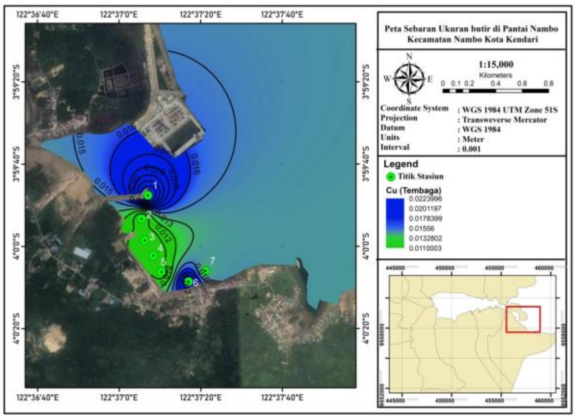

Figure 3. Pb (Lead) metal distribution

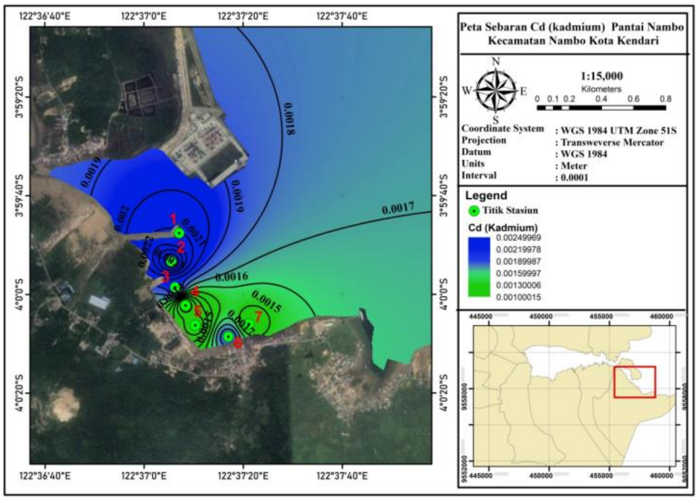

Figure 4. Distribution of Cd (Cadmium) metal

Compared with the value of heavy metal levels in nature, heavy metal levels on Nambo Beach are still lower, so based on this, heavy metal levels on Nambo Beach are still relatively safe. So, according to the results obtained, Nambo Beach, a well-known tourist destination in Kendari City, is still safe from heavy metal contamination because there are several factors, namely good beach management and awareness of the people living around to maintain the cleanliness of Nambo Beach. In addition, this is also supported by brightness measurements carried out at high tide ranging from 0.9-2.5 m and at low tide 0.8-2.2 m, where the brightness in these waters is still relatively good according to the Decree of the State Minister of Environment No. 51 of 2004 the quality standard value set >6 m for marine tourism.

3.2. Physical and Chemical Conditions of the Water at Nambo Beach

Measurements of water quality parameters on Nambo Beach in situ obtained relatively high values and varied at all stations, both at high and low tide. The pH value at high tide ranges from 8.1 – 8.7, which is relatively higher than alkaline, while the salinity level in these waters ranges from 21 – 30.6 ppt. The pH value at low tide ranges from 8.5 – 9.1, and the salinity ranges from 22 – 27 ppt. Comparison of water parameter values for higher salinity at high and higher pH values at low tide.

The difference in measured salinity values is influenced by several factors, namely weather and wind. If the weather is terrible and the wind is strong at the time of measurement, the salinity will be low, and vice versa. If the weather conditions are relatively sunny, the salinity will be high. The difference in the salinity value of seawater can also be caused by mixing due to sea waves or the movement of water masses caused by wind blows. The salinity value of Indonesian sea areas generally ranges from 28-33 ppt. The results showed that the salinity value in these waters was relatively high at high tide, which was 21-30.6 ppt, while at low tide, it was lower at 22-27 ppt. The average value of salinity measurement at high tide was 28.4 ppt <32 ppt, while at low tide, the average value was 24.27 ppt <32 ppt. This shows that the coast still influences these waters, allegedly from land, by mixing fresh water carried by river flows. This salinity level is still within the normal salinity limits of coastal water and mixed water. For coastal areas (coastal water and mixed water), salinity ranges from 32.0-34.0 ppt; for the open ocean, generally, salinity ranges from 33-37 ppt with an average of 35 ppt. The large salinity value in these waters is thought to be due to rainfall and river flow (Patty, 2013).

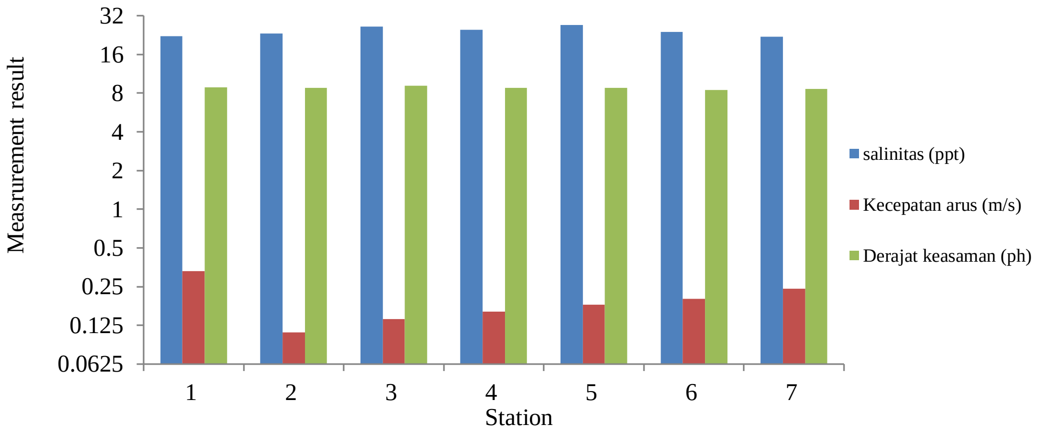

Figure 5. Quality parameters of Nambo Beach waters at low tide

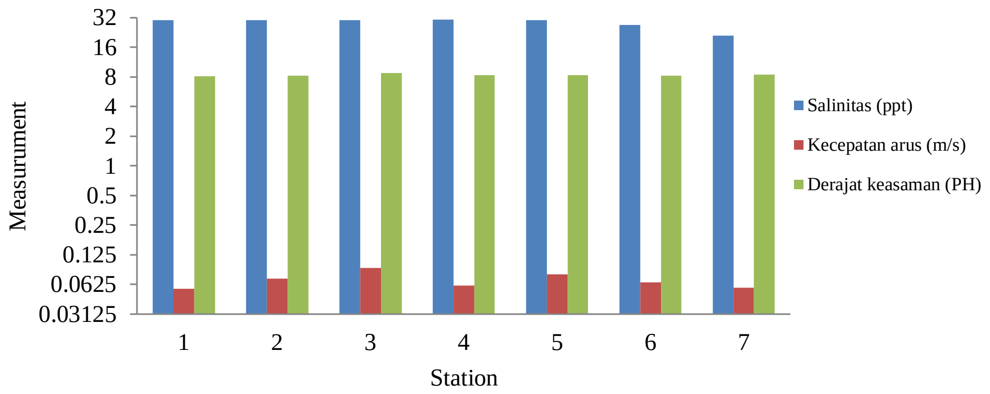

Figure 6. Nambo Beach water quality parameters at high tide

pH in water affects the presence of heavy metals in the water. If a water's degree of acidity (pH) is high, the heavy metal content that settles in the sediment will also be higher. An increase in pH causes the level of solubility of heavy metals in the water to decrease due to a change in the stability of carbonate compounds into hydroxide compounds that can provide binding power to particles contained in the water column and then form sediments, which will cause an increase in heavy metal toxicity if there is a decrease in pH. In addition to pH, salinity also affects the solubility of heavy metals in water. In contrast to pH, if salinity decreases, it will increase the accumulation of heavy metals in the organism's body. The higher the heavy metal content contained in water and the lower the salinity in these waters, the more it will affect the living organisms (Putu et al., 2020).

Based on the graph, current speed measurements in situ results also have varying values where the lowest speed occurs at high tide and the highest at low tide. The average speed at high tide is 0.069 m/s, so this current is included in the category of low current (0-0.025 m/s), while the average speed at low tide is 0.20 m/s so it is included in the category of medium current (0.025-0.5 m/s). The high and low current speed affects the type of sediment formed and also the concentration of heavy metals at each station, where the current speed is directly proportional to the kind of sediment developed, meaning that the higher the current speed, the type of sediment formed will also be coarser and vice versa. While the sediment type is inversely proportional to the concentration of heavy metals, the coarser the sediment type, the concentration of heavy metals is because the pores in the coarse sediment type are more significant and vice versa.

The lowest speed at low tide is at station 2 with a speed of 0.11 m/s, which means that the station has an acceptable sediment type, while the highest speed is at station 1 with a speed of 0.33 m/s with a coarse sediment type. These measurements show that station 1 should have a rough kind of sediment because the current is strong enough, while station 2 should have a type of smooth sediment because of the weak current. However, according to the analysis of the sort of sediment obtained, the smooth sediment type is at station 1, while the rough type is at station 7.

From these results, it is suspected that the current in these waters is parallel to the coast. Waves that propagate from deep waters to shallow waters (beaches) will experience changes in wave behavior (transformation). Breaking waves that form an angle with the coastline can cause longshore currents. Currents along the coast are one of the causes of the formation of coastal morphology. This can be caused because coastal parallel currents are sediment carriers that have been moved by waves and continue to move along the coast. For deep waters, the wave height is relatively the same. This is because the wave height in deep waters is not affected by changes in depth. The wave height gradually decreases as the wave enters transitional waters or shallow waters. However, as the coastline gets closer, the wave height value will increase again and break (Meilistya et al., 2012).

3.3. Grain Size Characteristics of Nambo Beach Sediments

Based on Figure 7, it can be seen that the type of sediment scattered in the research location with the smoothest type is at stations 1-2, which are characterized by degradation of blue, namely clay, and silt. This is because there is an estuary at the station, so the sediment type is finer than other stations. Stations 3-6 are marked by yellow degradation with a very fine sand sediment type, while station 7, with red degradation, shows that the station has a coarser sediment type than other stations, namely fine sand. Based on the results obtained, the type of sediment that dominates the research site is fine sands, where the sediment type in these waters is very fine due to the river's estuary at the research site. In addition, this type of sediment can be associated with heavy metal concentrations in sediments, where heavy metal concentrations are higher in sediments with finer grain sizes.

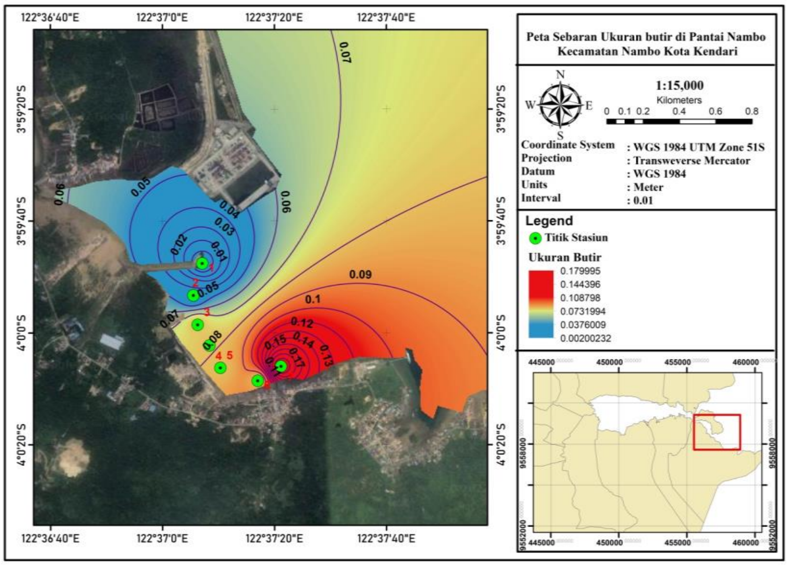

Figure 7. Distribution of sediment types on Nambo Beach

3.4. Levels of Heavy Metal Pollution in Sediments

To determine the pollution level in Nambo Beach, I_geo, Contamination Factors, and PLI analysis were used (Table 3). The calculation values of the geoaccumulation index of metals Pb, Cu, and Cd are presented in Table 4. It can be seen the value of the geoaccumulation index in Nambo Beach for Pb metal ranges from -3.501 to -6.907 (<0), so it is said to be unpolluted, Cu ranges from -0.284 to -1.310 (<0) (unpolluted) and Cd with values ranging from -11.551 to -12.873 (<0) unpolluted. The geoaccumulation index value of Pb, Cu, and Cd metals <0 means that these metals do not pollute the sediments on Nambo Beach. The calculation value using the criteria of contamination factors and pollution load index can be seen in Table 2.

Table 2. Heavy metal concentrations in nature

No	Heavy metals	The value of heavy metals in nature
1	Lead (Pb)	12.5
2	Copper (Cu)	55
3	Cadmium (Cd)	0.20

The resulting values using contamination factors for Pb, Cu, and Cd metals at all stations (<1) (low contamination level) and for pollution load index also yielded values of 0-2 (unpolluted to lightly polluted). So, based on the calculation results using the Geoaccumulation Index and Contamination Factor, sediment in Nambo Beach is still a natural category or not polluted by the metal, while using the pollution load index, it is said to be unpolluted to lightly polluted by Pb, Cu, and Cd metals.

Table 3. Criteria for the level of pollution and contamination (Ahmad, 2013)

Criterion		
Geoaccumulation Index (I_Geo	Pollution load index (PLI)	Contamination factor (CF)
I_Geo < 0, unpolluted 0<I-Geo<1, lightly polluted 1<I_Geo<2, moderately polluted 2<I_Geo<3, moderately polluted 3<I_Geo<4, severely polluted 4<I_Geo<5, unusually badly polluted I _Geo>5, very unusually badly polluted	< 0, unpolluted 0-2, unpolluted to lightly polluted 2-4, moderately polluted 4-6, severely polluted 6-8, very badly polluted 8-10, unusually badly polluted	CF<1, low contamination level 1<CF<3, moderate contamination level 3<CF<6, sufficient contamination level CF>6, very high contamination level

Table 4. The calculation results use I_Geo, Contamination Factor (CF), and Pollution Load Index (PLI)

Geoaccumulation index			Contamination factors (CF)			PLI
Pb	Cu	Cd	Pb	Cu	Cd	
-3,501	-0,284	-11,802	0,000848	0,000407	0,0105	1,20879E-09
-4,907	-1,284	-11,551	0,00032	0,000204	0,0125	2,71515E-10
-5,837	-1,297	-11,873	0,000168	0,000202	0,01	1,13018E-10
-6,907	-1,310	-12,873	0,00008	0,0002	0,005	2,66667E-11
-6,229	-1,233	-12,735	0,000128	0,000211	0,0055	4,94933E-11
-5,907	-0,521	-11,947	0,00016	0,000345	0,0095	1,7503E-10
-5,837	-0,962	-12,387	0,000168	0,000255	0,007	9,97818E-11

4. Conclusions

Based on the laboratory analysis results, heavy metals with the highest concentration were copper (Cu) with an average value of 0.014 mg/L, followed by lead (Pb) and cadmium (Cd) while using the calculation of Geoaccumulation Index (I_Geo) criteria, the Contamination Factor (CF) and Pollution Load Index (PLI) are still in the category of unpolluted to lightly polluted, which means that the quality of sediment in Nambo Beach is still categorized as unpolluted by heavy metals copper (Cu), lead (Pb) and Cadmium (Cd). The size of sediment grains scattered at the study site in the form of fine sand (1/8-1/4 mm), very fine sand (1/16-1/8 mm), silt (1/265-1/16 mm), and clay (<1/256 mm) which is dominated by very fine sand sediment types. This is due to the flow of the river that flows directly to the beach so that the sediment on Nambo Beach is smoother.

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