International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

https://ijpsat.org/
Vol. 57 No. 2 June 2026, pp. 911-916

Assessment of Pollution Status of Sediments in Teluk Awur Beach, Jepara Regency, Indonesia

[1,2]Prastyo Abi Widyananto, [2]Stefanie Jessica Henny Larasati

[1]Faculty of Fisheries and Marine Science
Study Program of Fisheries and Marine Technology and Business, Faculty of Fisheries and Marine Science, Diponegoro University, Semarang, Indonesia
[2]Faculty of Fisheries and Marine Science
Department of Marine Science, Faculty of Fisheries and Marine Science, Diponegoro University, Semarang, Indonesia

*Corresponding Author : Prastyo Abi Widyananto, Widyananto.abi@gmail.com

Abstract— Teluk Awur Beach, Jepara Regency, Indonesia, a strategic coastal zone experiencing high-intensity coastal activisty such as aquaculture and tourism activities. This study aim to evaluated the contamination status and potential sources of cobalt (Co) and aluminum (Al) in the surface sediments along the Teluk Awur Beach. Surface sediment samples were collected from three purposive stations (TA1, TA2, and TA3) characterizing the dynamic, semi-enclosed bay morphology. Trace metal concentrations were quantified using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) following acid wet digestion. The analysis revealed a distinct polarization between the elements; Co concentrations systematically decreased from West to East, peaking at station TA1 (1.6443 mg/L), whereas Al displayed an opposite trend, reaching its maximum at station TA3 (6.4584 mg/L). The contamination factors (CF) verified that the entire area falls under a low contamination status (CF < 1). Nevertheless, a distinct anthropogenic footprint was identified at station TA1, where CF Co (0.087) was threefold higher than at TA3 (0.029), driven by proximity to western jetty activity and adjacent landward aquaculture networks. Longshore currents and bay dynamics effectively disperse of Al concentration to eastward, allowing natural lithogenic sedimentation to dominate the coastal geofacies at TA3.

Keywords— Aluminum, Cobalt, Contamination Factor, Coastal Sediment, Teluk Awur.

I. INTRODUCTION

Coastal areas are dynamic ecosystems that serve as the ultimate accumulation zones for various materials originating from both natural processes and human activities on land [1]. Jepara Regency, located on the northern coast of Central Java, holds strategic economic and ecological value. This area is characterized by high-intensity human activities, including capture fisheries, aquaculture ponds, maritime transportation, and settlements[2]. These activities have the potential to generate waste containing pollutants, such as heavy metals, which are transported via river basins to coastal waters and eventually accumulate in sediments.[3]

Surface sediments in coastal areas serve as reservoirs for heavy metals because of their ability to bind particles through adsorption and deposition. Unlike the dynamic water column, sediments are more stable and can store traces of pollution over the long term [4]. Among geochemical elements, cobalt (Co) and aluminum (Al) are of particular interest. Cobalt is a transition metal that is essential in small amounts but can become toxic to marine biota if its concentration exceeds the safe limit. Co inputs to

International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

https://ijpsat.org/
Vol. 57 No. 2 June 2026, pp. 911-916

coastal regions are typically associated with industrial waste, agricultural runoff, and fuel combustion residues[5]. Conversely, aluminum is one of the primary elements forming the Earth's crust (lithogenic tracer), and its presence in sediments often reflects natural rock weathering processes, although certain industrial activities can increase its concentration [6]

Although numerous studies on heavy metals have been conducted along the northern coast of Java, research specifically integrating the combination of Co and Al metals in the Jepara Regency coastal area remains very limited. Most previous studies have tended to focus on classical industrial marker metals such as lead (Pb), cadmium (Cd), or copper (Cu). In fact, monitoring Co is important in line with increasing anthropogenic activities in the area, while Al is necessary as a fundamental geochemical comparator for local sediments. Therefore, this study aims to analyze the concentrations of cobalt (Co) and aluminum (Al) in surface sediments at Teluk Awur Beach. The results of this research are expected to provide accurate baseline environmental geochemical data and serve as a reference for policymakers in efforts to sustainably manage and restore coastal ecosystems in Jepara Regency.

II. RESEARCH METHODS

A. Site Location

A survey for field sampling was conducted at Teluk Awur beach, situated in Jepara Regency, in December 2025. This location was selected because of its unique coastal characteristics and ecological significance, which provide valuable insights into regional marine and environmental conditions. This area is characterized by a dynamic semi-enclosed bay morphology that experiences distinctive seasonal monsoonal influences that strongly govern its hydrodynamic patterns, sediment transport, and depositional characteristics [7]. The area supports a complex gradient of anthropogenic activities, ranging from traditional aquaculture (shrimp and milkfish ponds) and high-density artisanal fishing ports to thriving coastal ecotourism and proximity to urban-industrial runoff from the Jepara region[8].

Figure 1. Sampling plot location around coastal area of Teluk Awur Beach, Central Java, Indonesia.

B. Field Sampling and collection sample

Site location was determined using purposive sampling methods and divided into 3 stations (TA1, TA2, TA3) at the coastal area (Fig.1). At each station, surface sediment samples (0–5 cm depth) were collected during low tide using a stainless-steel shovel to prevent cross-contamination. To ensure representative mapping, composite samples were obtained by mixing three subsamples randomly taken within a 5-meter radius at each designated station. Immediately after collection, the upper layer of the sediment was carefully transferred into clean, airtight polyethylene zip-lock bags. The bags were labeled, stored in a cool box filled with ice packs at approximately 4°C during transit, and subsequently transported to the laboratory. [9]

C. Laboratory Analysis

In the laboratory, the procedure advances with an essential preparation phase prior to analyzing the Co and Al content. Initially, the sediment sample is dried in an oven set between 60–80°C until it reaches a stable weight. This is followed by grinding and sieving to achieve a uniform sample[10]. The dry, homogeneous sample is then subjected to wet digestion, where a specific amount of sediment is dissolved in a strong acid mixture [11]. This process extracts the total Co and Al content from the sediment matrix into the solution. The metal concentration in the resulting solution is then determined using high-precision instruments like Inductively Coupled Plasma-Mass Spectrometry (ICP-MS), with the final results expressed in parts per million (mg/L) [12].

D. Contamination Factor

The Contamination Factor (CF) is a vital geochemical index used to quantify the degree of enrichment and anthropogenic influx of single trace elements in surface sediments relative to their natural baseline concentrations[13]. In this study, the (CF) values for cobalt (Co) and aluminum (Al) were determined by calculating the ratio of each metal's concentration in the coastal sediment samples to its respective pre-industrial background value. While aluminum typically serves as a conservative lithogenic tracer representing natural crustal weathering, cobalt concentrations are highly susceptible to fluctuations induced by coastal industrialization, port activities, and terrestrial runoff. The CF was calculated using Equation 1. It becomes possible to establish whether the presence of these metals is predominantly governed by natural geological processes (CF < 1) or if there is a distinct signal of anthropogenic accumulation (CF >= 1) within the dynamic coastal system of Teluk Awur. Selecting the background value Cbackground is essential; it typically involves using the average continental crust value, like 20 ppm for Ni as per Turekian and Wedepohl[14].

$$\boldsymbol{CF = \frac{C_{sample}}{C_{background}}} \quad \textbf{(1)}$$

Where :

EF : Contamination Factor

C_{sample} : metal concentration in sample

$C_{background}$: reference concentration in background

III. RESULT AND DISCUSSION

The diverse concentrations of trace elements in the surface sediments at Teluk Awur beach revealed a contrasting pattern between cobalt (Co) and aluminum (Al), highlighting distinct source characteristics at different sampling stations. Co concentrations show a marked decrease from West to East, with the highest level at station TA1 (1.6443 mg/L) and a systematic

International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

https://ijpsat.org/
Vol. 57 No. 2 June 2026, pp. 911-916

reduction to 0.7199 (mg/L) at TA2 and 0.5467 (mg/L) at TA3. In contrast, Al exhibited an opposite distribution, with its lowest concentration at TA1 (4.8683 mg/L) and reaching its peak at TA3 (6.4584 mg/L). This pronounced spatial divergence suggests that while Al abundance is mainly controlled by natural hydrodynamic sorting and the deposition of fine-grained terrigenous aluminosilicate minerals towards the eastern curved bay, Co distribution is significantly affected by localized point-source inputs on the western edge of the study area.

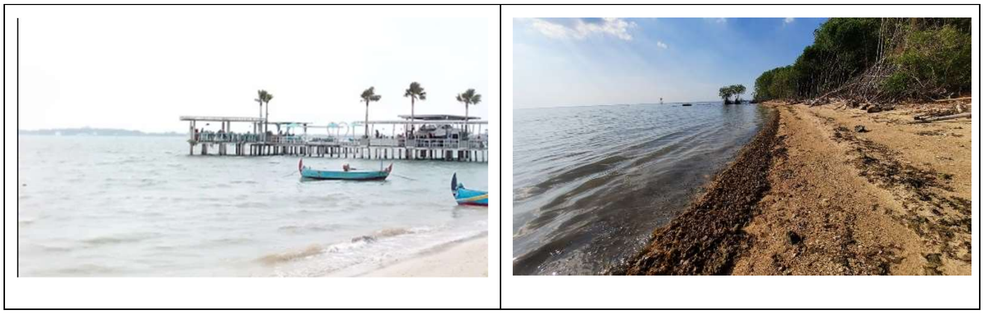

Figure 2. Near station TA 3 (left) and near station TA 1 (right).

Table 1. Concentration of Cobalt (Co) and Aluminum (Al) in each sampling points.

Station	Co (mg/L)	Al (mg/L)
TA 1	1,6443	4,8683
TA 2	0,7199	5,8252
TA 3	0,5467	6,4584
Reference[a]	19[a]	80[a]

[a]Reference : Turekian and Wedepohl (1961).

Table 2. Contamination factor (CF) in the sediment sample.

Station	CF Co	CF Al
TA 1	0,087	0,061
TA 2	0,038	0,073
TA 3	0,029	0,081

The geochemical polarization is further supported by the calculated Contamination Factors (CF), which assess anthropogenic enrichment against the pre-industrial baseline references of Turekian and Wedepohl . the CF values for both elements at all stations remain strictly below 1 (CF < 1), classifying the beach as having "low contamination." However, a more detailed

International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

https://ijpsat.org/
Vol. 57 No. 2 June 2026, pp. 911-916

diagnostic comparison reveals thatCF Co reaches its highest point at TA1 (0.087), which is three times greater than its lowest value at TA3 (0.029). In contrast, CF Al gradually increases from 0.061 at TA1 to 0.081 at TA3. As Al is a highly stable lithogenic tracer, its baseline-hugging CF trend reflects normal crustal weathering [15]. The disproportionate rise of CF Co at station TA1, despite being below the hazardous threshold, Co indicates a clear signal of modern localized trace element accumulation over the natural background. [16]

By integrating these geochemical matrices, a clear connection emerges between the high Co levels and nearby pollution sources. Station TA1 is located directly next to a prominent jetty/maritime infrastructure on the far west of the coast, where intensified boat docking, anti-fouling paint leaching, and localized artisanal fishing port emissions occur [17]. Additionally, the landward area directly behind TA1 and TA2 contains extensive aquaculture pond networks that discharge effluents directly towards the western beach sector. As the longshore currents and semi-enclosed bay dynamics of Teluk Awur could dilute and disperse these land-based discharges [18] moving eastward towards the relatively open and rural sandy stretch of TA3, the anthropogenic signature of Co diminishes, allowing natural lithogenic sedimentation (Al) to dominate the geofacies[19].

IV. CONCLUSION

This study demonstrates an understanding between cobalt (Co) and aluminum (Al) in the surface sediments of Teluk Awur beach, reflecting distinct governing mechanisms where Al distribution is driven by natural hydrodynamic sorting of terrigenous minerals toward the eastern bay, whereas Co is heavily dictated by localized anthropogenic activities on the western coast. Although the calculated Contamination Factors (CF) across all stations remain strictly below 1, classifying the entire area under a baseline-hugging "low contamination" status.

REFERENCE

[1] M. Postacchini and A. Romano, “Dynamics of the Coastal Zone,” JMSE, vol. 7, no. 12, p. 451, Dec. 2019, doi: 10.3390/jmse7120451.

[2] S. I. Wahyudi and H. P. Adi, “Evaluating Environment, Erosion and Sedimentation Aspects in Coastal Area to Determine Priority Handling (A Case Study in Jepara Regency, northern Central Java, Indonesia),” IOP Conf. Ser.: Earth Environ. Sci., vol. 140, no. 1, p. 012042, Apr. 2018, doi: 10.1088/1755-1315/140/1/012042.

[3] R. Liu, “The pollution and the ecological influence of chemical and industrial waste.,” JSTECEP, vol. 1, no. 6, Nov. 2024, doi: 10.61173/yjpa5f64.

[4] M. El-Sharkawy, M. O. Alotaibi, J. Li, D. Du, and E. Mahmoud, “Heavy Metal Pollution in Coastal Environments: Ecological Implications and Management Strategies: A Review,” Sustainability, vol. 17, no. 2, p. 701, Jan. 2025, doi: 10.3390/su17020701.

[5] K. S. Saili, A. S. Cardwell, and W. A. Stubblefield, “Chronic Toxicity of Cobalt to Marine Organisms: Application of a Species Sensitivity Distribution Approach to Develop International Water Quality Standards.,” Enviro Toxic and Chemistry, vol. 40, no. 5, pp. 1405–1418, Jan. 2021, doi: 10.1002/etc.4993.

[6] A. W. Apblett, “Aluminum: Inorganic ChemistryUpdate based on the original article by Allen W. Apblett,Encyclopedia of Inorganic ChemistrySecond Edition, © 2005, John Wiley & Sons, Ltd.,” Encyclopedia of Inorganic and Bioinorganic Chemistry, Dec. 2012, doi: 10.1002/9781119951438.eibc0007.pub2.

[7] R. Ruswahyuni, “Populasi dan Keanekaragaman Hewan Makrobenthos Pada Perairan Tertutup dan Terbuka Di Teluk Awur, Jepara
<i>[Macro Benthic Animal Population and Biodiversity In Closed And Open Waters In The Awur Bay, Jepara]<I>,” JIPK, vol. 2, no. 1, pp. 11–20, Apr. 2010, doi: 10.20473/jipk.v2i1.11676.

[8] D. A. Deviana, F. Purwanti, and S. Rudiyanti, "ANALISIS KESESUAIAN WISATA PANTAI TELUK AWUR DI KABUPATEN JEPARA JAWA TENGAH Suitability Analysis of Teluk Awur Beach Tourism in Jepara Regency of Central Java," Manage. Aqua. Resourc.J, vol. 8, no. 2, pp. 93–101, July 2019, doi: 10.14710/marj.v8i2.24232.

[9] C. F. Moffat, L. Webster, P. Pollard, A. S. Ahmed, M. Russell, and I. M. Davies, "Sampling Sediments in the Marine Environment," Encyclopedia of Statistics in Quality and Reliability, Dec. 2007, doi: 10.1002/9780470061572.eqr319.

[10] U. Bastakoti, J. Robertson, C. Bourgeois, C. Marchand, and A. C. Alfaro, "Temporal variations of trace metals and a metalloid in temperate estuarine mangrove sediments.," Environ Monit Assess, vol. 191, no. 12, p. 780, Nov. 2019, doi: 10.1007/s10661-019-7916-z.

[11] K. Analuddin et al., "The carrying capacity of estuarine mangroves in maintaining the coastal urban environmental health of Southeast Sulawesi, Indonesia," Egyptian Journal of Aquatic Research, vol. 49, no. 3, pp. 327–338, Mar. 2023, doi: 10.1016/j.ejar.2023.03.002.

[12] A. Eskdale, A. Gough, and S. Johnson, "The applicability of stream sediment geochemistry as a combined geological mapping, and prospective exploration tool for As-Co-Cu-Ni mineralisation.," May 2023, doi: 10.5194/egusphere-egu23-13447.

[13] N. Nawrot, E. Wojciechowska, M. Mohsin, S. Kuittinen, A. Pappinen, and S. Rezania, "Trace Metal Contamination of Bottom Sediments: A Review of Assessment Measures and Geochemical Background Determination Methods," Minerals, vol. 11, no. 8, p. 872, Aug. 2021, doi: 10.3390/min11080872.

[14] K. K. Turekian and K. H. Wedepohl, "Distribution of the Elements in Some Major Units of the Earth's Crust," Geol Soc America Bull, vol. 72, no. 2, p. 175, Jan. 1961, doi: 10.1130/0016-7606(1961)72[175:doteis]2.0.co;2.

[15] M. L. Rodriguez-Blanco, M. M. Taboada-Castro, and M. T. Taboada-Castro, "Geochemical phases of aluminum in the river sediments as indicators of its environmental availability," IOP Conf. Ser.: Earth Environ. Sci., vol. 362, no. 1, p. 012104, Nov. 2019, doi: 10.1088/1755-1315/362/1/012104.

[16] Y. Lv et al., "The Impact of Cobalt Species on the Hazardous Characteristics of Cobalt-Leaching Residue: A Case Study from Guangdong Province, China," Water, vol. 16, no. 20, p. 2953, Oct. 2024, doi: 10.3390/w16202953.

[17] M. A. Saito, "The biogeochemistry of cobalt in the Sargasso Sea," Massachusetts Institute Of Technology Woods Hole Oceanographic Institution, Jan. 2001. doi: 10.1575/1912/3041.

[18] K. Ondara and S. Husrin, "CHARACTERISTICS OF BREAKING WAVES AND ANALYSIS OF SEDIMENT TRANSPORT IN TELUK KENDARI," J. Ilmu dan Teknologi Kelautan Tropis, vol. 9, no. 2, pp. 585–596, Jan. 2018, doi: 10.29244/jitkt.v9i2.19293.

[19] J. Morillo, J. Usero, and I. Gracia, "Study of Fractionation and Potential Mobility of Metal from the Guadalquivir Estuary: Changes in Mobility with Time and Influence of the Aznalcollar Mining Spill," Environmental Management, vol. 36, no. 1, pp. 162–172, June 2005, doi: 10.1007/s00267-004-0216-5.