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The Management of Pusong Reservoir, Lhokseumawe City, Based on the Suspended Sediment Discharge

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Abstract

The city of Lhokseumawe often experiences flooding or stagnant rainwater. The Pusong Reservoir that was built could have been ineffective in overcoming the flooding problem due to siltation in the reservoir. Therefore, this study aims to review and recommend the management of the Pusong Reservoir based on suspended sediment discharge which is expected to overcome the silting problem of the reservoir. The sampling method was carried out by determining the stations for sampling based on the environmental baseline in determining the six reservation stations. Samples were analyzed for suspended sediment concentration, turbidity, and incoming sediment discharge. Analysis of suspended sediment concentrations ranged from 9.3 - 50.0 ppm, turbidity ranged from 2.17 - 14.42 NTU, and the incoming suspended sediment discharge was 0.00 - 6946.56 kg/day. Based on the analysis of suspended sediment discharge that enters the reservoir, it is necessary to control sediment transport to prevent siltation does not occur in the Pusong Reservoir. The management of the sediment transport control includes sediment traps, vegetative systems, and Spoil Bank Resulting from Sediment Dredging.

Keywords: Suspended Sediment, Management, Pusong Reservoir, Turbidity.

INTRODUCTION

Identifying the dominant areas in sedimentation and erosion is critical for analysis; this aims to provide information for reservoir management (Miranda et al., 2021). The most common problems associated with sedimentation are loss of storage volume, abrasion of hydraulic machines, clogging of outlets, and even damage to dams (Maavara et al., 2020). The reduced storage capacity of reservoirs has become a worldwide problem. The reduction in reservoir capacity is faster than that of the United States. In Taiwan, naturally, high erosion rates have resulted in rapid reservoir sedimentation, urging researchers to deal more quickly with reduced reservoir capacity and function (Wang et al., 2018).

The Pusong Reservoir, located in Lhokseumawe City, has high salinity waters (salty). This reservoir, with a capacity of 850,000 m3, was built in 2010 and is located on the coast, bordering Pusong Lama Village in the east and Mon Geudong Village in the west. This reservoir was designed to assist with flood control in Lhokseumawe, but it has also been used as a tourist attraction and a fish farming area with floating net cages. There are also residential areas and traditional markets surrounding the reservoir; thus, the pool indirectly accommodates waste from people's activities in the nearby area (Ezraneti et al., 2021).

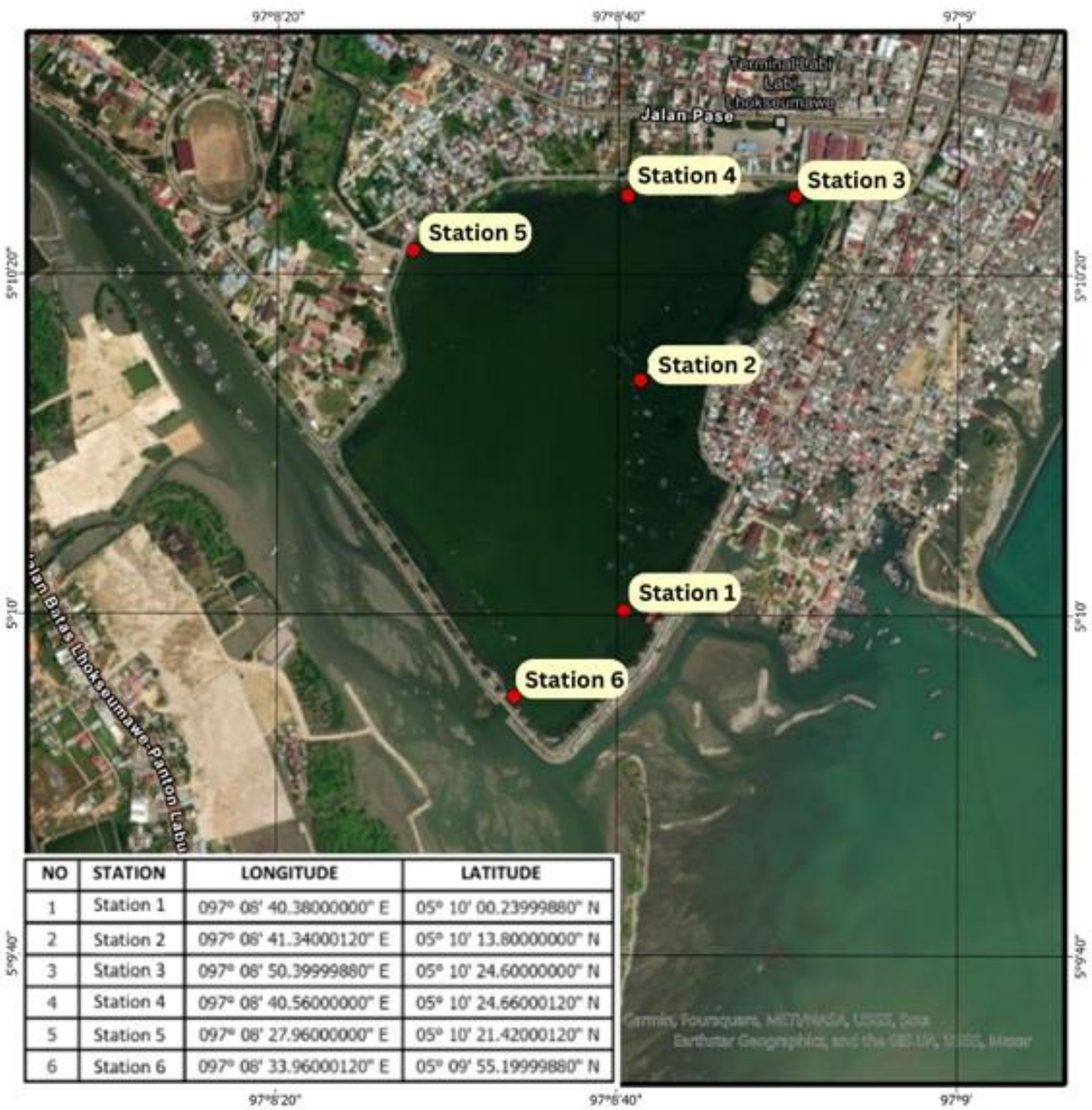
Water entering the Pusong Reservoir must be monitored for suspended sediment. Water flow that transports sediment will cause problems downstream, namely sedimentation. Sedimentation continuously depletes storage capacity and progressively reduces the reservoir's size to maintain its intended purpose.

Sedimentation also causes environmental impacts upstream and downstream of the pool. The reservoirs impacted by sedimentation will continue to lose their storage capacity. In some reservoirs, sediment deposits have disrupted the operation of dam outlets, water supply inlets, and boat ramps (Randle et al., 2021).

Based on the preceding, it is necessary to measure the concentration of suspended sediment, or total suspended solids (TSS), turbidity, and discharge of suspended sediments that enter the Pusong Reservoir, which is influenced by activities in the reservoir's vicinity, so that this information on sediment input into the Pusong Reservoir can be obtained.

RESEARCH METHODS

The study was conducted in May of 2022. It places at the Pusong Reservoir in the Banda Sakti District of Lhokseumawe, Aceh (Figure 1). The environmental baseline was used to determine six sampling and six observation stations. The discharge of water was measured using a River Surveyor M9 device. The River Surveyor M9 instrument was initially calibrated with a compass by swinging it like a wave and rotating it 360^0. The tool was then placed in the water in front of the sluice at each station by slowly pulling the rope back and forth.



NO	STATION	LONGITUDE	LATITUDE
1	Station 1	097° 08' 40.38000000" E	05° 10' 00.23999880" N
2	Station 2	097° 08' 41.34000120" E	05° 10' 13.80000000" N
3	Station 3	097° 08' 50.39999880" E	05° 10' 24.60000000" N
4	Station 4	097° 08' 40.56000000" E	05° 10' 24.66000120" N
5	Station 5	097° 08' 27.96000000" E	05° 10' 21.42000120" N
6	Station 6	097° 08' 33.96000120" E	05° 09' 55.19999880" N

Figure 1. Research map of the Pusong Reservoir in Lhokseumawe City

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A suspended sediment sampler was used to collect water samples. This study, 18 water samples were collected from 6 research stations and analyzed for Total Suspended Solid (TSS) using the spectrophotometric test method and turbidity using the turbidimetric test method. The measurement of suspended sediment discharge at each station is calculated using the formula below.

$$Qs = 0.001 \times Ct \times Q$$

Where:
Qs = Sediment discharge (Kg/dt)
Ct = Sediment Concertation (mg/L or ppm)
Q = Water Discharge (m^3/dt)

RESULTS AND DISCUSSION

Results of Suspended Sediment Research in the Pusong Reservoir

Station 1 was near tourist attractions and had several floating net cages. This station lacked a sluice gate to allow flow into the reservoir. At Station 2, there are floating net cells in the community and residential areas. Because there was no water gate into the pool at station 2, the water discharge into the reservoir was 0.000 m3/s. Station 2 had the lowest suspended sediment concentration of 9.33 ppm and turbidity of 2.28 NTU.

Aquaculture activities that release nutrients impact water quality in the aquatic environment (Kang et al., 2022). Station 3's entrance gate was adjacent to the bus station, fruit market, culinary tourism area, and mangrove trees. Station 4 had a cafe on the sluice's edge and several community-owned floating net cages. Station 5 was the sewage gate for Lhokseumawe City. A Temporary Waste Storage Site (TPS) was located to the right of the sluice. There were also schools and residential areas near this station. Inflow water at stations 3, 4, and 5 came from Lhokseumawe City wastewater and rainwater. At station 6, some entrances and exits were affected by tidal conditions. When the research was conducted, the state of the seawater was at high tide, so the seawater entered the reservoir through the sluice at Station 6.

Watergate at stations 3, 4, and 5 transported wastewater and rainwater. Based on the amount of rainfall on rainy days from May to December, it has continued to increase in the last five years (BMKG Aceh Besar Climatology Station, 2022). Therefore, the incoming water discharge in May at stations 3, 4, and 5 continues to increase until December. Rainfall plays a role in sediment transport. Raindrops also affect the movement of sediment in surface runoff, which is full of sediment. This can make the deposit move more efficiently, and the sediment particles can roll more easily (Zhang et al., 2018). The particles are released and transported during rainy conditions, and the sediment that settles in the Lhokseumawe City sewage moves downstream of the channel. Sediments that move with the flow will settle in the downstream part of the channel, the Pusong Reservoir.

Table 1. The results of suspended sediment research in the Pusong Reservoir

Station	Inflow Discharge (m3/s)	TSS (ppm)	Turbidity (NTU)	Sediment Discharge (kg/s)
Station 1	0	10.3	2.17	0.00
Station 2	0	9.3	2.38	0.00
Station 3	0.053	15.3	4.43	8.1×10^{-4}
Station 4	0.021	50	14.42	10.50×10^{-4}
Station 5	0.02	19.3	2.62	3.9×10^{-4}
Station 6	6.03	13.3	2.65	804×10^{-4}

Source: Research Results, 2022.

Management of Sediment Transport in the Pusong Reservoir

Three activities can be carried out to manage reservoir siltation, namely.

1. Reducing the load of sediment flowing into the reservoir,
2. Reducing the amount of sediment that will settle in the pool,
3. Dredging sediment deposits from the reservoir

Sediment Traps

The highest suspended sediment concentration value in the Pusong Reservoir was located at station 4, with a value of 50.0 ppm. At the time of the study, the weather conditions were not rainy, so the water discharge entering station 4 was relatively small at 0.021 m3/s, so the incoming suspended sediment discharge was 10.50 × 10^{-4} kg/s. The large flow discharge will impact the release of suspended sediment transported by the flow, which is also increasing in size (Ahmad et al., 2019; Hutari et al., 2018). In the Pusong Reservoir, the highest turbidity was at station 4. The station was affected by the wastewater flow of Lhokseumawe City at 14.42 NTU. However, stations 3 and 5 also have sluice gates affected by rainwater and sewage, which also require the management of sediment traps outside the reservoir. Sediment traps the reservoir upstream with a particular design, function as sediment traps of the upstream. Overall, the trapping of sediment from pools is a resource measure for controlling sediment deposition in reservoirs that are widely used throughout the world. This sediment trap is also effective when applied to the Xiluodu and Xiangjiabe reservoirs (Ren et al., 2021).

At station 6, some entrances and exits were affected by tides. The results sampling at high tide shows that water flow entered the reservoir to transport suspended sediments that settled in the pool. Based on the research by (Huguet et al., 2020), the application of external sediment traps located downstream of the port is very effective in reducing the rate of siltation in marine areas. This trap prevents sediment particles from the sea from entering the reservoir; therefore, it is necessary to have a sediment trap to reduce sediment input into the pool. This trap also serves as a surprise for sediment coming from the sea and needs regular monitoring and maintenance to continue being used efficiently. Therefore, trapping sediment outside the Pusong Reservoir at stations 3, 4, 5, and 6 is necessary. This aims to reduce sedimentation. These traps also function as a reservoir and control sediment flow.

Vegetative System in Lhokseumawe City

The most significant suspended sediment discharge in the Pusong Reservoir was at Station 6, which was 804 × 10^{-4} kg/s, with an inflow discharge of 6.03 m3/s, broken sediment concentration of 13.33 ppm, and turbidity of 2.65 NTU. According to Zhang et al. (2022). Research, the eroded seabed becomes a source of sediment that is transported and deposited in other areas. Syah (2020) says planting mangroves can prevent or reduce coastal abrasion. This method is being considered because it can save money and is more sustainable than dealing with the effects of reservoir sedimentation. By planting mangroves, Lhokseumawe City can engage in vegetative-based activities. Mangrove planting is required on the Pusong Reservoir's inside and outside edges and along the coast of Lhokseumawe City. Because the Anicennia sp mangrove was discovered at station 3, this type of mangrove can be planted on the reservoir's inner edge. Because Anicennia sp. and Rhizophora sp. have been found growing in that zone, the outer part of the reservoir facing the sea and the estuary on the reservoir's outside must be planted with those species.

High mangrove density will have an impact on low sedimentation rates. Meanwhile, low mangrove density will impact high sedimentation rates (Arifin et al., 2019; Erlangga et al., 2022). The function of mangrove roots is to trap and precipitate soil particles. Settled mud not be washed away by currents and waves (Arifin et al., 2019).

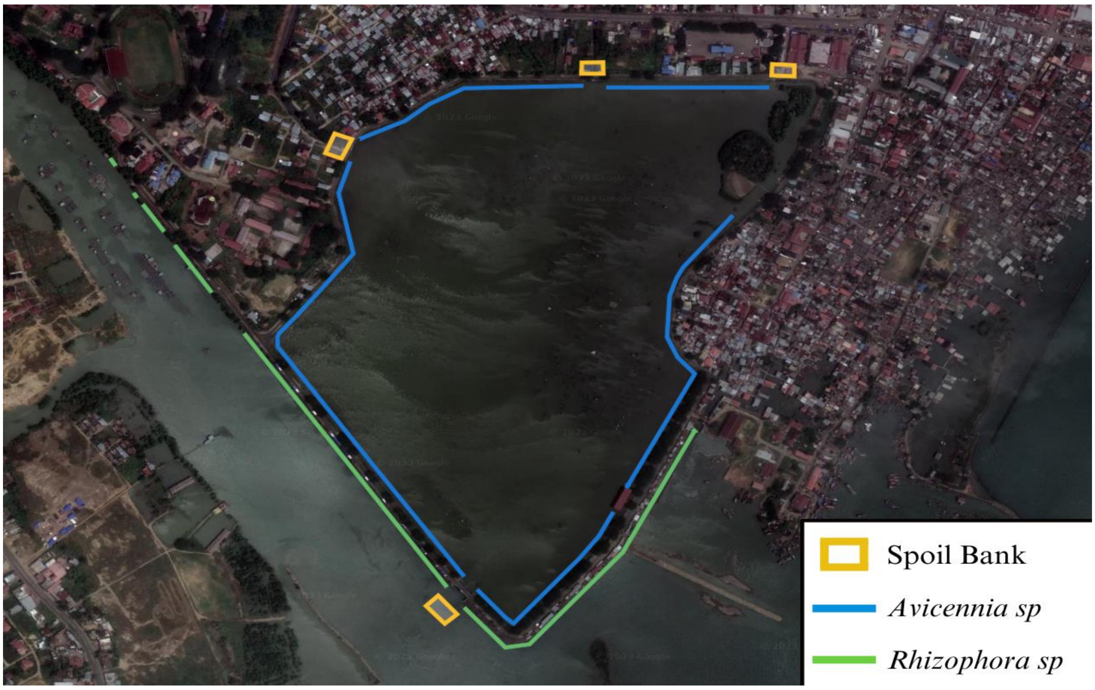

Fig 2. Management map of sediment traps and vegetative systems of the Pusong reservoir in Lhokseumawe City

Spoil Bank Resulted from Sediment Dredging

Dredging must be done regularly to keep the canals from becoming spots for precipitated sand (Duc et al., 2019; Ren et al., 2021). Reservoirs that experience siltation must be dredged using mechanical equipment. Dredging the sediment will directly remove the deposits in the pool (Ren et al., 2021). Sediment deposition in the reservoir needs to be dredged periodically to maintain the reservoir capacity that serves as a flood controller in Lhokseumawe City. Dredging (excavation) is carried out, especially in the reservoir's upstream part, where sediment accumulates. Sedimentation in the upstream region of the reservoir can result in sediment distribution to the entire reservoir surface, filling the pool with deposits. The reservoir dredging results will be placed in a spoil bank or storage area, which can be used as a landfill or for other purposes.

CONCLUSION

Analysis of suspended sediment concentrations ranged from 9.3 - 50.0 ppm, turbidity ranged from 2.17 - 14.42 NTU, and the incoming suspended sediment discharge was 0.00 - 804 × 10-4 kg/day.
Management of sediment transport control to prevent siltation in the Pusong Reservoir, namely sediment traps, dredged spill banks, and vegetative systems.

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