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Analysis of Sedimentation Rate In Peat Lakes : Case Study of Lake Teloko, South Sumatera

Dion Awfa[1], Cheisyha Alfiradina [2], Muhammad N. Hanif [3], M. Ridwan A. Aziz[4], Farhan B. Rozzan[5], Miftahul H. Genisia[6], Rifka N. Azizah[7*]

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***Abstract*— Teloko Lake in Ogan Komering Ilir, South Sumatra, is a peat swamp ecosystem revitalized through dredging to increase water storage capacity and reduce flood risk. This study analyzed post-revitalization sedimentation, assessed water quality, and identified suspended particle characteristics to support lake management. Objectives included determining the distribution of Total Suspended Solids (TSS), sedimentation rates, and relationship between particle properties and hydrological conditions to assess revitalization impact. Sampling was located at five locations at depths of 0.68 to 1.30 meters during dry season in September 2025. TSS concentrations ranged between 681 and 740 mg/L, with an average of 710.92 mg/L and a standard deviation of ±9.6%, indicating uniformity across locations and no significant dredging impact. A 72-hour sedimentation test showed a very low settling rate, with particles remaining suspended without forming a clear sediment layer. This is due to the dominance of colloidal particles less than 20 µm, containing positively charged organic matter, creating repulsive forces that inhibit natural sedimentation. The results confirm natural peat water properties and lake activities have a stronger influence on sedimentation than technical revitalization. These findings support long-term conservation by recommending ecological approaches, such as natural coagulants, to maintain water storage capacity and preserve ecosystem function.**

Keywords— Lake Teloko,Revitalization, Sedimentation, TSS, Colloids.Particles.

Corresponding Author: rifka.azizah@tl.itera.ac.id

I. INTRODUCTION

Water resource management in tropical regions faces serious challenges due to degradation of water quality and quantity. One major problem is lake sedimentation, which reduces storage capacity, degrades aquatic habitats, and disrupts ecosystem services such as flood control and water supply. Globally, sedimentation threatens the long-term functioning of inland waters, with capacity losses reaching 1–2% per year as land use change, deforestation, urbanization, and intensive agriculture accelerate soil erosion and sediment transport. Sediment is composed of rock fragments and organic material deposited through physical and chemical processes, and its rate of accumulation reflects the intensity of erosion and hydrological dynamics in the watershed. Sedimentation rate, defined as the mass of sediment deposited per unit area and time, depends on particle size, discharge, and flow characteristics, and serves as a technical indicator of lake siltation that guides management actions such as dredging and rehabilitation.

Tropical peat ecosystems are among the world's largest carbon stores. Indonesia has approximately 13.43 million hectares of peatlands that store more than 57 Gt of carbon, making them a global ecological asset [5]. Indonesia has numerous peat lakes that serve as carbon sinks, hydrological regulators, and biodiversity habitats. The unique nature of peat ecosystems, with their high organic content, makes them highly sensitive to hydrological changes and human activities. Land clearing, agriculture, and plantations increase erosion and carry organic sediment into water bodies, accelerating siltation. This situation necessitates management measures such as dredging to restore reservoir capacity and maintain water quality. However, the success of revitalization can only be demonstrated through direct monitoring of sediment parameters.

Sedimentation is the process of deposition and accumulation of solid particles (such as soil, mud, sand, or gravel) transported by a carrier medium (water, wind, or ice) when the carrier medium's velocity decreases, forming a layer of sediment. It is a significant issue in water resources management because it can reduce

Dion Awfa, Departement of Faculty of Technology Infrastucture and Region, Enviromental Engineering Study Program, Institution Teknologi Sumatera, Lampung, 36552, Indonesia. E-mail: dion.awfa@tl.itera.ac.id
Cheisyha Alfiradina, Departement of Faculty of Technology Infrastucture and Region, Enviromental Engineering Study Program, Institution Teknologi Sumatera, Lampung, 36552, Indonesia. E-mail: cheisyha.122250110@student.itera.ac.id
Muhammad Nashiruddin Hanif, Departement of Faculty of Technology Infrastucture and Region, Enviromental Engineering Study Program, Institution Teknologi Sumatera, Lampung, 36552, Indonesia. E-mail: nashiruddinhanif@gmail.com
M. Ridwan Al Aziz, Departement of Faculty of Technology Infrastucture and Region, Enviromental Engineering Study Program, Institution Teknologi Sumatera, Lampung, 36552, Indonesia. E-mail: muhammadridwanalaziz@gmail.com
Farhan Baroo Rozzan, Departement of Faculty of Technology Infrastucture and Region, Enviromental Engineering Study Program, Institution Teknologi Sumatera, Lampung, 36552, Indonesia. E-mail: farhanbaroo18@gmail.com
Miftahul Husna Genisia, Departement of Faculty of Technology Infrastucture and Region, Enviromental Engineering Study Program, Institution Teknologi Sumatera, Lampung, 36552, Indonesia. E-mail: miftahulgenisia@gmail.com
Rifka Noor Azizah, Departement of Faculty of Technology Infrastucture and Region, Enviromental Engineering Study Program, Institution Teknologi Sumatera, Lampung, 36552, Indonesia. E-mail: rifka.azizah@tl.itera.ac.id

storage capacity, worsen water quality, and threaten the balance of aquatic ecosystems. The sedimentation rate is influenced by hydrological conditions, particle size and properties, and land use in the catchment area. Therefore, measuring the sedimentation rate and Total Suspended Solids (TSS) concentration are key indicators for assessing sediment dynamics and assessing the effectiveness of lake rehabilitation efforts.

Resuspension is a phenomenon in which particles float again after sedimentation/suspension. Resuspension usually occurs in biotic and abiotic solids that accumulate at the bottom of water bodies and interact with each other. Resuspension can occur due to several external factors (fluid currents, bioturbation, and living organism activity) and internal factors (particle interaction, water intrusion, and physical and chemical processes of particles against fluids). The movement of resuspended particles cannot occur on its own; internal and external factors are what cause this to happen [29].

Resuspension often occurs in moving water bodies due to particle turbulence, which causes particles to move from their original positions. The effect of resuspension is the lifting of all solids affected by fluid movement. Resuspension rarely occurs in static waters such as lakes, due to the minimal potential for changes in flow direction in lakes. However, lakes with specific fluid characteristics, such as peat lakes, can cause natural resuspension due to the influence of organic content [30].

Tropical peat ecosystems are among the world's largest carbon stores. Indonesia has approximately 13.43 million hectares of peatlands that store more than 57 Gt of carbon, making them a global ecological asset [5]. Peat is formed from the accumulation of organic matter in anaerobic conditions and waterlogged for thousands of years. Indonesia holds about 36% of the world's tropical peat, with the largest areas located in Sumatra and Kalimantan.

Lake Teloko in Ogan Komering Ilir Regency, South Sumatra, is a prime example of a peat lake facing these pressures. This lake

plays a crucial role as a carbon store and water regulator, but receives input of organic sediment from surrounding peatlands and plantations. To reduce the risk of flooding and siltation, the government is revitalizing the lake by dredging the lakebed. This technical measure is expected to reduce sedimentation, but its impact on suspended particle dynamics and sedimentation rates remains.

One method widely used to understand sediment characteristics is the settling column test. This test simulates sedimentation conditions in a static water column to determine settling velocity, initial consolidation, and water quality after particles settle. Data from the settling column test is useful in designing sediment storage capacity, predicting dredging requirements, and evaluating the efficiency of sediment traps or settling ponds [28].

This study was designed to assess the impact of Lake Teloko revitalization by measuring sedimentation rates at five observation points. Analysis included turbidity levels, TSS concentrations, sedimentation rates, and the types and characteristics of suspended particles that influence the sedimentation process. By linking the physical conditions of the waters with the revitalization results, this study is expected to provide a scientific basis for more effective peat lake management, while also offering recommendations such as the use of natural coagulants to maintain storage capacity and ecosystem function.

II. METHOD

2.1. Determination of Sampling Points

The sampling locations were at five points on Lake Teloko that had undergone revitalization. The sampling points were determined based on the period of work, so that sampling at point 1 was the first period of revitalization or excavation work. At point 2, the location is further from the mainland than point 1. Point 2 is 65 meters from the edge of the lake, which is located to the west. At Point 2, the nearest land use is a peatland oil palm plantation, similar to Point 1. At point 3, the lake shore area is the same as point 2, where there is no soft soil area, but rather compact soil. The depth at point 3 is lower than the previous point, at 1.04 meters. Point 4 is located 275 meters from the eastern shore of the lake, almost the same as point 3.

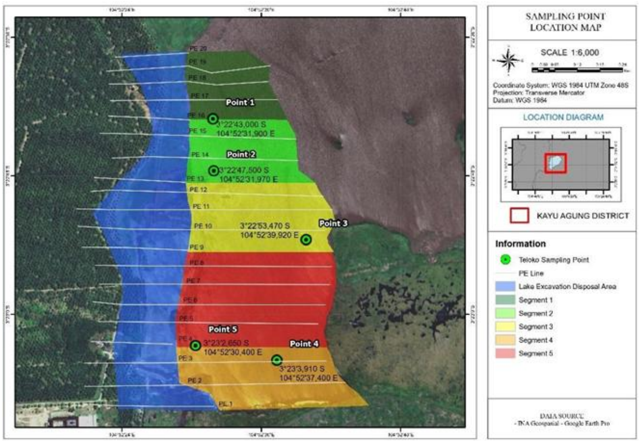

Figure 1. Sampling Point Location Map.

Point 4 has the same land use as point 3, namely wild grass and tall reeds. Point 4 has the lowest depth, which is 0.68 meters, Point 5 is a busy location for excavator traffic because it lies on the disposal route, about 58 m east of the lake. Its land use is similar to Points 1 and 2 (oil palm plantations) but lies 30–50 m from the compact disposal area. The site contains a wide soft-soil zone extending 5–10 m from the shoreline, with a depth of 1.2.

2.2. Data Collection

The research was conducted in September 2025 at Teloko Lake, with sampling carried out between 9:00 and 11:00 a.m. Samples were collected using the grab sampling method following SNI 6989.57:2008 (Surface Water Sampling Method) and the APHA Standard Methods 1060 B (APHA, 2017) guidelines. In this method, water is taken directly

and instantly from the lake using a clean container to capture the actual physical conditions at the time of collection, minimizing changes that might occur during storage or transport. The study employed a grab sampling method, where water samples were collected directly from the lake at each designated point at a specific moment in time. This method allows for an immediate representation of the water quality and depth at the sampling points. Each sample was carefully collected using clean containers and handled according to standard procedures to avoid contamination and ensure reliable results.

The horizontal water sampler is used by first opening the caps on both sides of the device. The device is then placed in the lake water to a certain depth. The horizontal water sampler used is a horizontal point sampling device that complies with SNI 6989 67 2008 concerning Surface Water Sampling.

(1). Velocity Analysis

The flow velocity measurement method uses a current meter. The use of a current meter in flow velocity testing is in accordance with SNI 8066:2015 on Procedures for Measuring River and Open Channel Flow Rates Using Flow Meters and Floats. The method of measuring water flow velocity using a current meter is a technique commonly used in hydrology and environmental engineering to measure flow velocity in rivers, lakes, or waterways. The measurement procedure using the current meter method is as follows Determine the water depth at the measurement location and select several depth points to measure the flow velocity. After the depth is determined, submerge the current meter's turbine into the water at the designated measurement point. Measurement results are displayed in meters per second (m/s) via an automatic speed counter connected to the sensor on the device.

(2) Depth of Sampling Point

The method of measuring the depth of the sampling point is done manually. This method is carried out by lowering an anchor or weight from the boat to the bottom of the lake, then measuring the length of the rope or chain submerged in the water. The measurement steps are as follows the prepare a weight that can be attached to the end of the Prepare a weight that can be attached to the end of the rope; in this case, a Horizontal Water Sampler is used. Then lower it slowly into the water until it reaches the bottom of the lake; ensure that the rope remains straight and does not tilt. Next, lift the weight back up and measure the length of the rope from the marked point to the end of the weight using a measuring tape, thereby obtaining the depth of the sampling point.

(3) Set Up Reactor

After water samples were collected from the lake, laboratory experiments were conducted using a reactor to analyze sedimentation characteristics. Each reactor was a transparent container with a known volume, filled with water samples from the corresponding sampling point. The setup procedure was as follows (a). Preparation of Reactor is like the reactor container was cleaned thoroughly. The volume of water added to the reactor was recorded. (b). Sample introduction, (c). Experimental Conditions, (d) Sedimentation Observation, (e). Data Collection, after the experiment, the sediment volume and water clarity were noted for further analysis.

2.3 Analytical Method

Total Suspended Solids (TSS) were measured following the Indonesian National Standard (SNI) 06-6989.3-2004, which describes the gravimetric method. In this method, distilled water was first filtered through Whatman Glass Microfiber GF/C 47 mm filter paper using a vacuum pump, ensuring complete removal of water. The filter paper was dried in an oven at 103–105°C for 1 hour, cooled in a desiccator, and weighed to obtain the initial weight. A 50 mL water sample was then filtered using the pre-weighed filter paper. The filter paper containing the sample residue was dried again at 103–105°C for 1 hour, cooled in a desiccator, and weighed to determine the final weight.

$$TSS\ (mg/l) = (A - B)\ x\ 1000/L \tag{1}$$

where A is the weight of filter paper plus residue, B is the weight of the filter paper alone and L is the sample volume.

The method for measuring water turbidity using a turbidity meter refers to ISO Standard 7027-1, which specifies the method for measuring turbidity using the principle of light scattering (nephelometric). ISO Standard 7027-1 emphasizes the importance of device stability and calibration accuracy to ensure consistent measurement results.

2.4 Column Test

The Sedimentation Rate Test, also known as the Column Test, aims to determine the rate at which suspended particles settle in a liquid. In conducting the column test, a measuring glass is used to fill the sample water and observe the settling process. The procedure for conducting the column test is described as follows (a).

Prepare five 1-liter measuring cups, corresponding to the number of samples to be tested, (b).Homogenize the samples thoroughly to ensure even distribution of suspended particles, then pour each sample into the measuring cups, (c) Record the pouring time as t0, which serves as the starting point of the test, (d) Observe at specific time intervals to note visual changes in the sample, particularly in the sediment layer, turbid layer, and clear layer that form, (e) Record the height of the sediment layer at each time interval to calculate the sedimentation rate of suspended particles.

2.5 Descriptive Analysis

The purpose of this descriptive analysis is to provide a summary of the data, including the mean, standard deviation, minimum and maximum values, and the distribution pattern of the data. The data is explain by the histogram.

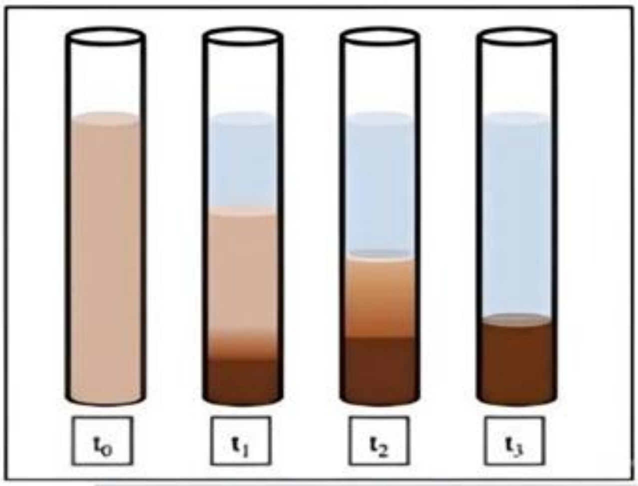

Figure 2. Turbid Phase Column Test Sedimentation Over Time

III. RESULTS AND DISCUSSION

3.1 Characteristics of Lake Teloko

Lake Teloko has a flow velocity of 0 m/s, so sediment within it does not move from one point to another. With a depth ranging from 0.6 to 1.3 meters, the revitalized Lake Teloko is classified as a shallow lake. Generally, sedimentation rates in deeper lakes tend to be higher because low turbulence allows sediment to settle more efficiently. Meanwhile, in shallow lakes, sediment particles are more easily resuspended due to wind or water movement, resulting in lower sediment accumulation rates compared to deeper lakes with more stable sedimentation [8]. However, since Lake Teloko revitalization does not have flow velocity, sediment deposition in this lake depends solely on the characteristics of the sediment particles themselves, such as their size and density. Figure 3. Flow Velocity of Lake Teloko.

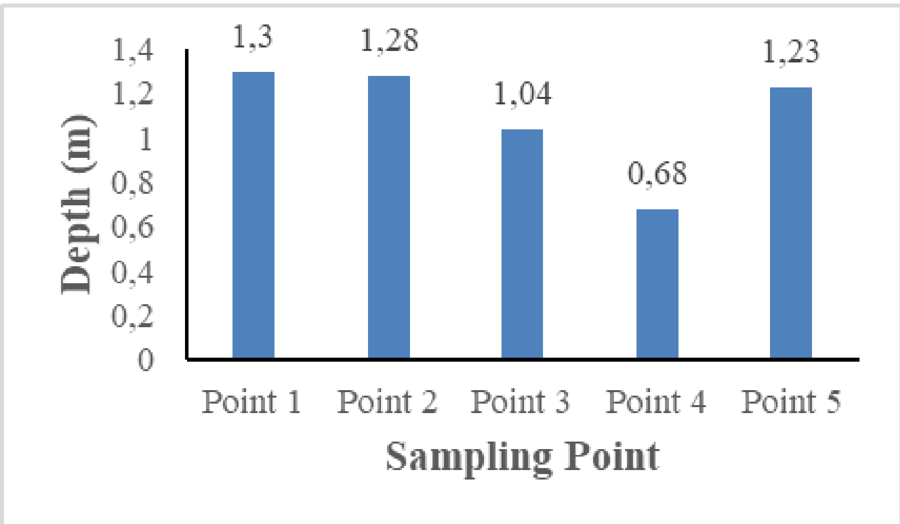

Figure 4. Depth of Lake Teloko

3.2 Water Quality of Lake Teloko

Based on the TSS graph data, the standard deviation value of 681.7 indicates that the TSS variation is only 9.6% of the average value, which is 710.92, which is below 10%. This shows that the distribution of TSS in Lake Teloko is relatively stable and is not affected by ongoing dredging activities. With the absence of water flow, factors that could potentially alter TSS distribution, such as resuspension due to currents or physical activities, are virtually nonexistent. This stability of TSS reflects that the suspended components in the lake water are primarily influenced by internal factors such as natural sedimentation and particle structure, rather than external activities. This relatively constant TSS also indicates that the lake is in a state of calm water, where the deposition of suspended particles occurs more stably and is not influenced by the dynamics of lake water [10]. Measurement results showed TSS concentrations at five.

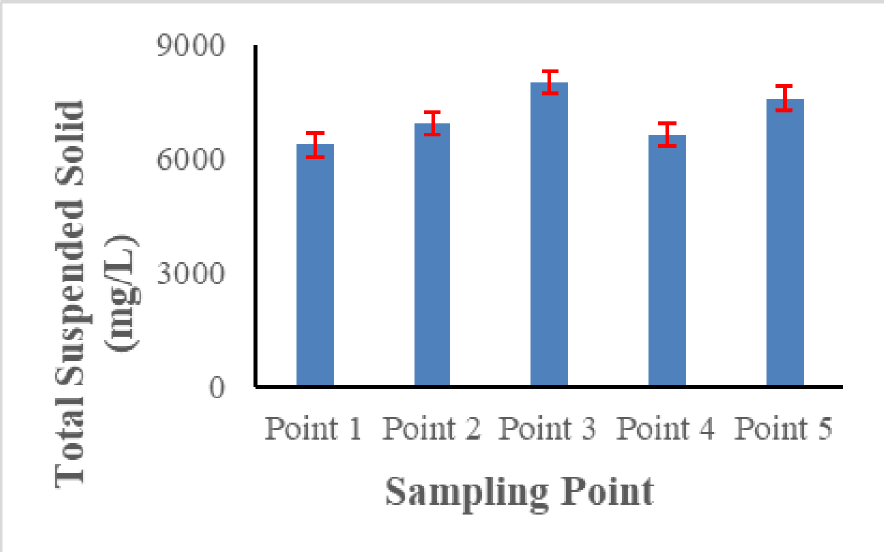

Figure 5. TSS levels in Lake Teloko

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The sampling points ranged from 6,368 to 8,014 mg/L. The highest values were found at Point 3 (8,014 mg/L) and Point 5 (7,594 mg/L), which are adjacent to the discharge route and excavator activity, while the lowest value was recorded at Point 1 (6,368 mg/L). This pattern indicates greater sediment disturbance in areas with intensive revitalization activities, requiring special monitoring and control to maintain water quality and the lake's capacity.

This is partly because rising temperatures can increas lake productivity through the indirect mobilization of nutrient dynamics. For example, higher water temperatures can accelerate the rate of organic matter decomposition in lakes which in turn supports higher primary productivity [15]. At temperatures that are too high, flocs tend to break apart easily, thereby, inhibiting the sedimentation rate. The maximum sedimentation rate is generally achieved at temperatures between 5 and 15°C, increasing up to 20°C, then decreasing sharply at temperatures of 25°C or higher [23].

3.3 Sedimentation Disposition Rate

The rate of sediment deposition in Lake Teloko in this experiment is expected to form a clear separation between the clear phase and the turbid phase within a certain period of time, which is influenced by gravitational force. In the sedimentation column test process, sediment particles undergo phase separation in a container or tube without any inflow or outflow, so that gravitational force works optimally to deposit solid particles to the bottom [21].

In this experiment, it can be seen in the column test below that the sedimentation rate did not show a significant decrease over time, indicating that the components in the water could not settle by gravity in a short period of time. This is because Lake Teloko contains organic matter and is influenced by the size of the sediment particles. These factors certainly affect the natural sedimentation process at various levels.

One factor that affects the rate of sedimentation in water is particle size. Large, heavy particles settle faster, so they can be removed by collecting them in large tanks. Such particles require a coagulation process using chemical agents to increase particle size, thereby enhancing the sedimentation rate [19]. This is supported by Stokes' law, which states that larger particles or flocs settle faster than smaller particles, provided they have the same composition and density. However, when comparing flocs and non-porous solid particles of similar size, flocs experience lower resistance during settling because their pores contain water.

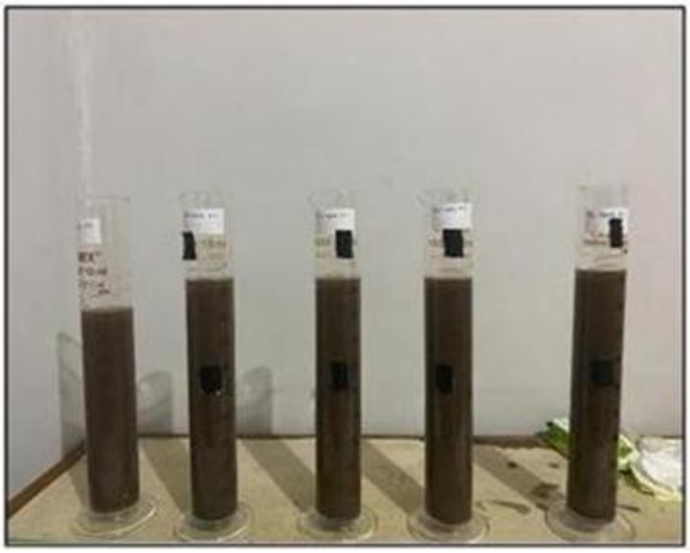

Figure 6. Column Test (Volume x Time)

Therefore, flocs tend to settle faster than solid particles of the same size [11]. Tan states that the sedimentation rate of pure clay flocs is much higher than that of lighter porous clay particles of similar size. Additionally, in fine particles that are initially dispersed, the settling velocity increases significantly in larger flocs [20]. The presence of organic matter also significantly impacts the sedimentation rate, as organic matter can alter buoyancy, viscosity, density, and other characteristics of water, which influence the sedimentation process.

The adsorption properties and surface chemical characteristics of sediment particles can also potentially accelerate or inhibit the sedimentation process [9]. Research by Zhong Yue Li et al. shows that the sedimentation rate decreases as the organic matter content increases, while the floc size actually increases with increasing organic matter content [14]. Furthermore, Jean Berlamont et al. added extracellular polymeric substances to water, which resulted in a significant decrease in the sedimentation rate of flocs. To understand the specific influence of organic matter on sediment settling velocity, field measurements or simulations are generally required in practical.

Figure 7. The particulates of Sedimentation

From this, it can be concluded that organic matter influences sedimentation rates, although its sedimentation behavior varies depending on the composition of organic matter and different water conditions. Therefore, there is still potential for further research to explore the impact of organic matter on sedimentation rates.

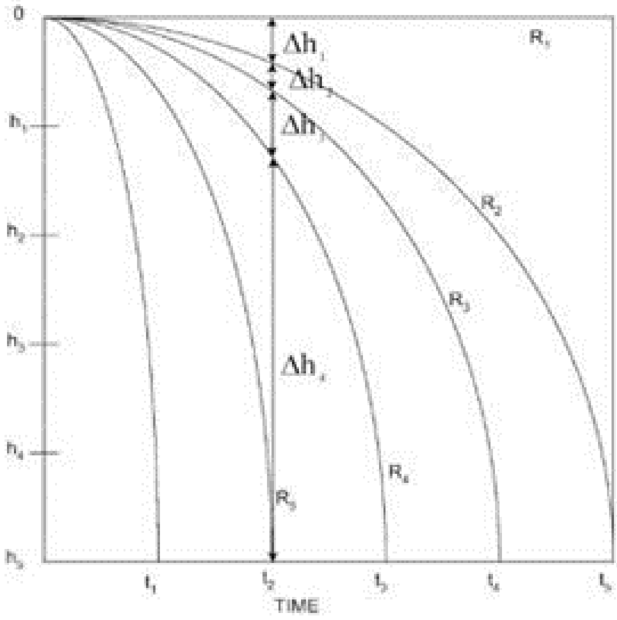

Figure 8. Sedimentation Efficiency Graph Based on Time and Depth

As shown in the figure 8, it is known that the deeper a fluid area is, the longer its settling time. Smaller particles have longer settling times, requiring more time for chemical interactions to form larger particles. Depth also affects the time it takes for particles to settle to the bottom, so there is a correlation between particle size, depth, settling time, and settling velocity.

Type 2 sedimentation is sedimentation that occurs due to additional interactions between molecules. This sedimentation is commonly performed and occurs because the particles in the fluid have low mass, size, and settling velocity, resulting in a very long settling time or even no settling at all because the density of the particles is lower than the density of the fluid. A chemical process is required to aggregate particles, resulting in mixing and the formation of particles with greater mass, size, and density than before. The new particles formed through this chemical process are expected to have a higher settling velocity than before, leading to particle settling in the fluid. Depth also affects the time it takes for particles to settle to the bottom, therefore there is a correlation between particle size, depth, settling time, and settling velocity. This sedimentation commonly occurs because of type 2 sedimentation, which causes the particle size to become larger. Higher particle concentrations also affect the decrease in sedimentation rate due to particle compression in the area.

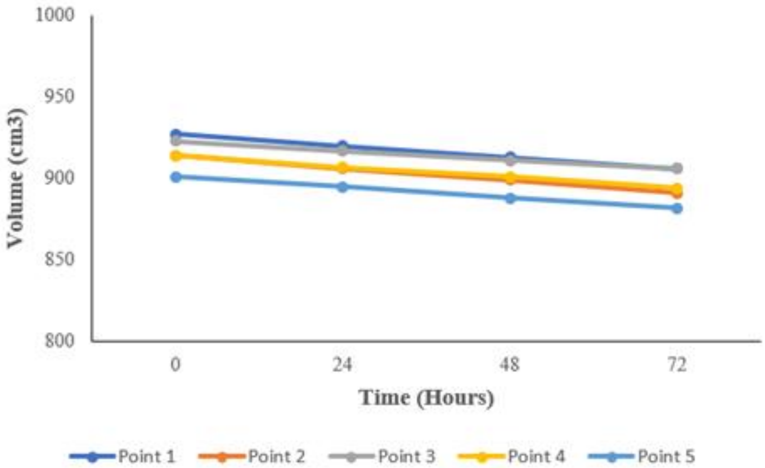

Figure 9. 72 Hour Column Test (t172)

The graph shows that Point 1 has the highest volume due to the dominance of fine particles and organic colloids that are difficult to settle, while Point 5 has the lowest due to the influence of dumping activities and excavator traffic that add larger particles so that they settle slightly faster. Points 2, 3, and 4 are in an intermediate position, reflecting a mixture of organic and mineral particles. This pattern confirms that differences in site conditions influence suspension stability, although overall settling rates at all points remain very low.

3.4 Typers and Characteristic of Sediments

Sieving is often used to classify sediments based on size, but according to Mitscherlich, sieves also sort particles partly based on their shape. Many particles with irregular shapes and diameters larger than the sieve openings can still pass through. The size distribution obtained through sieving should represent the number of particles that can pass through a sieve with a specific square opening.

The sieve diameter is defined as the length of the smallest square opening that a particle can pass through. When particles are analyzed using sieves, the particle size distribution between two sieves is not directly visible. The average or median particle size in this group depends not only on the size range but also on the frequency of particle sizes within that range. Sometimes, the arithmetic or geometric mean of the sieve sizes passed and retained can be used as an estimate of the particle diameter in that fraction [16].

The previous section explained that there was no significant sediment deposition, indicating that the particles in the peat water were not affected by gravity. Based on testing using 20-micrometer filter paper, many particles passed through the filter, indicating that their size is smaller than Total Suspended Solids (TSS). This indicates that most of the particles in peat water are likely to be colloidal particles. Colloids are dispersions of small particles ranging in size from 1 nanometer to 10 micrometers, covering the 'nano' to 'micro' scale. Colloidal particles can be dissolved macromolecules or macromolecular structures composed of smaller structural units, and can exist in separate phases such as aerosols, powders, pigments, emulsions, microfoams, and finely pigmented plastics.

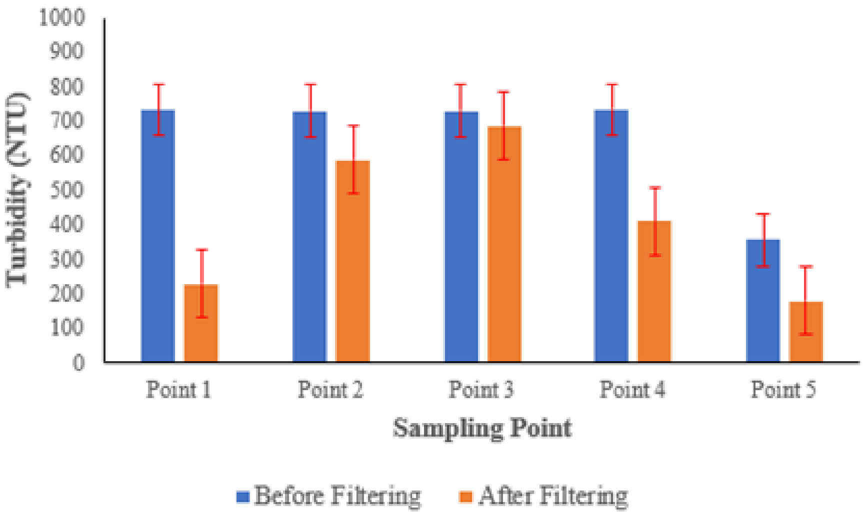

Figure 10. Sedimentation Particle Size

The graph shows that the turbidity levels at all points remained almost unchanged after 20 µm filtration, indicating that the particles causing the turbidity were predominantly <20 µm in size. Point 5 had the highest turbidity (800 NTU), followed by Point 1 (720 NTU), while Points 3 and 4 had the lowest (420-470 NTU). This condition explains the low sedimentation rate because fine particles and colloids remain stable in suspension, so turbidity control requires a coagulation-flocculation process, not just mechanical filtration.

There are six main characteristics that distinguish colloidal particles from larger particles, namely (a) Mobility due to thermal kinetic energy, (b) absence of inertial effects, (c) negligible gravitational influence, (d) molecular interactions within the system through adhesion, (e) size influence on thermodynamic properties, and interaction with electromagnetic radiation. Colloidal particles exhibit unique behaviors that differentiate them from larger particles, and these characteristics play a significant role in determining their stability within aquatic systems. First, their mobility is strongly influenced by thermal kinetic energy, which causes continuous random motion, commonly known as Brownian motion. Unlike larger particles, colloids do not experience significant inertial effects, making their movement highly sensitive to surrounding fluid dynamics.

In addition, the gravitational influence on colloidal particles is negligible due to their extremely small size, preventing them from settling easily under normal conditions. Another important feature is their molecular interactions, particularly through adhesion forces, which allow colloids to remain suspended and sometimes form aggregates depending on the environmental chemistry. The particle size itself also affects their thermodynamic properties, such as surface energy and solubility, leading to behaviors distinct from bulk materials. Finally, colloidal particles interact with electromagnetic radiation, which explains their optical properties, such as scattering and absorption of light, often observed as turbidity or color in water. Together, these six characteristics highlight why colloids behave differently from larger suspended solids and why their presence has a critical impact on water quality and sedimentation processes.

The high surface area to volume ratio of colloids makes these particles very effective at absorbing free ions. This absorption process occurs because of the electrical charge on the surface of the colloid, which creates a repulsive force between particles, keeping the colloid stable in solution. Hydrophobic colloids, which are typically derived from organic materials, play a role in water coloring and contain functional groups such as $R\text{-}NH_2$ or R-OH, which form hydrogen bonds with water molecules and create a layer that prevents colloidal particles from aggregating, thereby enhancing their stability. Characteristics, as water characteristics also affect the particles contained within it, such as in peat water and river estuary water.

Particle size is an important factor in the particle deposition process. This is because particle size affects viscosity and density [13]. Viscosity is a measure of fluid thickness that indicates the amount of friction in a fluid [1]. Density, on the other hand, is the mass per unit volume of a substance, which is determined by the mass and volume of the substance, providing an indication of the mass per unit volume of the substance. Particle size affects the amount of friction between the surface area of the substance and the fluid, so that the larger the particle size, the greater the frictional force on the fluid. The relationship between particle size and density is such that if the density of the solid substance (particles) is lower than the density of the fluid, the particles tend not to settle. The correlation between particle size and viscosity and density is directly proportional. Thus, particle settling can be influenced by viscosity values, where higher viscosity slows down the settling rate of particles. However, the ability and potential for settling can also be seen from the density value of particles relative to the fluid.For example, in a column with uniform particles, gravitational force pulls the particles downward, while diffusion force pushes them upward. If these two forces are balanced, a stable condition called sedimentation equilibrium is achieved [5].

Overall, the rate of colloid precipitation in peat water under the influence of gravity takes a relatively long time, given the characteristics of colloid particles, which tend to be stable in solution. This is further reinforced by the characteristics of peat water, which is reddish-brown in color, acidic, naturally hydrophobic, and contains organic colloidal particles that are difficult to settle due to the repulsive forces between charged particles [17].

IV. CONCLUSION

Conversely, hydrophilic colloids typically originate from minerals with negatively charged surfaces that inhibit agglomeration. In colloid applications, in addition to gravitational forces, diffusion forces, osmotic pressure, Brownian motion, electrostatic forces, and light and heat convection must also be considered, as they can either support or inhibit particle settling. If a particles come to rest due to various forces balancing each other, the total sum of these forces is zero. In this case, the colloidal particles in suspension reach a state of statistical equilibrium. At sedimentation equilibrium, the opposing gravitational and diffusion forces are balanced.

In a fluid, there are usually particles contained within it, and their size varies depending on the location of the fluid. In dynamic fluids such as river water, runoff water, and drainage water, there is usually a high particle content because they carry particles that they pass through. On the other hand, static fluids tend to have low particle content because sedimentation has occurred due to gravitational forces. However, in some cases, particle content is also influenced by water.

The results of this study show that revitalization activities around Lake Teloko do not significantly affect TSS concentrations, as values remain relatively uniform across sampling points. This suggests that construction is not the main factor controlling turbidity, but rather the natural properties of suspended particles. The very low sedimentation rate also indicates that particles require a long time to settle due to their colloidal nature, organic content, and positive charges that prevent agglomeration. Thus, turbidity persistence is driven more by physicochemical properties of particles than by short- term human interventions.

Further research with time-series analysis is recommended to capture particle distribution over longer periods, while hydrological studies are needed to assess runoff potential and seasonal influences on water quality. Practically, revitalization and conservation strategies should integrate ecological and chemical approaches, such as natural coagulants or ecological engineering, alongside structural measures to address colloidal dominance. Such efforts are essential to improve water clarity, support ecosystem sustainability, and maintain lake environmental quality.

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