Cerucuk Filter Modified (CFM) Design as Sediment Traps to Reduce Total Suspended Solids (TSS) Concentration in the Drainage Mine Reclamation Area: An Field Experiment

H U Surapati¹ and A Mizwar²

¹Mentor with Honors-Understanding Research Methods Course by SOAS University of London at Coursera
²Assistant Professor at Environmental Engineering Faculty of Lambung Mangkurat University

untung.gv@gmail.com

Abstract. One of the environmental issues for the physical components of soil and water, is the potential risk of carrying soil particles by runoff. However, sedimentation and high TSS concentrations still occur in settling ponds before flowing into river, lake or sea. Transfer of such pollutants from solid to aqueous phase at the interface of sediments/particles facilitates their entry into the food chain and further bio accumulation in neighboring fauna and flora. A vast variety of geogenic (rocks weathering and soil erosion) and anthropogenic sources (mining activities, urban and agricultural run-offs, industrial and municipal sewer overflows, etc.) may cause toxic metals discharge into water bodies. The metals can be dissolved in the water column, absorbed/adsorbed to the sediments/particulates or accumulated in biota. In comparison with other media, river bed and suspended sediments play a more significant role in overall pollution and environmental risks. This research is improvement of USEPA recommendations for the installation of sediment traps in drainage channel. The advantage of using this additional modification is that it can significantly reduce TSS concentration. The results of the water samples test and statistical test show that this research provides significant result in reducing TSS concentrations.

1. Introduction

In the stages of the mineral and coal mining process, one of them uses the open pit method to exploit mining materials. This method starts with land clearing activities, stripping of top soil and overburden, and then to getting mineral and coal. Referring to the Best Mining Practice, the mining excavation is then returned as close as possible to the initial baseline in accordance with the Environmental Impact Assessment (EIA) research that has been done. One of the environmental issues for the physical components of soil and water, is the potential risk of carrying soil particles by runoff. USEPA has provided the best practice to reduce the impact caused by runoff by making water bags in drainage channels at reclamation areas.

However, sedimentation and high TSS concentrations still occur in settling ponds before flowing into river, lake or sea. This field experiment was carried out to provide additional treatment for sediment traps in the mine reclamation drainage channel.
Key Questions

- What design of sediment trap can be applied with the concept of environmentally friendly.
- How to design a sediment trap to function optimally. So that it can significantly reduce TSS concentration.

2. Literature review

Clay and sludge particles have electro-magnetic properties that bind hybrid grains together to give mass or mass cohesion. This process is called "Flocculation" which occurs when the dispersed colloidal phase (i.e., sludge) forms discrete particles that can precipitate from the dispersion medium (i.e., water) [2]. Settle rate for erosion and deposit of cohesive and non-cohesive particles, the treatment is different. Particles of cohesive aggregates to form larger particles with higher precipitation speeds will pull particles out of the water column, reduce turbidity, and increase the clarity of water. This process is the result of electrical charges on the surface of cohesive particles (clay and sludge) [2].

The theoretical concept of 'Sediment Delivery Ratio' (ratio between yield and total amount of eroded sediments) illustrates the fact that not all deposits are eroded in a particular catch area that reaches the sewer (because, for example, deposition in the floodplain). Such storage opportunities usually increase in larger size catches, resulting in a lower sediment delivery ratio [3]. Although suspended sediment is a natural component of aquatic ecosystems, excess sediment degrades stream ecosystems and is implicated as a leading cause of water quality and aquatic life impairment. Suspended sediment transport is also strongly associated with nutrient and contaminant transport. Phosphorus is commonly adsorbed to fine sediment particles and sediment-associated transport often dominates the total phosphorus load exported from a catchment, which can cause eutrophication problems in water bodies downstream. Additionally, pesticides, organic contaminants, heavy metals, and other pollutants are stored and transported along with fine sediments [4].

According to Maeden and Kapetsky [5], the presence of solid charge can absorb and reflect the spectrum of light radiation that penetrates down the surface of the water, but its effect more are emission back scattering so show the form muddy water. Sediment trap is a common term used in very different contexts. Farmers throughout the world have built small sediment traps in erosion-sensitive agricultural areas to protect rivers from suspended load and related pollution. No universal name exists for sediment traps. In the literature, similar structures have been called detention/deposition/sedimentation/retention/sediment retarding basins, sediment traps, open/slit check dams, SABO dams, torrential barriers, and debris flow breakers [6]. Sediment traps are formed by excavating an area or by placing an earthen embankment across a low area or drainage swale. Sediment traps are designed to capture drainage from disturbed areas less than one acre and allow settling of sediment. Sediment traps can be used in combination with other layers of erosion and sediment controls to trap sediment from small drainage areas (less than one acre) or areas with localized high sediment loading. For example, sediment traps are often provided in conjunction with vehicle tracking controls and wheel wash facilities [7]. A straw bale barrier is a linear wall of straw bales designed to intercept sheet flow and trap sediment before runoff exits a disturbed area. Appropriate uses of properly installed straw bale barriers may include; as a perimeter control for a site or soil stockpile, as a sediment control at the toe of an erodible slope, along the edge of a stream or drainage pathway to reduce sediment laden runoff from entering the waterway [7].

Transfer of such pollutants from solid to aqueous phase at the interface of sediments/particles facilitates their entry into the food chain and further bio accumulation in neighboring fauna and flora. A vast variety of geogenic (rocks weathering and soil erosion) and anthropogenic sources (mining activities, urban and agricultural run-offs, industrial and municipal sewer overflows, etc.) may cause toxic metals discharge into water bodies. The metals can be dissolved in the water column, absorbed/adsorbed to the sediments/particulates or accumulated in biota. In comparison with other media, river bed and suspended sediments play a more significant role in overall pollution and environmental risks [1].
Total suspended solids (TSS) is a commonly used monitoring indicator of Non Point Source (NPS) pollution. TSS is the dry-weight of particles trapped by a 0.45-μm filter and does not include dissolved solids in stormwater. It may include water-insoluble inorganic material (e.g., sediment and clay) and insoluble organic matter (e.g., fecal matter, plankton, vegetation, and microorganisms). For typical stormwater samples, TSS are significantly larger than dissolved solids. All water bodies contain TSS due to natural processes, but anthropogenic activity results in elevated TSS concentration. Thus, monitoring of TSS concentration is a very good predictor of water quality. Moreover, TSS is linked to other pollutants, such as phosphorus, organic compounds, and some heavy metals, since they tend to be adsorbed in particles. More than 80% of adsorbed pollutants are linked to TSS during rainfall events. Herngren et al. found that some heavy metals in water, such as Cu, Pb and Fe, have a close relationship with TSS. In addition, TSS plays an important role in the transport of anthropogenic nutrients and heavy metals in streams [8].

3. Methodology

This research uses quantitative methods (postpositivist claims) and uses the method of sampling, purposive random sampling.

3.1 Sediment traps installation

Drainage channel built on mining reclamation land aim to reduce the potential impact of sedimentation. This drainage channel is made following the slope that has been determined in accordance with the geotech studies that have been conducted. In addition to reducing the potential impact of sedimentation, this sediment traps also reduces the runoff rate that occurs. This method has been recommended by USEPA (1991). Theoretically, the sediment traps function as settling ponds, which are when the first pool is filled with water, it will flow into the next sediment traps without any turbulence mechanism in it. So that the mixing process for dilution does not occur. Besides that, the runoff time for the process is too close. (see figure 1).

![Figure 1. Work principle of sediment traps](image)

3.2 Cerucuk Filter Modified (CFM) installation

The main function of the first treatment is to reduce the potential impact of sedimentation due to runoff. Additional treatment is needed, so that the first treatment functions maximally, especially for the reduction in the concentration of Total Suspended Solid (TSS). The design for CFM is made with “environmental friendly” considerations. By utilizing materials that are easily obtained and have not potential to pollute the environment. The simple design of CFM can seen in the figure 2. Based on the basic design of CFM, an installation in the field is carried out as shown in the figure 2.

Materials:
1. Tree trunk
2. Stones
3. Coconet
4. Grass thatch

Figure 2. Sediment traps dan cerucuk filter modified design

Figure 3. Cerucuk filter modified installation at reclamation area drainage channel
1. Installation of wooden stakes 2. Coconet installation 3. Filling coconet with grass thatch 4. Cerucuk filter modified along the path of drainage channel

4. Discussion

The experimental treatment construction of sediment traps in the reclamation area drainage channel was completed on November 16, 2017. At the time of construction the rain had not yet occurred, it is hoped that after the rain the sediment traps could function optimally.
When it rains, sediment traps function well as runoff containers. The runoff flow rate is reduced, where the runoff flow in the drainage channel first enters the sediment trap. Water sampling is carried out after the rain falls. The water sampling point is before and after the Cerucuk Filter Modified. CFM process in the field as shown in the figure 4.

**Figure 4. CFM Process in the field**

A. CFM series in the drainage channel  B. Light rain and the slope is covered with straws  C. Slope begins to overgrow cover crops  D,E. CFM after heavy rain  F,G. CFM sipped runoff functions as a filter

| Date | Nov (mm) | TSS (mg/l) Before | TSS (mg/l) After |
|------|----------|--------------------|------------------|
| 17   | 21,0     | 175                | 74,2             |
| 18   | 0,0      | 0                  | 0                |
| 19   | 0,0      | 0                  | 0                |
| 20   | 0,0      | 0                  | 0                |
| 21   | 0,0      | 0                  | 0                |
| 22   | 0,0      | 0                  | 0                |
| 23   | 0,0      | 0                  | 0                |
| 24   | 0,0      | 0                  | 0                |
| 25   | 30,0     | 163                | 80,7             |
| 26   | 16,0     | 125,3              | 92,5             |
| 27   | 13,0     | 121                | 87               |
| 28   | 1,5      | 0                  | 0                |
| 29   | 25,0     | 119                | 94,3             |
| 30   | 24,0     | 127                | 104,8            |

The water sample is then analyzed at the Enviro Laboratory. The results of the TSS concentration analysis during the experiment can be seen in table 1. Based on measurement data of TSS concentrations before and after the Cerucuk Filter Modified shows that the filter is functioning properly. TSS shows a trend of decreasing concentration. (figure 5).
To find out the correlation of TSS analysis result before and after using CFM, the analysis was continued with the auto correlation test, with the correlation coefficient criteria as follow:

- 0.00 – 0.199 = Very low
- 0.20 – 0.399 = Low
- 0.40 – 0.599 = Moderate
- 0.60 – 0.799 = Strong
- 0.90 – 1.000 = Very Strong

The test result shows the value of the correlation coefficient of 0.94424, that is with very strong criteria. Auto correlation results can be seen in Table 2 and Figure 6.

**Table 2. Auto correlation test of CFM**

| Lag | Correlation | p   |
|-----|-------------|-----|
| -7  | -0.63705    | 0.12387 |
| -6  | -0.48306    | 0.2253 |
| -5  | -0.0057276  | 0.98833 |
| -4  | 0.21763     | 0.54584 |
| -3  | 0.0027378   | 0.99363 |
| -2  | 0.084081    | 0.79502 |
| -1  | 0.33254     | 0.26694 |
| 0   | **0.94424** | 3.84E-07 |
| 1   | 0.33137     | 0.26872 |
| 2   | 0.059679    | 0.85383 |
| 3   | 0.07257     | 0.83208 |
| 4   | 0.20317     | 0.57346 |
| 5   | -0.053575   | 0.89112 |
| 6   | -0.47827    | 0.23061 |
| 7   | -0.62885    | 0.13033 |
5. Conclusions

Cerucuk Filter Modified (CFM) application with environmental friendly design concepts, has given positive results of this research. The results of the CFM experiment showed a significant decrease in Total Suspended Solid (TSS) concentration. The more runoff that occurs, the decreased concentration of TSS after using the Cerucuk Filter Modified also decreases its concentration. This shows that besides functioning as a sediment trap to reduce the potential for sedimentation downstream, it also functions as a filter to reduce the high concentration of Total Suspended Solid (TSS) as one of water quality key parameters in the mining activity. Further research is needed to refine the results of this research, as well as flowrate measurements. So that it can be seen how much the maximum discharge of this modified filter receptacle is functioning optimally.

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