AWERProcedia Advances in Applied Sciences

Vol 1 (2013) 837-842

1st Global Conference on Enrivonmental Studies 2013

Turbidity and suspended solids as affected by the sampling procedure under the same rainfall event in a water channel

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Suggested Citation:

Shah, H., M., S., Yusof, W., K., Mustaffa, Z., Hashim, M., A. & Ehsan, A. Turbidity and suspended solids as affected by the sampling procedure under the same rainfall event in a water channel. *AWERProcedia Advances in Applied Sciences*. [Online]. 2013, 1, pp 837-842. Available from: http://www.world-education-center.org/index.php/paas. *Proceedings of Gobal Conference on Environmental Studies* (CENVISU-2013), 24-27 April 2013, Zeynep Sentito Hotel, Belek – Antalya, Turkey.

Received November 19, 2012; revised January 20, 2013; accepted March 17, 2013.
Selection and peer review under responsibility of Dr. Nehir Varol.

Abstract

When the embankments are bare, it leads to erosion of the top soil and exposes the subsoil. The subsoil is considered to have fragile structure which leads to the increased runoff that aids the sedimentation process which is considered among the major off-site effects of the soil erosion process that influences the water quality and the capacity of the stream channels. This paper comprises of a field study which was conducted on the road side inclination with the gradient of 1 on 1.5 (≈ 30˚). This study concerns about the comparison of turbidity and the presence of the suspended solids obtained from a bare surface which was monitored at different intervals of time under the same simulated rainfall condition of 52 mm/hour for which the rainfall data was obtained for the Perak state from Meteorological Department, Malaysia. A prominent difference was observed in the water quality and suspended solids depending on the way of collecting the water samples. The maximum turbidity and

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suspended particles obtained by disturbing the settled particles were 6000 (NTU), and 244.3 (mg/L) and for the undisturbed settled particles the maximum values were found to be 2585 (NTU), and 58.3 (mg/L).

Keywords: Turbidity, suspended particles, bare soil, simulated rainfall;

1. Introduction

It is essential to identify the turbidity values during the procedure of removing sediments of a reservoir in the river downstream channels in the absence of stream training works. This consideration gives the ratio of annual values of the discharged sediments to the annual maximum discharged water which is considered as a function of average annual turbidity [1] for which attempts have been made by the catchment stakeholders to get the data on soil erosion and its impact on the water quality at catchment scales [2]. It is not possible to reduce the stream sediment loads without reliable information of the constituents that contribute to the overall sediment production [3]. It is therefore recommended to study both the processes i.e. suspended particles and settled particles which are occurring in the water phase and are settled [4]. Enters (1998) highlighted 16 off-site effects of which the most vital are in-stream water quantity and quality problem, sediments deposit in the reservoirs, decrement in the availability of irrigation water, worsening of the potable water, accumulation of silt, runoff that leads to flooding, slow processing of the hydrological cycle, and ground water recharge [5].This paper concerns with the water quality (turbidity) and monitors the presence of suspended particles. To monitor the suspended sediment and to determine the optical properties of water, its turbidity is determined. The influence of the particle size, water color, organic particles, and minerals influences the relationship between the turbidity and the suspended sediment concentration [6].

2. Literature Review

The literature review accumulates several problems, which are associated with the turbidity and suspended solids. Several setbacks have been reviewed from the background researches, which are essential to establish a context for this research.

Chou (2010) stated that Taiwan faced the earthquake of severe intensity, measured 7.3 on Richter scale. The earthquake caused avalanches and large-scale land sliding which had significant impacts in the concentration of the suspended particles and in the stream flow turbidity. The turbidity rates surpassed the treatment limit of the treatment plants which raised the scarcity of the public water demands [7].

Coffin (2007) reviewed that Logging roads allows exposure of soil in a watershed which is a notable matter as it is linked with the sediments deposition and erosion rates in a stream channel. This affects the stream morphology and creates shallow pools which leads to the increased turbidity and raises the water temperature that affects the fish species [8].

Sthiannopkao (2007) highlighted that the Ubolratana dam received 1.50 million tons/year of the average annual amount of siltation which worsened the water capacity by 32.90 million m^3 which equal 1.4% of total storage capacity of the dam, reported by the Electricity Generation Authority of Thailand (EGAT) during the year 1965-1990 [9].

3. Problem Statement

The influx of sediments from different sources has aggraded the stream channel, which makes it necessary to predict the sediment production in assessing their impact on the water quality. The significance of the bare road embankment for the production of sediments cannot be neglected when compared with the agricultural lands as it carries the detached soil particles in the form of overland flow. Moreover, roads are reported to be more active in increasing annual runoff yield when

compared with the forest destruction [10]. This results in contamination of the water channel and the water quality by allowing the suspended particles to move freely in water due to their light density.

4. Objectives

The primary objective of the study is to understand and compare the response of bare road embankment when exposed to the simulated rainfall intensity of 52 mm/hour. The study will attempt to:

- Study the water turbidity caused by the surface runoff for a given rainfall event.
- Determine the presence of suspended solids affected by the soil detachment for a given rainfall intensity.

5. Methodology

5.1. Site location

The study was conducted at Universiti Teknologi Petronas, Perak State Malaysia. To conduct the experimental run the site was selected to meet the requirement of the roadside slopes for which the gradient is usually taken as 1 on 5 (≈ 30°). It was further provided with an appropriate drainage for putting the designed V-notch container for the collection of detached soil particles, surface runoff, turbidity samples and suspended solids which was among the major requirements of the experimental run.

5.2. Detailed drawing of the study area

Figure 1 shows the detailed drawing of the experimental area. The bare plot chosen for the study has an area of 2m x 6m. The rainfall simulators were used to provide the rainfall effects. The rainfall data for the Perak state was analyzed and the rainfall intensity of 52 mm/hour was modeled in the experiment.

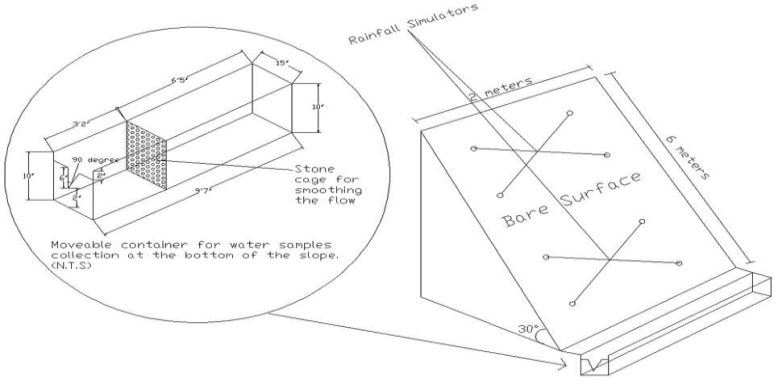

Figure 1. Description of the study area and the bottom container

5.3. Rainfall data

The rainfall data for the Perak State (2005-2011) was obtained from Meteorological Department Malaysia. Figure 2 shows the average high rainfall intensity from the three stations i.e. Ipoh, Lubok Merbau, and Sitiawan, which give an average of 52 mm/hour for the high rainfall events.

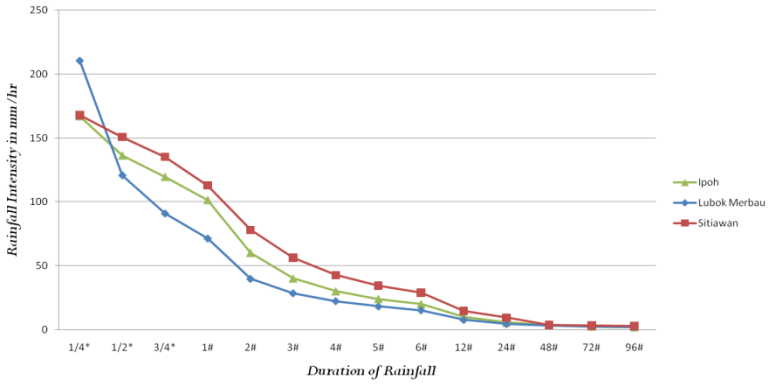

Figure 2. The average high rainfall intensities for the Perak State

6. Results and Discussions

To determine the turbidity and suspended solids obtained from the bare soil surface, two tests were conducted under the same rainfall event to observe the difference among the values.

6.1. Turbidity

Figure 3 shows the turbidity values obtained during the first run when the settled sediments were disturbed while collecting the water samples and the turbidity values obtained during the second run when the settled sediments were not disturbed under the rainfall intensity of 52 mm/hour at different time intervals of 15 min, 30 min, 45 min, 60 min, 75 min, 90 min, 105 min, and 120 min.

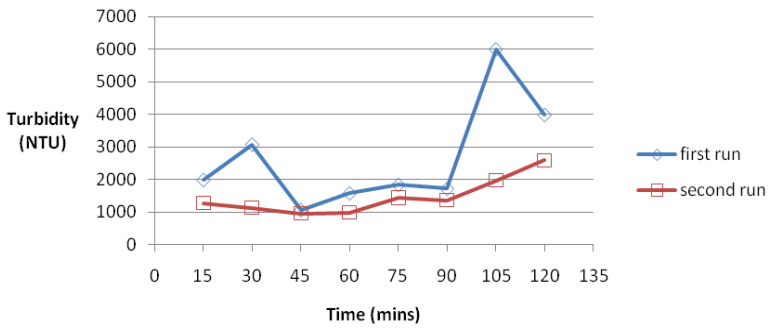

Figure 3. The water quality tested under the rainfall event of 52 mm/hour, first and second run

6.2. Suspended solids

Figure 4 shows the values of suspended solids obtained when the settled sediments were disturbed during the first run and the values of suspended solids obtained when the settled sediments were not disturbed during the second run at different time intervals of 15 min, 30 min, 45 min, 60 min, 75 min, 90 min, 105 min, and 120 min.

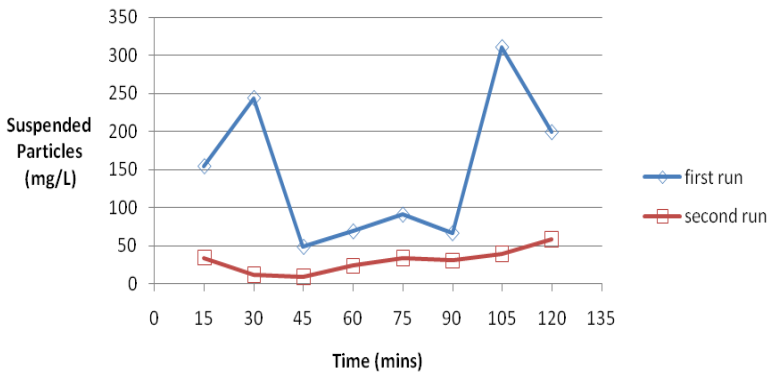

Figure 4. The presences of suspended particles at different time intervals under the rainfall intensity of 52 mm/hour, first and second run

The graph of turbidity for both the runs exactly coincide with the graphs of suspended particles which indicates that higher the turbidity rates more would be the suspended solids present in the water. The graph for turbidity and suspended solids does not go up linearly for which the reason is suggested to be the amount of soil eroded at different intervals of time i.e. for the interval of fifteen minutes the individual erosion rates were quite different from interval of thirty minutes and so on. For the first run, the settled soil was disturbed and stirred up for collecting the water samples at different intervals of time. The water samples were extremely turbid and contained the suspended solids in bulk. However, for the second run the settled solids were not disturbed and the water sample were collected precisely from the top which were low in turbidity and suspended particles. The plot was observed under the same rainfall event but the difference in the turbidity rates and suspended solids was drastic, for which the reason could be the density of the soil particles which were settled or remained in suspension.

7. Conclusions

The experiments carried out on the bare soil under the rainfall intensity of 52 mm/hour concluded that turbidity is correlated to the suspended particles. When the settled particles were disturbed the maximum values for turbidity and suspended particles were found to be 6000 (NTU) and 244.3 (mg/L) and for the undisturbed settled particles the maximum values were found to be 2585 (NTU) and 58.3 (mg/L).It is however, recommended that while collecting the water samples for determining the turbidity rates and suspended particles, the water samples must be taken precisely without disturbing the settled particles as turbidity is the measure of degree of water transparency affected by the presence of “Colloidal particles”. Moreover, suspended particles remain in suspension; however for its estimation settled sediments are not to be disturbed.

8. Acknowledgement

The author would like to acknowledge URIF grant (code # 22/2012) and Universiti Teknologi PETRONAS for the continuation of the Graduate Assistantship Scheme and for providing the platform to conduct the study in the real field conditions.

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