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EFFECT OF DIFFERENT SOIL SURFACE ON HYDRAULIC PARAMETERS AND SEDIMENT CONCENTRATION

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ABSTRACT

This study focuses on the effect of different soil surfaces on hydraulic parameters and sediment concentration. The hydraulic parameters including flow velocity, flow depth, shear stress and stream power. Furthermore, it analysed the effect of different slopes and soil surfaces (sand and gravel). The sediment transport channel was utilized to create various soil surface types, including sand, gravel, and clay, with slope angles that ranged from 0°, 5°, and 10°. The volume of sample water was collected at multiple intervals (20, 40, 60, 90, 100 and 120 min) for two (2) hours. Then, the hydraulic parameters and the concentration of the sediments were measured. Consequently, the slope angle between 5° and 10° produces the biggest increase in the relationship between sediment discharge and hydraulic parameters. Additionally, the flow discharge had a greater impact on the observed sediment discharge. On the other, flow velocity and unit stream power were directly had positive relation between the sediment discharge. Generally, the information regarding the hydraulic parameters and sediment relations under various soil surface can facilitate water resources planning and management projects in soil process-based erosion modelling.

1.0 INTRODUCTION

Soil erosion is a global problem that the land has been disturbed by agriculture, farming livestock, logging, mining, building, and recreational activities. Soil erosion by water occurs when soil detachment and deposition occur simultaneously during erosion process. Soil erosion is strongly connected to sediment concentration. Even though sediment load has a significant impact on some overland hydraulic characteristics. The difficulty in distinguishing between backward and forward processes contributes to a lack of understanding of the effects of eroded sediment on the associated hydraulics component in eroding beds [1]. The concentration of sediment is since the movement of the detachment of soil particles from the soil surface is due to a few factors. Sediment concentration is strongly associated with erosion. Reciprocal overburden for foliar erosion and infill erosion areas are landslides and soil runoff affected by rains. The size of particles that make soil move over a wide extent of soil and large are called rock, sand, build up or earth depending upon predominant measure of particle interior the earth. Fine material is easier to transport than coarse material, thanks to factors such as the decomposition of the mixture and, consequently, the development of the superficial crust which also causes an increase in the flow of the finest material [2].

To depict soil by their particle size, some affiliations have made atom estimate course of action. Slope gradients are essential variables that control soil erosion on hill slopes due to overland flow. The steepness of the slope gradient really affects the hydraulic parameters. As the slope gradient becomes steeper, the overland shear stress increases as an example [3]. The hydraulic parameters properties of the soil are seen in a variety of ways. As previously stated, sediment load can impact flow hydraulics including mean velocity, flow regime, shear stress, and resistance [1]. The unit of hydraulic parameters necessary for the

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study of the transport of water and sediment concentration. There are many hydraulic parameters of the surface unit, such as flow rate, flow depth, stream power and unit power. From these parameters, the sediment concentration will be determined by characterizing the erosive power of the flow. Several experiments have also been carried out to investigate the relationship between aggregate stability and hydraulic conductivity, as well as the possibility of using the aggregate stability index to establish a soil erosion model [1]. Several studies have been conducted to examine sediment transport capacities in various experimental flows on various slopes, as well as their responses to hydraulic parameters such as slope gradient, flow discharge, mean flow rate, and shear stress [4].

This study utilized an experimental study on different soil surfaces using sediment transport flow channel to investigate the impact of a sediment transport channel on soil transport. The main objectives of this study were the following: (1) To measure the flow discharge, sediment discharge and hydraulic parameters of different soil surface and (2) To investigate the relations between flow discharge, sediment discharge and hydraulic parameters of different soil surface.

2.0 METHODS AND MATERIAL

This research is focused on investigating the relationships between sediment concentration and hydraulic parameters on various surface soils through experimental study. First, the sieve analysis is completed, allows to induce totally different aggregate sizes which pass the metric linear unit of the sieve by 1.18 mm and 0.60 mm. The soil surfaces are sand and gravel. The sediment transport channel apparatus is to be used in the experiment. While the information about sediment production in the flow was collected and measured in the environment laboratory using Total Suspended Solid (TSS) test.

Soils can be identified by different characteristics that distinguish them from each other. It can be identified by studying at the qualities of the soil, such as its strengths and weaknesses. The soil surface which is sand and gravel. The samples are compacted in sediment transport channel of 75 mm wide, 150 mm high and 1.5 m long. Then, placed the different slope steepness of θ = 0°, θ = 5° and θ = 10°. The sediment transport channel is run for 2 hours with the volume of water collected every 20 minutes. The output Q (m^3s^{-1}) is then determined. The purpose of the experiment is to investigate the relationships between sediment discharges, flows and hydraulic parameters of different soil surfaces. The different soil surfaces represent the sediment discharge while the hydraulic parameters will be the controlled variables in this experiment. Firstly, the sediment transport channel is used to set up various soils such as sand, and gravel, and run them at a 20-minute interval for 2 hours. Then, the TSS test was done in the laboratory for determining the sediment discharge, Q_S (gm^{-3}).

The Total Suspended Soil test (TSS) where the surface runoff collected will filtered using the filtering apparatus. This test is to diverge the water and sediment after the sample was dried in the oven for 1 hour under temperature of 105 °C. So, after finishing all the experiment the runoff discharge, Q (m^3s^{-1}), and sediment concentration, Qs (gm^3), will be determined. The runoff discharged is calculated by using the Equation 1 as below. The volume of water flow, V (m^3), is obtained from the calculation of the channel area multiplies the flow depth. Time duration, t is taken when the sediment is collected (time interval). For example, when the sediment is collected at time interval 20 minutes, the t is 20 minutes then convert to second (s).

$$Q = V/t \quad (1)$$

$$Q_s = m/V \quad (2)$$

Equation 2 is used to calculate the sediment concentration discharge, Qs (gm^{-3}). The mass of the dry sediment, m (g), is obtained from the TSS test. The flow velocity, v (ms^{-1}), is the important parameter to calculate the other hydraulic parameters. This parameter is depending on the flow discharge and slope gradient [5]. For the average depth flow, D (m), was determined as Equation 3 [6]. While the flow of water was introduced on the whole surface of the soils. The changes of average unit flow discharge per unit width, q over the channel length were measured.

$$D = q/v \quad (3)$$

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The next hydraulic parameter is shearing stress, τ. The shear stress was calculated as Equation 4 [7]. The density of water flowing, ρ, is 1000 kgm^{-3} [8], while the gravitational acceleration, g = 9.81 ms^{-2}.

$$\tau = \rho g D S \tag{4}$$

Unit stream power (U) is one of the hydraulic parameters. The unit stream power, U (ms^{-1}) was calculated using Equation 5 as follows [6]:

$$U = vS \tag{5}$$

3.0 RESULTS AND DISCUSSION

Flow discharge and sediment discharge on different soil surface

Figure 1 shows the result of flow discharge on different soil surface for sand and gravel. The graph indicated that the highest and lowest flow discharge of different soil at slope $\theta = 0^0$, $\theta = 5^0$ and $\theta = 10^0$. The slope gradient was shown to be a crucial factor that directly affects the overland flow discharge [9]. The flow discharge of sand which are 1.6×10^{-7} m^3s^{-1} and it shows decreasing trend. While, for gravel the flow discharge shows decreasing trend starting 9.0×10^{-7} m^3s^{-1} to 5.0×10^{-7} m^3s^{-1}. The plotted data of sediment discharge were shown in Figure 2. The graph showed the greater efficiency of sand. The range of sediment discharge for sand was 1.00 to 2.73 gm^{-3}. The graph of gravel same pattern at slope $\theta = 0^0$ and $\theta = 5^0$. Then showed the increase sediment discharge at slope $\theta = 10^0$. In general, the flow resistance coefficient increased with increasing roughness [10].

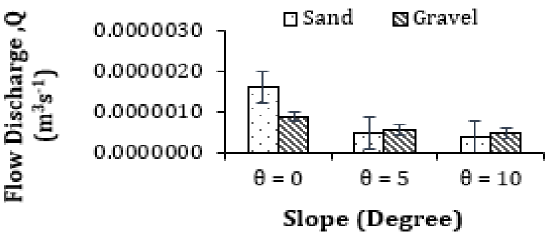

Figure 1. Flow discharge on Different soil surface

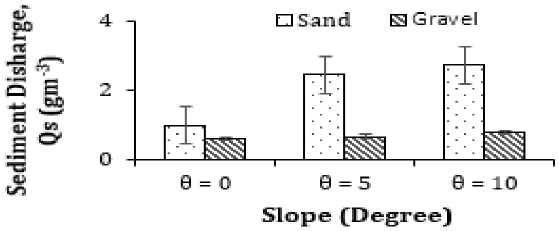

Figure 2. Sediment discharge on different soil surface

Hydraulic parameters on different soil surface

From Figure 3 were shown about the result of measured hydraulic parameter for different soil surface. The flow velocity is represented in Figure 3(a) with different soil surface. The sand was increased for slope $\theta = 0^0$. Meanwhile the flow velocity is shown increasing trend for slope $\theta = 5^0$ and $\theta = 10^0$ on gravel. Soil loss was determined to be the most closely connected hydraulic parameter to flow velocity [6, 9]. In additional, the data of flow depth were shown in Figure 3(b). When compared the flow depth between sand and gravel, the higher flow depth at $\theta = 5^0$ which is 2.24×10^{-5} m for sand. Moreover, Figure 3(c) shows the result of shear stress. Meanwhile, from the Figure 3(d) well-defined the unit stream power. The higher shear stress and unit stream power is sand, and the tangent value of the bed slope degree affects the equation, no values for shear stress at flat slope were presented [11].

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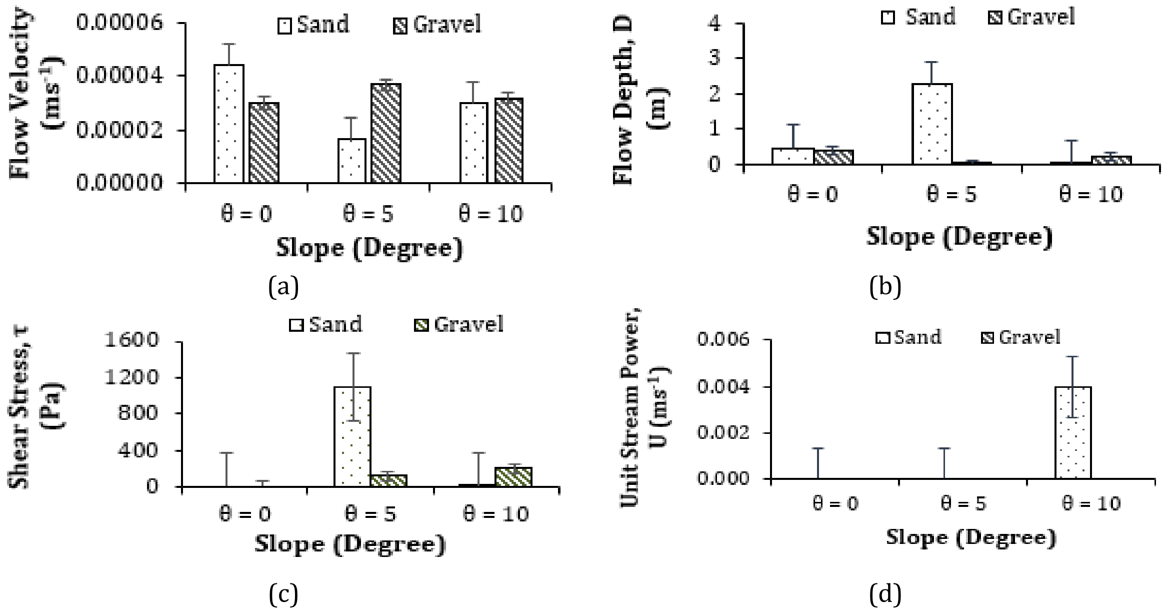

Figure 3. Measured hydraulic parameter (a) flow velocity, (b) flow depth (c) shear stress and (d) unit stream power with different soil surface at slope θ= 00, θ= 50 and θ= 100

Relation between flow discharge and hydraulic parameters

Figure 4 and Figure 5 show the relation between the measured flow discharge and hydraulic parameters with different soil surface at slope $\theta = 0^0$, $\theta = 5^0$ and $\theta = 10^0$ respectively.

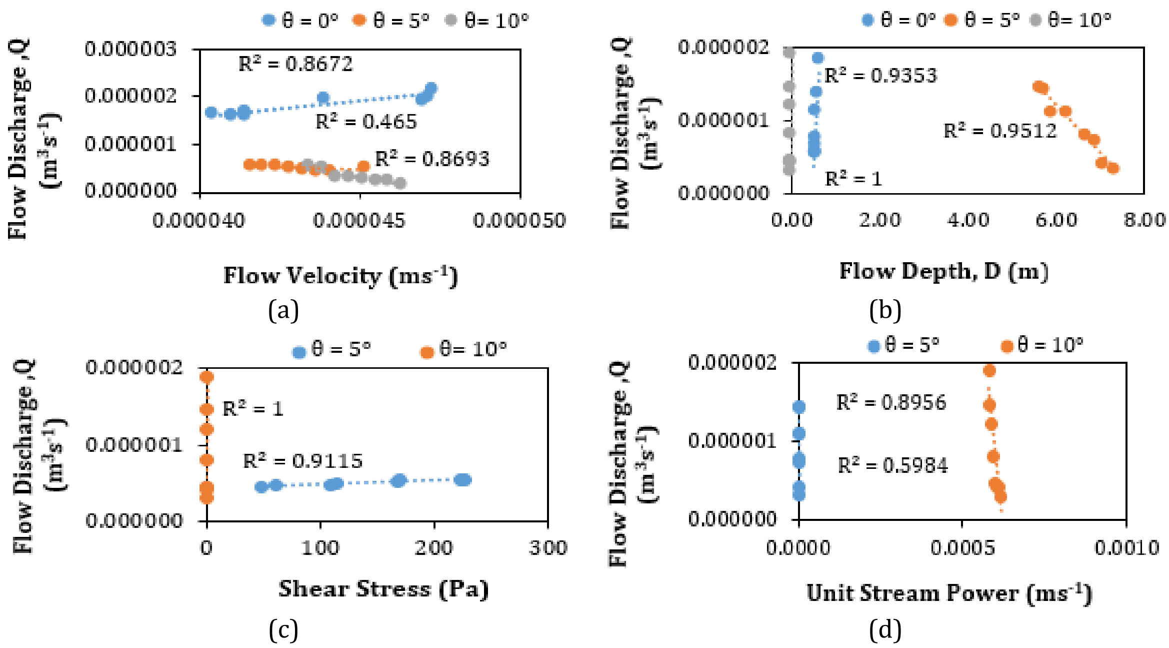

Figure 4. Measured hydraulic parameter (a) flow velocity, (b) flow depth (c) shear stress and (d) unit stream power with sediment discharge at slope $\theta = 0^0$, $\theta = 5^0$ and $\theta = 10^0$ of sand

As graphed from the Figure 4 of sand, flow discharge had a positive relation between hydraulic parameters which is flow depth and shear stress. It found that both the flow velocity and flow depth could be accurately expressed for each slope using simple power functions with the slope gradient and the flow discharge as predictor variables ($R^2 > 0.8$). As opposed to, flow velocity and unit stream power had a negative relation with the flow discharge with different slope. However, the R^2 was higher than 0.5. The power functions describing the unit stream power had negative exponents for the flow discharge across all surface soils, indicating that the unit stream power became less sensitive to changes in the flow discharge at high flow discharge value [9].

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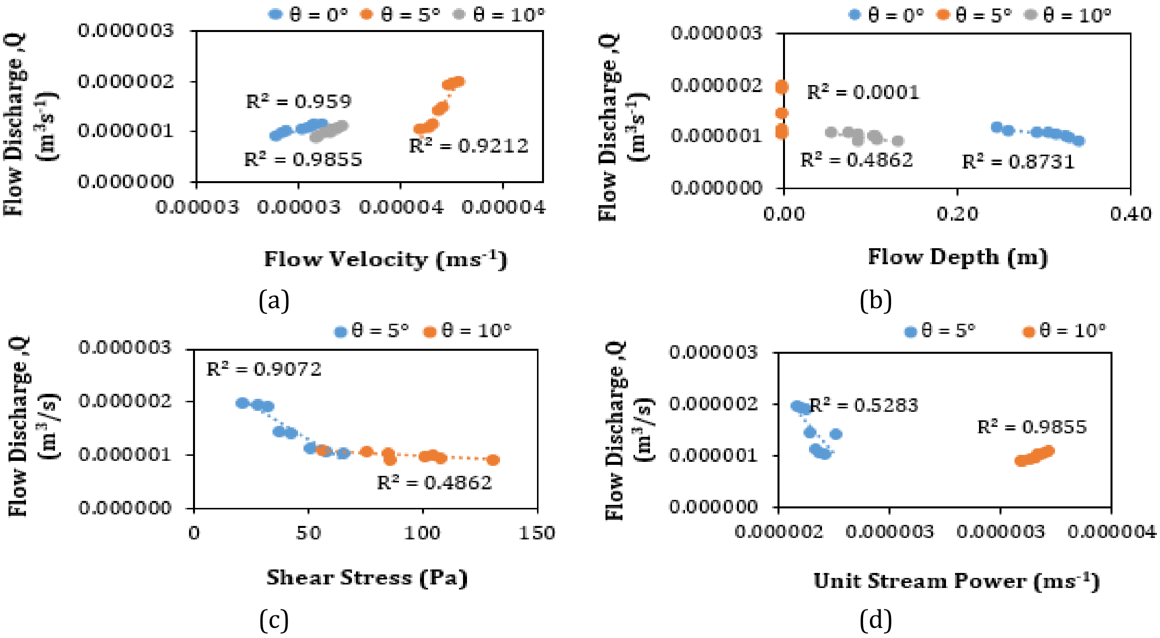

Figure 5. Measured hydraulic parameter (a) flow velocity, (b) flow depth (c) shear stress and (d) unit stream power with sediment discharge at slope θ= 00, θ= 50 and θ= 100 of gravel

Relations between sediment discharge and hydraulic parameters

From the Figure 6 and Figure 7 when compared soil surface sand and gravel for sediment discharge, the soil surface of sand has greater production than gravel. The finer soil surface related to the availability of smaller soil surface and thus smaller pores in this soil may be the cause for the higher values of hydraulic parameters in the sand. This shows that the sand soil surface has a higher sediment discharge [12]. Moreover, almost the greater production come from θ= 0^0, θ= 5^0 and θ= 10^0 because the slope was steeper. The steeper slope can transport the sediment discharge easily than flat slope [13]. Figure 6, figure of sand, flow velocity and unit stream power had positive relation. While in Figure 6(b) flow depth and (c) shear stress showed the negative relation between soil surface of sand with sediment discharge.

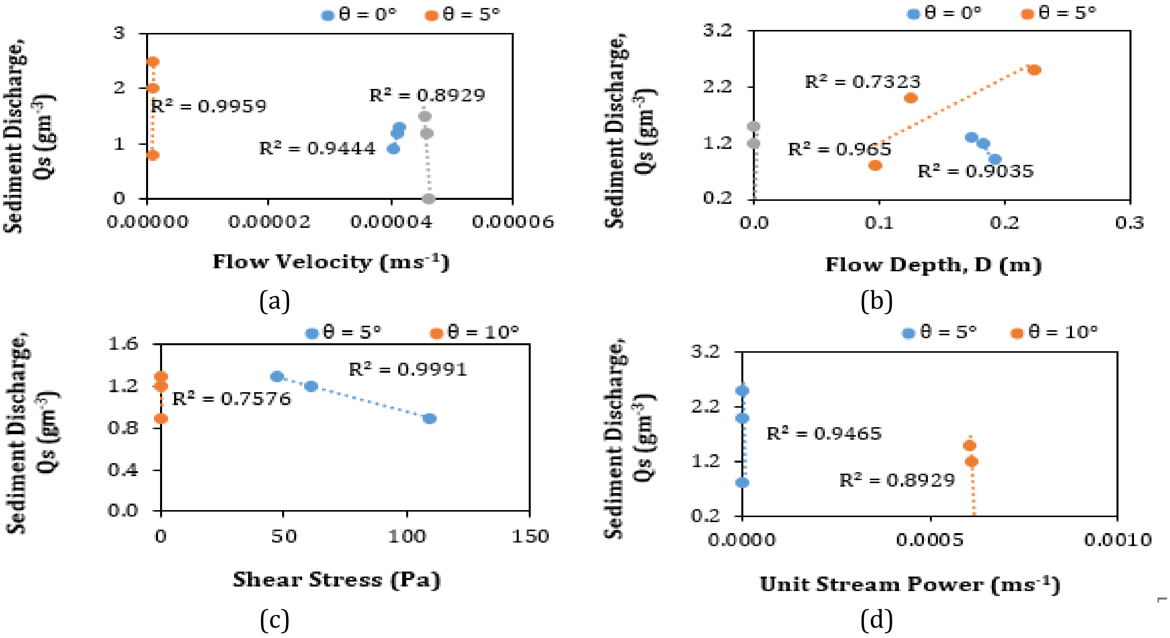

Figure 6. Measured hydraulic parameter (a) flow velocity, (b) flow depth (c) shear stress and (d) unit stream power with sediment discharge at slope θ= 0^0, θ= 5^0 and θ= 10^0 of sand

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Next, Figure 7 of gravel with hydraulic parameters flow velocity, flow depth and shear stress showed the negative graph for related of sediment discharge. Figure. 7(d) showed the good graph line between sediment discharge. This means that higher erosive powers are caused by higher flow rates and higher sediment [14].

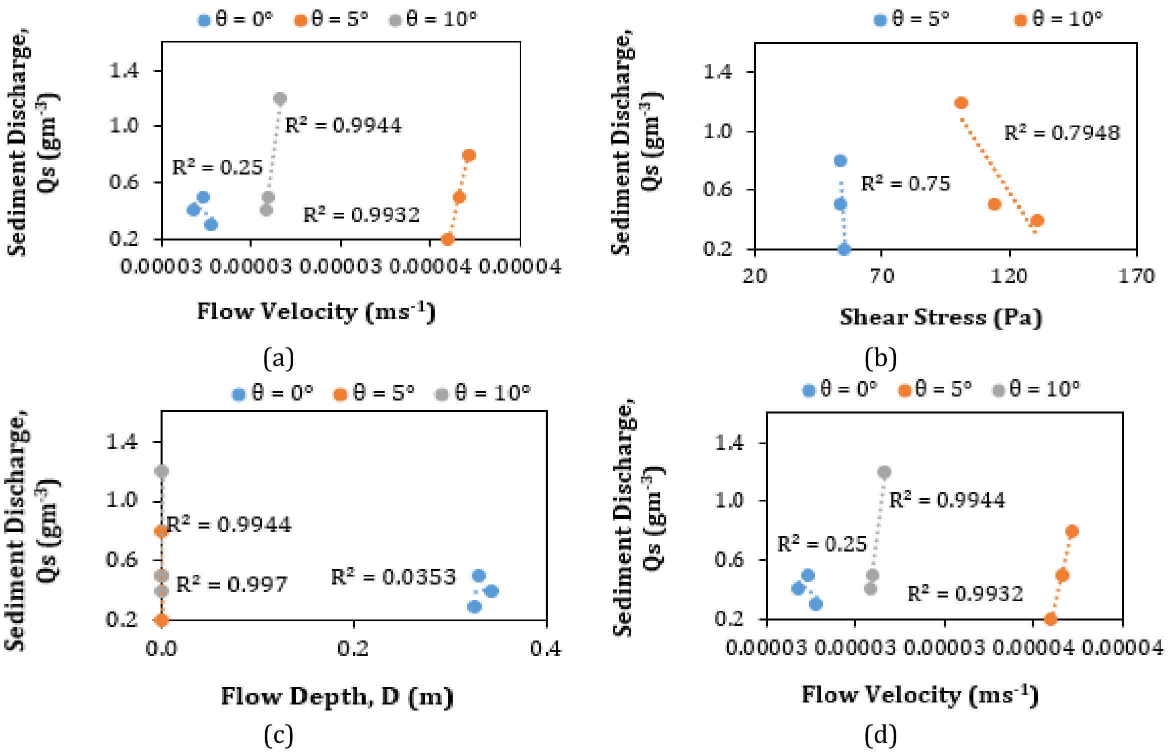

Figure 7. Measured hydraulic parameter (a) flow velocity, (b) flow depth (c) shear stress and (d) unit stream power with sediment discharge at slope $\theta = 0^0$, $\theta = 5^0$ and $\theta = 10^0$ of gravel

4.0 CONCLUSIONS

Several important points may be obtained from the experiment that was carried out to measure and investigate the relations between flow discharge, sediment discharge and hydraulic parameters of different soil surfaces. For flow discharge and sediment discharge on different soil surfaces, the sediment discharge of sand was higher compared to soil surface of gravel. For hydraulic parameters on different soil surfaces, flow velocity was affected on hydraulic parameters. Flow discharge soil surface of sand there was a direct relationship between hydraulic parameters. For relation between sediment discharge and hydraulic parameter more affected than flow discharge. The sediment discharge was higher in soil surface of sand compared to flow discharge because the slope was steeper. Sediment discharge had a positive relation between flow velocity and unit stream power.

5.0 CONFLICT OF INTEREST

The authors declare no conflicts of interest.

6.0 AUTHORS CONTRIBUTION

Mohamad Zahir, N. (Conceptualisation; Methodology; Validation; Formal analysis; Data curation; Investigation; Resources; Writing - original draft)
Suif, Z. (Conceptualisation; Methodology; Validation; Formal analysis; Data curation; Writing - review & editing; Supervision)
Ahmad, N. (Writing - review & editing; Supervision)
Jelani, J. (Writing - review & editing; Supervision)
Hamizah, S. N. (Validation; Formal analysis; Data curation; Investigation)

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