

# Physics on soil erosion in Batang Sinamar, West Sumatra

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**Abstract.** Erosion can be caused by natural events and negative human behavior. Therefore, people need to understand how nature works. This paper would like to reveal the occurrence of soil erosion of the area of Batang Sinamar, West Sumatera based on physics point of view. Through qualitative descriptive analysis method, this research finds some physics concepts that exist on the erosion event such as friction, energy, momentum impulse, and fluid. In order for the community to be more aware of erosion disaster, it is necessary to increase literacy. One of them can be done through the provision of physics enrichment materials in schools. This study concludes that many physical phenomena can be analyzed in the event of erosion that needs to be disseminated to the community, especially the students around.

## 1. Introduction

Soil erosion has become a serious and widely recognized global issue. Nevertheless, we still have difficulty in determining the magnitude and level of erosion [1]. Preventive efforts are required to cope with the worse impact on any disaster [2]. One of the efforts that can be done is through the improvement on community mitigation and preparedness in the face of disaster with a number of competencies [3]. Targeted, systematic and measurable activities that can increase community competence in dealing with disasters are through education.

Education on natural disasters should be given early on. One of them through the integration of learning. Erosion Disaster is one form of natural phenomena that can be explained by using a physics approach. In erosion disasters, there are many physical reviews closely related to the laws of motion in objects, especially the concept of mechanical fluid [4,5]. The mechanical fluid can be explained in two overviews of fluid and the concept of motion contained in the flow of streams.

The explanation of natural phenomena physically aims to provide an explanation of how nature works. Physical explanation in the phenomenon of erosion and flooding aims to provide an overview of the public and the school community in the first and middle level about the existence of physics in everyday life [6]. On that basis, physics learning in schools should be presented contextually [7]. Any explanation given will be more easily absorbed and accepted because the phenomenon can be directly witnessed. Related to this matter, this study aims to provide explanation and physical description of the natural phenomenon of river wall erosion that occurred in Batang Sinamar, West Sumatra.

## 2. Method

This study is a preliminary study using qualitative descriptive phenomenological approach. The selection of this method is based on a discussion of the phenomenon of erosion in terms of the effects



of the phenomenon [8,9]. The object discussed is the phenomenon of Batang Sinamar erosion of the area of Limapuluh Kota, West Sumatra.

The research procedure begins with the observation of the disaster site, finding the cause and analyzing it. Field findings are brought into the Focus Group Discussion (FGD). The final result are the result of mapping the existing physical concepts in erosion events that can be integrated into physics learning in the classroom.

### 3. Results and discussion

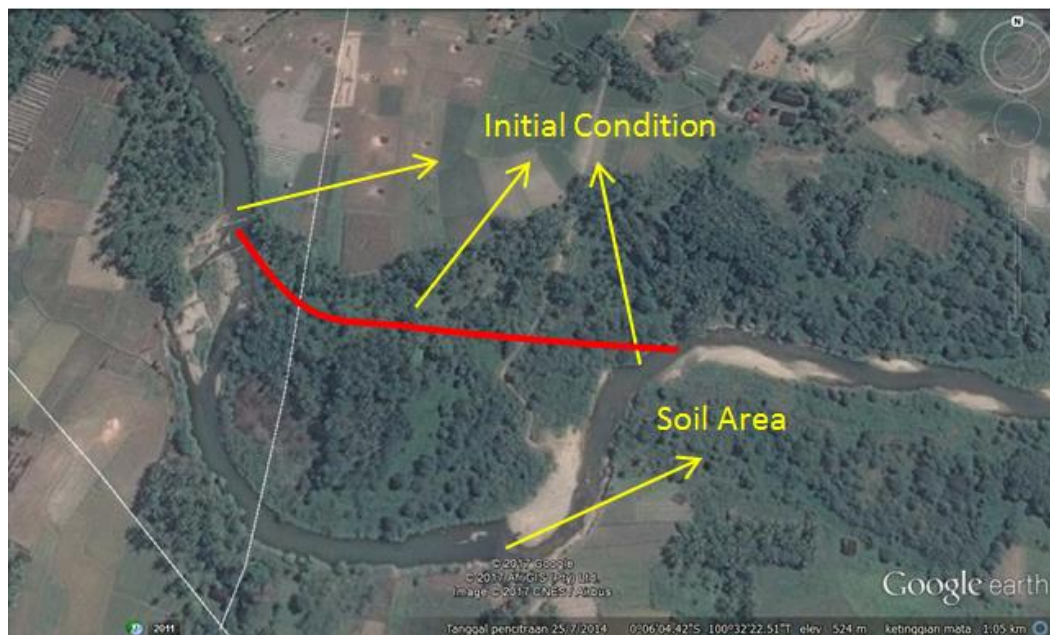
Batang Sinamar is a river that belongs to the periodic river because the water in this river tends to overflow when the rainy season comes and decreases from the dry season. In this study, the object of observation is the part of the Sinamar rod river which is in the river valley so that the slope of the river is relatively smaller and with the depth not too big [10].

Events of erosion of the river wall basically have occurred from the river upstream. In the upper part of the river the form of erosion that occurs to the form of vertical erosion that causes the river to become deeper. In the part of the river basin, the erosion that occurs is horizontal erosion causing the river walls to fall and collapse into the river [11].

In Batang Sinamar, erosion events have occurred in a long time and repeated. This can be seen from the changing topography of the region that has changed quite far. Based on figure 1 and figure 2 shows that there is a change in the position of the river body that has moved due to the brunt of river water every rainy season comes. When the rain comes, the volume in water will increase and the water velocity tends to become larger because the quantity of water in the upstream (source) becomes abundant.



**Figure 1.** Soil erosion in Batang Sinamar.



**Figure 2.** Shifting river bodies (Source:Google Earth).

Physically, the process of shifting the river body occurs due to considerable water discharge that causes the erosion of the soil. Mathematically the water discharge formula is given in equation 1 [12]:

$$v_1 \times A_1 = v_2 \times A_2 \quad (1)$$

where  $v$  is the stream flow velocity and  $A$  is the cross-section of the river represented by the depth of river water and the width of the river surface. So that by reviewing the increase of water debit upstream will cause an increase in river flows velocity because the cross-sectional area of the river is relatively fixed. Equation (1) is the basic equation used to describe how an increase in flow velocity occurs. However, in the real context, the process of shifting and expanding the river body is due to many things. One of them is the uneven riverbed due to the rocks carried by the river. The uneven riverbeds will give the effect of flow changes in turbulence.

In some cases, turbulent flow caused by an uneven riverbed will cause the flow of flow in the area. An uneven riverbed will give the consequence of the value of the cross-sectional area of equation 1 being non-fixed so that the discharge formula is transformed into equation 2

$$\int v_1 A_1 = \int v_2 A_2 \quad (2)$$

with the integral boundary used is the change from the bottom of the river.

The river flow certainly brings a lot of material besides water as the main ingredient for river fillers. With the review of a moving material, it can be stated that the mechanical concept of river flows, in general, is the momentum of impulse, friction, and energy. The moving fluid will provide friction in the river wall as a container of the fluid. Frictional interactions that occur can be expressed through the basic equations of the friction force, namely:

$$F_s = \int N \cdot u \quad (3)$$

where  $N$  is the normal force against the river wall which in this context is represented by the hydrostatic pressure received by the river wall while  $u$  is the coefficient of friction between the surface of the river wall itself. The coefficient of friction is closely related to the surface of the river wall. The rough river wall surface has a larger coefficient of friction causing the frictional force received by the river wall to increase.

In the case of river walls, the roughness of river walls is influenced by the constituent material [13,14]. River walls composed by the majority of the sand content will have a greater friction coefficient compared to the river wall composed of clay. So it can be stated that the river wall composed of sand has the possibility of erosion. In addition, fluid properties can infiltrate into small gaps also contribute to the increase in erosion-causing factors. This is supported by the fact that the sand has a small material density so there is a lot of space or gap between the sand particles and this will allow the outer particles to be carried away by water due to friction and large flow currents. Field facts found in the erosion area are the majority of constituent materials in the form of coarse soils and fine sand soils.

In the condition of matter that moves with velocity  $v$ , it can be considered big kinetic energy carried by the material. For river water, large kinetic energy can be expressed in equations 4 and 5 [15]:

$$E_k = \frac{1}{2}mv^2 \quad (4)$$

$$E_k = \frac{1}{2}\rho Av^3 \quad (5)$$

with  $\rho$  is the density of the river water. This, of course, has a high complexity which in the water of the river itself is not really pure water but many are interfering with other materials such as garbage and materials due to the erosion of the previous land.

These innate material factors will cause the value of the river water type to increase and cause the kinetic energy of the river water to increase. As a consequence of the large kinetic energy, it will lead to an increase in frictional force and river water momentum. This increase in frictional and momentum forces leads to greater erosion [16,17,18].

The last explanation related to the phenomenon of river bank erosion according to the physics point of view is momentum and impulse. Momentum and impulse occur when an object pounding other materials. In the case of river erosion, a collision event will occur to the curved part of the river. Water that carries large kinetic energy will result in massive collisions of the type of collision occurring as a partial collision. This is because at the time of pounding the river wall then the water will try to get into the cracks at the river wall and because this event is sustainable and with great intensity will cause the release of material from the river wall. When the lower part of the river wall is empty due to erosion, the upper part will collapse due to the effects of Earth's gravity and the small material density level [19]. In a long time and without proper handling, erosion can spread further. Topographic changes such as the appearance of horseshoe lakes in the area are one of the impacts of sustained erosion events [20].

Overall erosion events cause harm to humans so it takes an effort to anticipate it. Based on the explanation of the above physical concepts can be formulated an attempt to minimize the possibility of erosion. Among them is by doing reforestation plant roots riding around the river mouth. It aims to bind sand and so the soil indirectly increases the density of the soil itself. In addition, the roots of the plant can retain water and can be the framework of the underlying material. Next is to make terraces to reduce soil contact with river water. Making terraces can also break with the flow of water and slow the flow for short distances. Next is to literate the community not to throw garbage into the river because actually by throwing the waste into the river then the density of the river waters will increase and as a result of the increase will cause the increase of kinetic energy from river water. As has been explained also when the kinetic energy increases then the collision itself will also increase and the friction between river water and the wall becomes much larger.

#### 4. Conclusion

The phenomenon of erosion as one of the disasters can be caused by many factors such as the quantity of river water, the speed of river water flow, the type of river water flow, the river water type, and the river wall. From the physics point of view, the erosion of the river wall can be explained by using the basic approach to impulse momentum, friction force, mechanical fluid, and energy. However, in the explanation and calculation of the value of each of these magnitudes cannot be done directly because the river itself is a very complex system. The complexity of river water is influenced by irregular river



water type, the basic shape and uneven river surface and non-uniform wall material type. So for a mathematical explanation can be used as a follow-up study of this conceptual study.

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