BIS ENERGY AND ENGINEERING

Volume 2 2025 | DOI: 10.31603/biseeng.375
6th Borobudur International Symposium on Science and Technology (BIS-STE) 2024

UNIMMA PRESS
UNIVERSITAS MUHAMMADIYAH MAGELANG

A simple determination of runoff coefficient in open pit mine areas

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Abstract

The runoff coefficient is one of the factors in determining runoff discharge. Determining the coefficient can be done by calculating the slope of an area, then obtaining the appropriate runoff coefficient value. Open-pit mines have characteristic areas that do not have vegetation cover and are commonly included in the slope category >15% with a coefficient value of 0.9. In fact, open-pit mining areas sometimes have land slopes of <15% at some open-pit mining locations. This research aims to determine the runoff coefficient based on the slope of open mining land with the help of google earth, by analyzing contour map data of mining areas in South Kalimantan province. From several open mine locations, it was found that the land slope value ranges from 7% -13% so that the runoff coefficient value for open mines is 0,7.

Keywords

Runoff coefficient, Open pit mine, Google earth

Introduction

South Kalimantan Province is one of the largest mineral-producing provinces in Indonesia. Endowed with abundant natural resources such as coal, rock, and metal, the province, based on data from the Provincial Energy and Mineral Resources Agency in 2022, has 362 mining business permits (IUPs), comprising 200 coal IUPs, 16 metal IUPs, 15 non-metallic mineral IUPs, and 119 rock IUPs, with 12 of these being foreign-owned and the remaining 350 being domestic-owned. The presence of the mining industry has both positive and negative impacts on the surrounding areas, affecting both the economy and the environment. Sound environmental management is key to mitigating the negative impacts of mining processes. One of the significant challenges in mining operations is the presence of substantial amounts of water. Effective water control and management can be achieved through well-planned mine drainage systems.

Published:
May 31, 2025

Selection and Peer-review under the responsibility of the 6th BIS-STE 2024 Committee

The open-pit mining method creates large depressions that can accumulate both surface and groundwater. During heavy rainfall, these pits can flood, resulting in muddy mining faces [1]. Mine drainage is a systematic endeavor implemented in mining operations to prevent, dewater, or divert water ingress into mine openings. This practice aims to mitigate disruptions to mining activities caused by excessive water, particularly during the rainy season [2].

Open pit mine drainage system design requires comprehensive calculations, data analysis, and optimization for informed decision-making. Calculations encompass runoff, design storm, channel, culvert, and sump/pump volumes. Information technology can streamline this process through specialized software applications [3].

Simplified hydrological models, commonly used for peak discharge estimation, can be constructed using multiple methods. The runoff coefficient (C) is a crucial parameter in these models. Asdak (2004) defines the runoff coefficient as the ratio of surface runoff to effective rainfall. Several methods, such as the U.S. Forest Service, Hassing, and Cook methods, are available for determining the runoff coefficient.

The runoff coefficient is determined through field observations and topographic mapping. Factors influencing the coefficient include vegetation, topography, land use, and soil type. By estimating the percentage of the area with varying conditions, a representative runoff coefficient for the catchment can be obtained. The magnitude of the runoff coefficient is affected by factors such as surface soil conditions, catchment area size, and slope.

Mine drainage calculations involve several factors, including:

1. Catchment area: The area of the watershed boundary that is determined by the highest elevation point. To calculate the area, draw a line from the highest point around the sump to form a closed polygon.
2. Runoff coefficient: The ratio between the amount of rainwater flowing above the ground and rainfall. This coefficient is determined based on soil conditions and vegetation.
3. Rainfall intensity: A factor used to calculate runoff discharge.
4. Concentration time: A factor used to calculate runoff discharge

To determine the total of the runoff debit, the calculation of the runoff debit was done using rational equation:

$$Q = 0{,}278 \; x \; C \; x \; I \; x \; A \qquad \text{(eq 1)}$$

Where:

Q = Maximum debit of runoff (m3/h)

C = Runoff coefficient representing the runoff ratio rainfall (mm/h)

A = Rainfall catchment area

The runoff coefficient in open-pit mines has been analyzed using various methods. Different surface areas have varying runoff coefficients, as indicated in the Table 1 below.

Table 1. Runoff coefficient table [4]

Slope (%)	Cover	Runoff coefficient
<3%	Paddy field, Swamp	0,2
	Forest, Plantation	0,3
	Residential area with gardens	0,4
3% - 15%	Forest, Plantation	0,4
	Residential area	0,5
	Sparse vegetation	0,6
	Vegetation-free, Disposal area	0,7
>15%	Forest	0,6
	Residential area	0,7
	Sparse vegetation	0,8
	Vegetation-free, mining area	0,9

The objective of this study is to determine the surface runoff coefficient using a surface method with an application. It is expected that the output of this research will obtain the surface runoff coefficient value for open-pit mines in a simple way.

Open-pit mines are characterized by areas with no vegetation cover, and thus, are often categorized under slopes greater than 15% with a coefficient value of 0.9 [4]. However, open-pit mines sometimes have land slopes less than 15% in certain locations.

Method

Open-pit mining is a surface mining method where mineral resources are extracted from an open excavation can be seen on Figure 1 and 2.

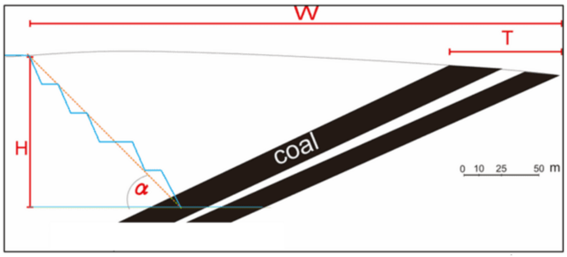

Figure 1. Open-pit mine illustration (coal) [5]

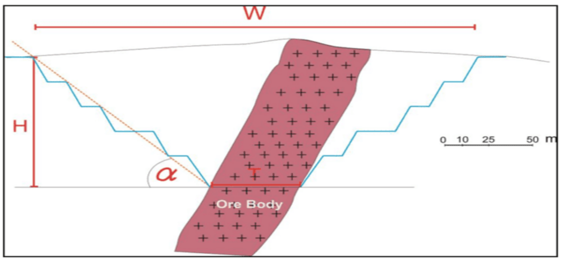

Figure 2. Open-pit mine illustration (mineral) [5]

Watershed delineation is conducted by conducting a topographic survey of the existing area. From this topographic mapping, the correlation of points with the same elevation can be identified to form a boundary in each area. Based on this correlation, the direction of surface runoff towards a common point can be determined (Figure 1 and Figure 2).

Determination of catchment area is done by conducting topographic mapping of the existing area. From this topographic mapping, Runoff Coefficient Determination A slope map was generated from Google Earth imagery by extracting the Digital Elevation Model (DEM).

The study was carried out at an open pit mine in South Kalimantan, equipped with a sump. The exact location was determined using data extracted from Google Earth layers.The slope of the catchment area within the open-pit mining region was determined using the contour map. The derived runoff coefficient values were tabulated.

Results and discussion

The study was conducted in an open-pit mining area in Tapin Regency, South Kalimantan, Indonesia, characterized by the presence of a sump. The specific location was determined through the acquisition of layer data from Google Earth (Figure 3 and Figure 4).

Figure 3. Research location (1)

Figure 4. Research location (2)

Runoff coefficient determination

The determination of runoff coefficient was conducted using slope maps derived from Google Earth imagery. The contour maps of the open-pit mining area were processed to determine the slope of the watershed, and the results were plotted on a table of runoff coefficient values. Example angle of inclination of a slope from Research location can be seen on Figure 5.

Example of calculating the angle of inclination of a slope (picture A)

$$\tan \alpha = \frac{different\ height(m)}{distance\ (m)}$$

$$\tan \alpha = \frac{(86\ m - 63\ m)}{300\ m}$$

$$\tan \alpha = \frac{23\ m}{300\ m}$$

$$\tan \alpha = 0{,}076$$

α = 4,4° → Angle of inclination of a slope 7,6% → **Runoff coefficient = 0,7 based on Table 1.**

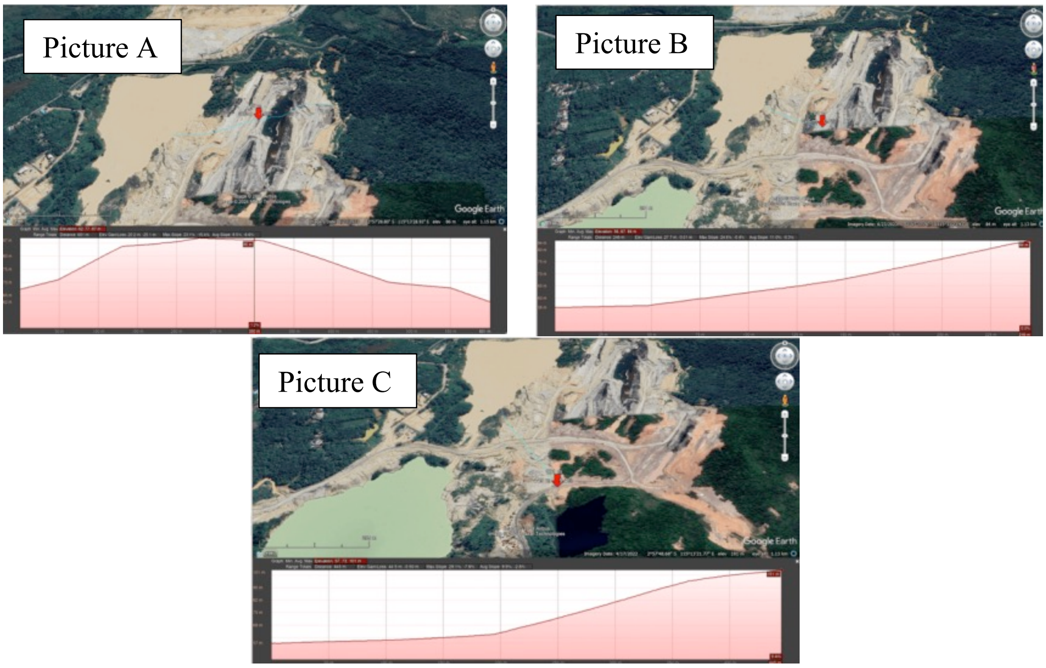

Figure 5. Example angle of inclination of a slope from Research location (1)

Based on the actual slope calculations, the runoff coefficient values obtained are presented in the following Table 2 and example angle of inclination of a slope from Research location can be seen on Figure 6.

Table 2. Runoff coefficient values calculations Research location (1)

No.	Picture	Slope (%)	Runoff coefficient (C)*
1	A	7,6	0,7
2	B	11	0,7
4	C	11	0,7

*Following Table 1

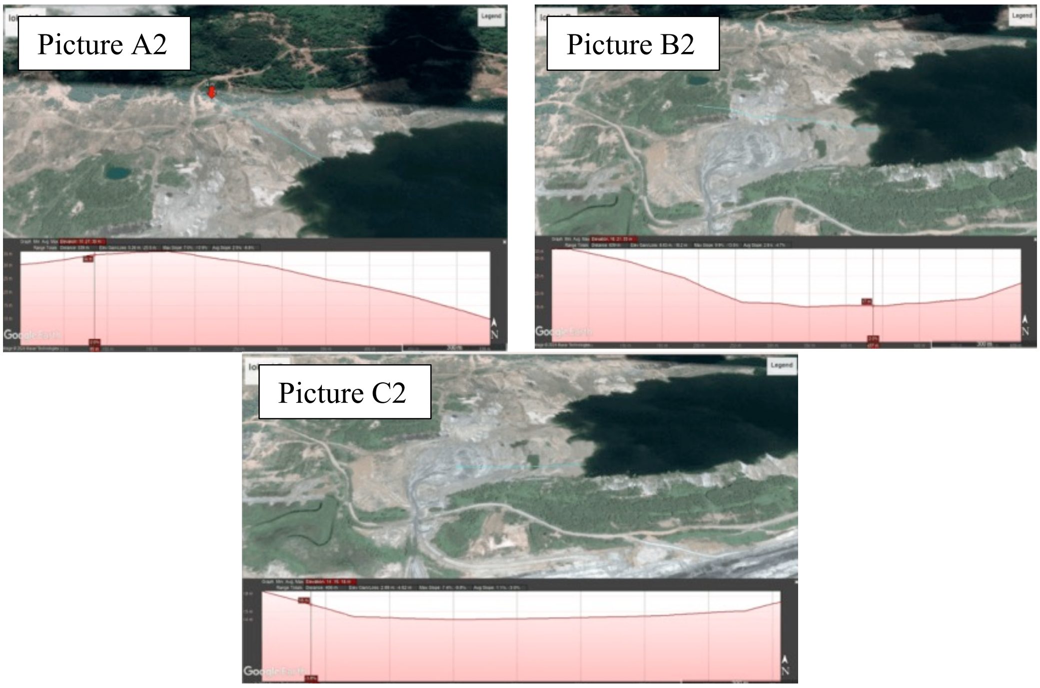

Figure 6. Example angle of inclination of a slope from Research location (2)

Based on the actual slope calculations, the runoff coefficient values obtained are presented in the following Table 3.

Table 3. Runoff coefficient values calculations Research location (2)

No.	Picture	Slope (%)	Runoff coefficient (C)*
1	A 2	6,8	0,7
2	B 2	6,1	0,7
4	C 2	5	0,7

*Following Table 1

Based on data processing, the coefficient value for the open pit mine area was found to be 0.7. The runoff coefficient calculation in this study was conducted using an empirical method, employing a runoff coefficient table based on actual land use types and slope gradients obtained from Google Earth. As a result, the runoff coefficient values used are highly accurate. Accurate runoff coefficient values are crucial for designing effective drainage systems in mining areas, estimating the volume of runoff to be contained or discharged, and playing a significant role in preventing environmental pollution caused by mining waste.

Conclusion

From several open-pit mining locations, it was found that the land slope values ranged from 5% to 11%, resulting in an open-pit mine runoff coefficient of 0,7. Accurate runoff coefficient values are crucial for designing effective drainage systems in mining areas, estimating the volume of runoff to be contained or discharged, and playing a significant role in preventing environmental pollution caused by mining waste.

Acknowledgement

This journal article was authored by Rahma Norfaeda and her research team. The authors bear full responsibility for the content.

References

[1] Endriantho, M.; Ramli, M. Tambang Terbuka Batubara. 2009, 09, 29–40.

[2] Syarifuddin, S.; Widodo, S.; Nurwaskito, A. Kajian Sistem Penyaliran Pada Tambang Terbuka Kabupaten Tanah Bumbu Provinsi Kalimantan Selatan. J. Geomine 2017, 5, 84–89, doi:10.33536/jg.v5i2.132.

[3] Prahastini, S.D.; Gautama, R.S. Perancangan Aplikasi Untuk Sistem Penyaliran Pada Tambang Terbuka. J. Teknol. Miner. 2012, 19.

[4] Gautama, R.S. Sistem Penyaliran Tambang; Penerbit ITB: Bandung, 2019;

[5] Indonesia Keputusan Menteri Energi Dan Sumber Daya Mineral Nomor 1827 K/30/MEM/2018 Tentang Pedoman Pelaksanaan Kaidah Teknik Pertambangan Yang Baik.; Indonesia, 2018; pp. 93–94;.