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RESEARCH ARTICLE

Geomorphology and Geology Studies Using Digital Elevation Model (DEM) Data In the Watershed Area of Kampar Regency, Riau Province

Husnul Kausarian [1,*], Sandy Masdriyanto[1], Batara[2], Adi Suryadi[1], Muhammad Zainuddin Lubis[3]

[1]*Geological Engineering Program, Universitas Islam Riau, Jl. Kaharuddin Nasution 113,Pekanbaru 28284, Indonesia.*
[2]*State Key Laboratory of Marine Geology and School of Ocean and Earth Science, Tongji University, Shanghai, China.*
[3]*Department of Geomatics Engineering, Politeknik Negeri Batam. Batam, Indonesia*

* Corresponding author : husnulkausarian@eng.uir.ac.id
Tel.:+62 761 674674
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Abstract

This research was conducted in the area of Kampar Regency, Riau Province .it was located at coordinates including 01° 00' 40" - 00° 27' 00" South Latitude and 100° 28' 30"- 101° 14' 30" East Longitude. The purpose of this study was to determine the geological condition of the watershed, and it was determined the geomorphological condition of the watershed, to determine the number of divisions of the watershed, to determine the relationship between the watershed and rainfall, to determine the geological and geomorphological relationship with the watershed in the study area. The method used starts from field sampling, core description, distribution analysis of geological data, geomorphology, watershed analysis, and analysis of rainfall. Based on the analysis of the distribution of geological data in the research area, there were 12 geological formations from the results of geological mapping, namely: the Sihapas Formation, the Telisa Formation, the bekasap formation, the Bahorok Formation, the Farmer Formation, the Manggala formation, the Talang Akar formation, the Telisa Atas formation, the Palembang Tengah formation, Basement, members of the Lower Palembang formation (Air Berakat), members of the Upper Palembang formation (Muara Enim). In subsurface geology there were 8 well points in the study area, 2 correlations were carried out, namely the 1st correlation between CR-04, CR-03, CR-01, CR-02, CR-08, and the 2nd correlation between CR-05, CR-06, CR- 07. Geomorphological conditions were divided into 4 namely lowland areas, low hill areas, hilly areas, and high hill areas. The watersheds in the research area were divided into 2 watersheds, namely the Kampar and Siak watersheds. Watershed rainfall observations in the study area for 5 years from 2015 – 2019 were located at 5 different stations, with fluctuating rainfall intensity

Keywords: *Geology, Geomorphological Analysis, Watershed Analysis, Rainfall*

1. Introduction

A watershed is an area that supplies rivers with water and sediment in the form of a basin bounded by water-dividing lines. The water dividing line is the line that connects the highest points that limit the drainage basin. In a watershed system, the main river, branches, and order as a whole form a drainage pattern. Usually, this pattern is controlled by geological structures such as joints, bed slopes, folds, faults, rock types, and so on.

The upstream watershed area is characterized as a conservation area, has a higher drainage frequency, is an area with a greater slope (greater than 15%), is not a flood area, and the regulation of water use is determined by the drainage pattern. While the downstream area of the watershed is a utilization area, the drainage density is smaller, is an area with a small to very small slope (less than 8%), and in some places, it is a flood area (Asdak, 1995).

The research area is located in Kampar Regency, Riau Province, which is one of the largest districts in Riau Province and part of the Central Sumatra Basin which has a diversity of geological processes. With such a large area, it can be an interesting object of research study because it has geological aspects, especially geomorphology, and watersheds. The control of geological processes greatly influences the formation of geomorphology and watersheds in the study area, therefore an understanding of the geological conditions, geomorphology, and watershed characteristics is very important to conduct more studies.

2. Study Area

Geographically the study area is located at 01° 00' 40" - 00° 27' 00" South Latitude and 100° 28' 30" - 101° 14' 30" East Longitude which is included in the geological map sheet 13-0617_0717 Kampar Regency (M.C.G Clark dkk 1982).

2.1 Geology & Physiography

Geologically, Kampar Regency is in the Central Sumatra Basin, a back arc basin(back-arc basin) that developed along the west and south coasts of the Sunda Shelf in southwestern Southeast Asia. Rocks from the agesTertiarywhich were lifted to the surface using a graben structure and then deposited with tertiary sedimentary rocks in the basin and produced tertiary intrusive rocks. Erosion results from intrusive rocks that are carried away and settle around the river flow, producing sediment alluvial (Koesomadinata and Matasak, 1981).

The Central Sumatran Basin was formed due to the subduction of the Indian Ocean plate which moved relatively to the north and infiltrated under the Asian Continental plate (**Figure 1**).

The Central Sumatra Basin was formed at the beginning of the Tertiary and is a series of structures helped digseparated by blockshorst, resulting from an extensional force trending East - West. Tertiary rocks are exposed from Bukit Barisan in the west of Sumatra to the plains of the east coast of Sumatra. Several areas helped digthis is filled with non-marine clastic sediments and lake sediments (Eubank dan Makki 1981 dalam Heidrick, dkk, 1993).

Based on the Geological Map of the Pekanbaru Sheet and the Geological Sheet of Solok by Hendrick & Aulia 1996 (2nd edition) and P.H Silitonga & Kastowo 1995 (2nd edition) in the study area there are 21 formations. These formations are: (**Figure 2**).

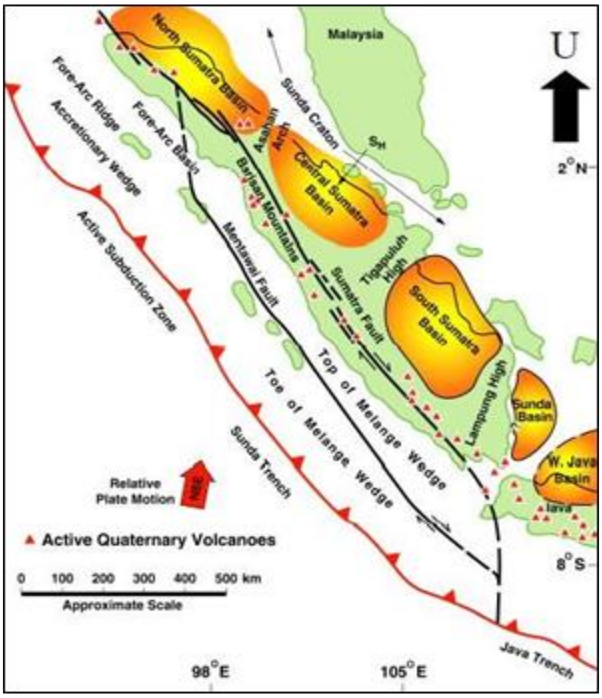

Fig 1. Regional Map of the Central Sumatra Basin (Heidrick and Aulia,1993).

Fig 2. Regional Geology of Research Area

Tup (Farmer Formation) Consists of carbonaceous mudstone, lignite, a little siltstone, and sandstone. Tmt (Telisa Formation) Consists of gray limestone mudstone, thin limestone, siltstone, and a little glauconite sandstone.
Tms (Sihapas Formation) Consisting of Conglomerate Sandstones, Siltstone, and Tanjung Pauh Members (Pukt) Consisting of dominant Muscovite, Chlorite, Carbonate Schist with Strong Liciation.

The Pematang Formation (Tlpe) consists of mudstone, conglomerate, breccia, and conglomerate sandstone. Soft Granite (Mpiul) Consists of Leaf Granite, Tuhur Formation (Mtr) Members of Batusabak, and Shale of Tuhur Formation (Trts) Consists of Batu slate, Shale, Chert intercalated marl shale, Radiolite, eroded black shale, and metamorphosed Grewake thin layers.

The Lower Member of the Palembang Formation (Tpl) Consists of claystone with some intercalated sandstones and glauconitic sandstones.

The lower members of the Telisa Formation (Tmtl) consist of clay marl, lignite sandstones, tuff, andesitic breccias, and glauconitic sandstones. Filite and Shale Members of the Kuantan Formation (Pcks) Consist of Shale and Filit, inserts of Batusabak, Quartzite, Batulanau, Chert, and Lava Flows.

The lower members of the Ombilin Formation (Tmol) consist of quartz sandstone containing mica intercalated with arkose shale clay, quartz conglomerate, and coal.

The lower members of the Kuantan Formation (Pckq) consist of quartzite and quartz sandstone with inserts of slate, shale, volcanic rock, chlorite tuff, conglomerate, and chert.

Limestone Members of the Kuantan Formation (Pckl) Consist of Batusabak Limestone, Filite, Shale, and Quartzite. The Middle Member of the Palembang Formation (Tpm) Consists of sandstone, sandy loam, lignite inserts, and tuff. Porphyritic Quartz (Qp) is Composed of Porphyry Quartz with quartz phenocrysts.

Young Alluvium (Qh) Consists of gravel, sand, and clay. The Minas Formation (Qpmi) consists of gravel, distribution of gravel, sand, and clay. Qtr Consists of decomposed minor volcanic rocks. River Alluvium Consists of Clay, Sand, Gravel, and Boulders. Inseparable Volcanic Material (Qtau) Consists of Lahar, and Conglomerate.

3. Methodology

3.1 Research Object

To carry out all research methodologies, the researcher summarized all research steps. The research steps consisted of several stages: secondary data processing in the form of geological mapping data, subsurface geology, geomorphological observations from DEM, watershed observations, and rainfall observations.

Analysis of the data used in this research started with geomorphological analysis and watershed analysis DAS.

3.2 Geomorphological analysis

Geomorphological analysis includes morphographic, morphometric and morphogenetic aspects.

3.2.1 Morphography

Broadly speaking, the description of the shape of the earth's surface can be divided into: plains, hills or mountains, volcanoes and valleys. The description of the absolute landform based on the difference in elevation can be seen in **Table 1**.

Table 1. Description of Absolute Landforms Based on Differences in Altitude (Van Zuidam,1985).

Height (meter)	Description
< 50	Lowland
50 – 100	Inland lowland
100 – 200	Low Hills
200 – 500	Hills
500 – 1.500	High Hills
1.500 – 3.000	Mountains
> 3000	High Mountains

In addition to the landform above, in this morphographic analysis there are supporting data in the form of flow pattern data shown in table 2 following:

Table 2. Modified Flow Patterns (Howard, 1967)

Modified Flow Pattern	Characteristics
Subdendritic	Generally Structural
Pinnate	Fine rock texture, easily eroded
Anastomatic	Floodplain, delta/swamp
Dichotomic	Alluvial Fan, delta
Subparallel	Elongated Slope, controlled by the form of elongated hill land
Colinear	Alignment of the land form with fine material (sandbar)
Subtrellis	The land form is parallel elongated
Directional Trellis	Sloping Homoclin (gisik shoals)
Bend Trellis	Elongated fold
Fault Trellis	United branch / scatter, fault parallel
Angulate	Burly, fault in sloping area
Karst	Limestone

3.2.2 Morphogenetic

A process of formation of the earth's surface to form plains, hills, mountains, volcanoes, plateaus, valleys, slopes, and drainage patterns. The known geological processes are endogenous and exogenous.

Endogenous processes are influenced by forces or forces from within the earth's crust, thereby changing the shape of the earth's surface. Processes from within the earth's crust include intrusion, tectonics, and volcanism. The intrusion process will produce intrusive hills, the tectonic process will produce folded, faulted, and fractured hills, the volcanism process will produce volcanoes and tephra dunes. As a result, climatic influences can be referred to as physical and chemical influences. Exogenous processes tend to change the earth's surface gradually, namely the weathering of rocks.

3.2.3 Morphometry

Where is a quantitative assessment of the shape of the land a supporting aspect of morphography and morphogenetics thus the qualitative classification will be more assertive with clear numbers? Variations in the slope values obtained were then grouped based on the slope classification according to van Zuidam (1983, in Hindartan, 1994) that the slope class was named. The technique for calculating the slope of the slope can be done using a grid cell technique measuring 2 x 2 cm on a topographic map scale of 1: 12,500.

The classification of the slope can be seen in **Table 3** below this :

Table 3. Classification of Slope Based on Van Zuidam (1983, in Hindartan (1983, dalam Hindartan, 1994).

Classification	Tilt		Height Difference (m)	Coloring
	Percent (%)	Degree (°)		
Flat	0 – 2	0 – 1,15	< 5 m	
Slightly sloping	2 – 7	1,15 – 4	5 – 25 m	
Sloping	7 -15	4 – 8,5	25 – 75 m	
Rather steep	15 -30	8,5 – 16,7	75 – 200 m	
Steep	30 – 70	16,7 – 35	200 – 500 m	
Quite steep	70 – 140	35 – 54,5	500 – 1000 m	
Very steep	> 140	> 54,5	> 1000 m	

3.3 Watershed

Watershed analysis includes aspects of watershed boundary determination, river network analysis and hydrological analysis.

3.3.1 Determination of watershed boundaries

Determining watershed boundaries is based on topographic maps (DEM) and river flow maps. Determining the watershed boundaries is based on the scale of the watershed mapping. The determination of the watershed mapping scale is determined based on the area of each watershed following the following provisions.

3.3.2 River Network Analysis

The ordo river is the branching position of the river channel in its sequence to the main river of a watershed. In addition, the more river orders, the larger the watershed area, and the overall length of the river channel will be longer. Based on the Strahler Method, the most upstream river channel that has no branches is called the first order (order 1), the meeting between the first orders is called the second order (order 2), and so on until the main river is marked with the largest order number.

The number of river channels for an order can be determined by the index number which states the level of river branching (bifurcation ratio) which is obtained from the quotient between the number of one order divided by the number of the next order. In Schumm (1956), the river branching level index (Rb) can be expressed in the following circumstancest:

1 Rb < 3: The river channel will have a rapid rise in the flood water level, while the decline is slow.
2 Rb > 5: The channel has a rapid rise in the flood water level, as well as a rapid decline.
3 Rb 3 - 5: The river channel has a rise and fall of the flood water level that is not too fast or not too slow.

3.4 Hydrological Analysis

Hydrological analysis includes the calculation of average daily, monthly and yearly rainfall intensity. This analysis was carried out using rainfall intensity data from the Riau BMKG (Meteorology, Climatology and Geophysics Agency) for 5 years starting from 2015 to 2019 in the Kampar Regency area. The rainfall observation stations in the study area are: Bangkinang Station, XIII Koto Kampar Station, Kampar Kiri Station, North Kampar Station, Petapahan Raya Station, Mining Station.

4. Result and Discussion

In the research area, there is data availability in the form of 8 core points, rainfall data from BMKG for 5 years (2015 – 2019), a location map of the core point research area, a location map of geological mapping research, a regional geological map of the research area, and *DEM* research area.

4.1 Geological Analysis

The distribution of geological data is taken from secondary data, where this secondary data is geological mapping data in the study area. Kampar Regency itself is located on the Pekanbaru regional geological sheet prepared by (M.C.G. Clarke, W. Kartawa, A. Djunuddin, E. Suganda, and M. Bagdja, 1982) and the Solok regional geological sheet prepared by P.H Silitonga and Kastowo (1995). Geological mapping data consists of 8 previous research locations in 5 Districts, namely: Kuok District, Koto Kampar Hulu District, XIII Koto Kampar District, Bangkinang District, and Kampar Kiri District, previous researchers consisted (Brinda June Ferdana, 2018, M. Revanda Prastya, 2019, Fahrul Rahman, 2019, Dilla Permata Sari, 2018, Seppia Khairani, 2018, Yoan Pratama, 2019, Indah Novita, 2018, Rahmat Adlan, 2018) **(**Figure 3).

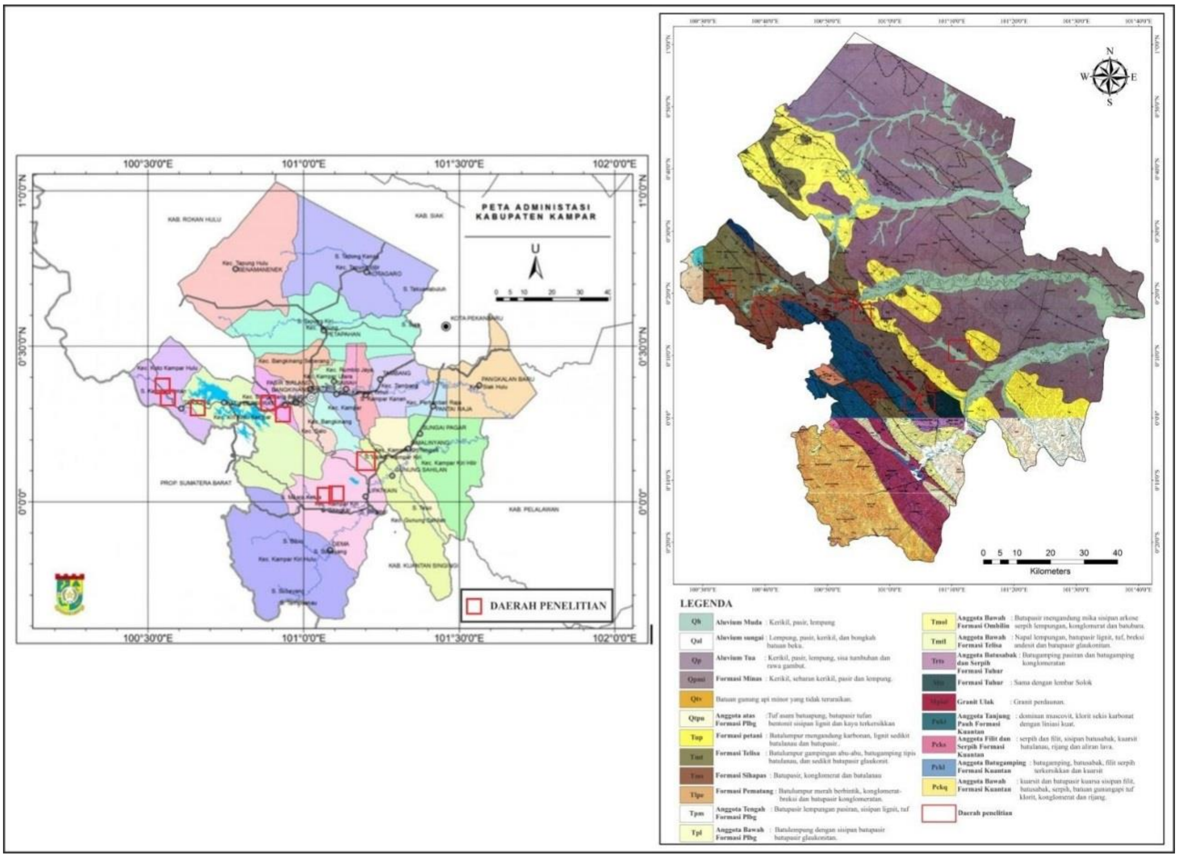

Fig 3. Geological mapping data collection location and Administrative Map.

Based on the results of geological mapping, it was possible to analyze the distribution of geological data in the watershed area of the research area. There are 10 geological formations, namely: the Sihapas Formation, the Telisa Formation, the Besap Formation, the Bahorokformation, the Farmer Formation, the Manggala Formation, the Talang Akar Formation, the Upper Member of the Telisa Formation, the Middle Member. the Palembang Formation, the Bahorok Formation, and the Lower Member of the Palembang Formation (Air Berakat), along with the explanation: The Sihapas Formation has 2 rock units namely: a siltstone unit and a claystone unit. Where this unit is in the Bangkinang District and XIII Koto Kampar District. The siltstone unit consists of one lithology, namely siltstone and the claystone unit consists of 2 types of lithology, claystone, and sandstone. **(figure 4)**

The Telisa Formation consists of 3 rock units: siltstone units, claystone units, and carbonate claystone units. Where this unit is located in the District of Koto Kampar Hulu, District of Bangkinang, and District of Kuok. The siltstone unit consists of one lithology, namely siltstone, the claystone unit consists of 2 types of lithology, namely claystone and carbonate shale claystone, and the carbonate claystone unit consists of 3 types of lithology, namely carbonate shale claystone, sandstone, and siltstone.

The Bekasap formation contains only one rock unit, namely the sandstone unit. Where this unit is located in Koto Kampar Hulu District. This unit consists of fine sandstone lithology to coarse sandstone and siltstone.

The bekasap formation contains only one rock unit, namely the sandstone unit. Where this unit is located in Koto Kampar Hulu District. This unit consists of fine sandstone lithology to coarse sandstone. (Figure5).

Fig 4. Sihapas Formation (A) Siltstone units (B) Claystone units.

Fig 5. Bekasi Sandstone Formation

The Bahorok Formation consists of 3 rock units: slate, schist, and sandstone. Where this unit is located in XIII Koto Kampar District, Kampar Kiri District, and Bangkinang District. Slate consists of 3 types of lithology, namely slate, quartzite, and sandstone. The schist unit has 3 types of lithology, namely schist, slate, and sandstone units consisting of several lithologies, namely sandstone, siltstone, claystone, and conglomerate.

The Farmer Formation consists of 2 rock units, namely sandstone units and siltstone units. Where this unit is located in Kampar Kiri District. The sandstone unit and siltstone unit both consist of 2 types of lithology, namely fine sandstone, and siltstone.

In the Menggala formation, there are 2 rock units, namely sandstone units and conglomerate units. Where this unit is located in Kouk District. The sandstone unit has 2 types of lithology, namely sandstone and conglomerate and the conglomerate unit has 1 lithology, namely conglomerate.

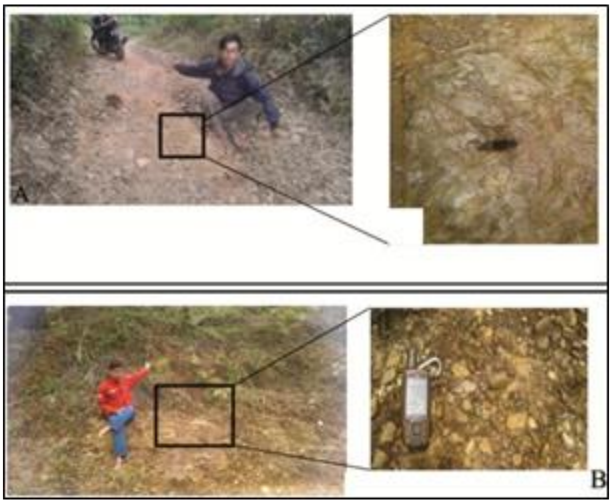

Fig 6. Menggala Formation (A) Sandstone Unit and (B) Conglomerate Unit.

Fig 7. Upper Members of the Claystone Unit Telisa Formation.

The Talang Akar Formation contains only one rock unit, namely the sandstone unit. Where this unit is located in Kampar Kiri District. This sandstone unit has 2 types of lithology: conglomerate and conglomerate sandstones.

The upper part of the Telisa Formation contains only one rock unit, namely a claystone unit. Where this unit is located in Kampar Kiri District. This unit has 3 types of lithology namely claystone, siltstone, and sandstone (figure 7).

The Central Part of the Palembang Formation has 3 rock units namely conglomerate units, conglomerate sand units, and claystone units. Where this unit is located in Kampar Kiri District. The conglomerate unit has 2 types of lithology, namely fine sandstone and conglomerate sandstone, the conglomerate sand unit has 2 types of lithology, namely conglomerate sandstone and coarse sandstone and the claystone unit has 3 types of lithology, namely claystone, sandstone, and non-carbonate siltstone.

The lower part of the Palembang Formation has only one rock unit, namely the carbonate siltstone unit. Where this unit is located in Kampar Kiri District. This carbonate siltstone unit has a lithology, namely siltstone.

It can be concluded that from the previous 8 research locations, the research area has a basement with schist, slate, and quartzite lithology that is Permian to Triassic in age, and almost all research areas have sandstone lithology and several other lithologies such as claystone, siltstone, and conglomerate that are Tertiary age with from the Early Miocene to the Late Miocene.

The stratigraphy in the study area is based on the regional geology of the Pekanbaru sheet and the regional geology of the Solok sheet.

4.2 Subsurface Geology

Subsurface geology was taken at the exact research area in Rumbio Jaya, Kampar Regency, consisting of 8 well points. Drilling depth taken up to 4 meters into the ground**(Figure 8).**

Fig 8. Core Retrieval Point Locations.

4.2.1 Core Data Analysis

Core data analysis was carried out by means of a description including grain size, color in each core layer. The cores that are described include from #CR-01 to #CR-08. The results obtained after being described are as follow in table 4.

CR-01 was drilled to a depth of 150 cm consisting of 6 layers having an elevation of 18 m. #CR-01 is dominated by medium-coarse sand sediments, there are also very fine-fine sand sediments, clay, and also silt. Coarse sand sediment contains a small amount of gravel with a size of 0.5 cm. There are also organic traces in the form of fine plant roots. #CR-02 was drilled to a depth of 250 cm consisting of 8 layers having an elevation of 50 m. #CR-02 is dominated by fine-coarse sand sediments. There is gravel with a size of 0.3 - 3 cm and there are organic traces in the form of small to rather large plant roots.

#CR-03 was drilled to a depth of 350 cm consisting of 6 layers having an elevation of 22 m. #CR-03 is dominated by fine sand and silt sediments. There are organic traces of plants in the form of fine roots. #CR-04 was drilled to a depth of 200 cm consisting of 3 layers having an elevation of 22 m. #CR-04 is dominated by fine sand sediments. No pebbles or roots were found.

Table 4. Core data

No	Core Name	Thickness (m)	Coordinate
1	#CR – 01	1,5	0°21'6.20"N , 101° 7'30.40"E
2	#CR – 02	2,5	0°20'7.59"N, 101° 7'32.90"E
3	#CR – 03	3,5	0°21'36.30"N, 101° 7'35.30"E
4	#CR – 04	1,95	0°21'36.30"N, 101° 8'30.90"E
5	#CR – 05	3,2	0°21'29.00"N, 101° 9'40.60"E
6	#CR – 06	4	0°21'04.9"N, 101° 9'39.8"E
7	#CR – 07	2,5	0°19'54.3"N, 101° 9'45.7"E
8	#CR – 08	3,5	0°19'58.6"N, 101° 8'04.6"E

#CR-05 was drilled to a depth of 200 cm consisting of 5 layers having an elevation of 19 m. #CR-05 contains very fine sand sediments - gravel, as well as silt. There are pebbles with a size of 1-4 cm and in almost every layer organic traces in the form of fine roots are found. #CR-06 was drilled to a depth of 400 cm consisting of 5 layers having an elevation of 27 m. #CR-06 is dominated by fine - medium sand sediments, and also silt. In each layer, organic traces in the form of fibrous roots were found**.**

CR-07 was drilled to a depth of 250 cm consisting of 4 layers having an elevation of 18 m. #CR-07 is dominated by fine-coarse sand sediments, and also silt. There is gravel with a size of 1.5 cm, and also in each layer organic traces in the form of fibrous roots are found. #CR-08 was drilled to a depth of 350 cm consisting of 7 layers having an elevation of 16 m. #CR-08 is dominated by fine-coarse sand sediments, and also silt. There is gravel with a size of 0.2 - 5 cm, and also in each layer organic traces in the form of fine roots are found.

Based on the results of the subsurface geological analysis that the study area is dominated by sand sediments. Overall the subsurface layer consists of gravel sand to fine sand, silt, and clay. In layers close to the surface, some organic materials such as plant roots are found.

4.3 Subsurface Geological Correlations

In the research area there are 2 correlations that can be done, namely:

4.3.1 Correlation 1

This correlation correlates 5 subsurface geological data, namely CR-04, CR-03, CR-01, CR-02, CR-08. Each core has a different elevation where CR-01 is 2 meters lower than CR-04 and CR-03, CR-01 and CR-08 are 32 meters lower and 34 meters lower than CR-02. From this difference in elevation CR-02 is the highest area in the study area. These 5 cores have the same sediment in each core, after it is interpreted that fine sand sediments in core CR-04 at a depth of 39 cm - 195 cm can be correlated with core CR-03 at a depth of 100 - 151 cm.

The CR-03 core with silt sediment at a depth of 180 cm – 200 cm can be correlated with the CR-01 core at a depth of 135 cm – 145 cm. CR-01 has moderate to coarse sand sediments at a depth of 35 cm - 58 cm which can be correlated with CR-02 at a depth of 206 cm - 250 cm. In CR-02 it has fine sand sediments at a depth of 144 cm - 161 cm which can be correlated with CR-08 at a depth of 0 cm - 52 cm (figure 9).

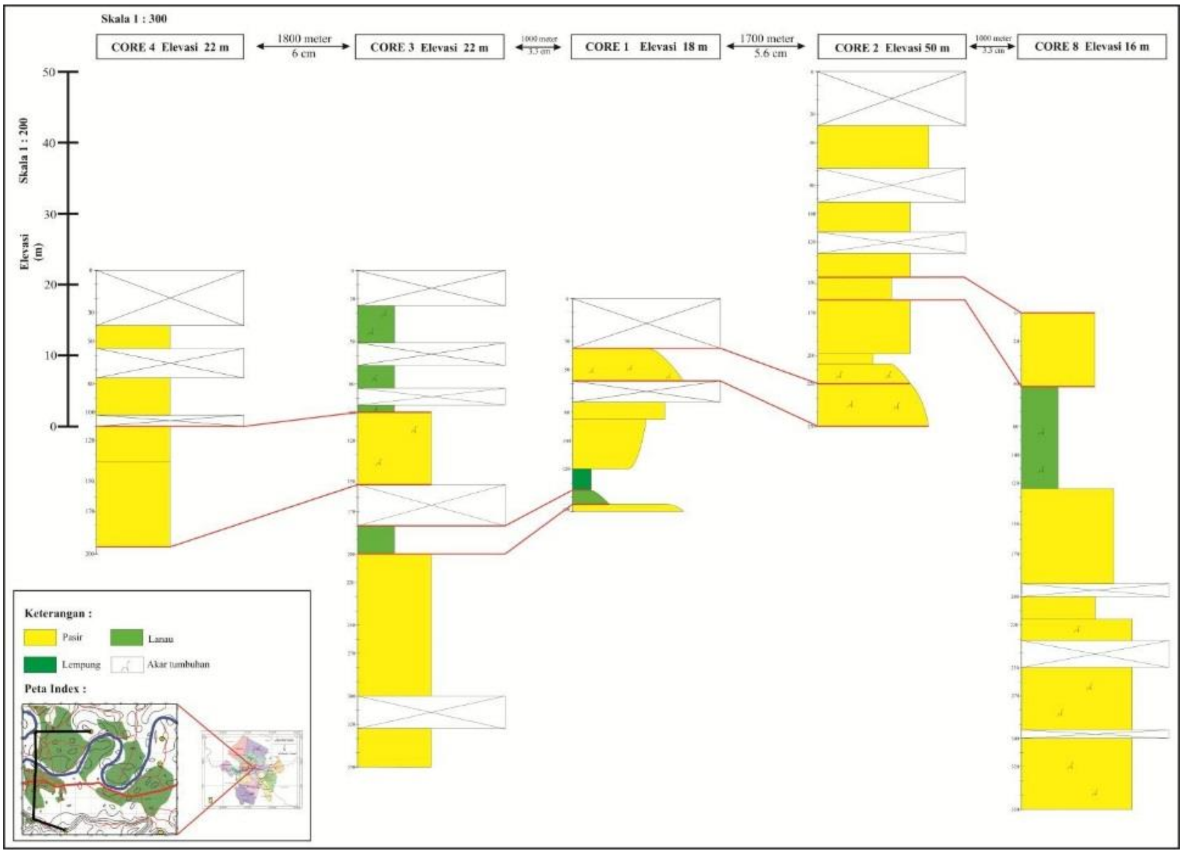

Fig 9. correlation CR-04,CR-03,CR-01,CR-02,CR-08.

4.3.2 Correlation 2

From the core data after being correlated it can be interpreted that silt sediment CR-05 with a depth of 0 cm – 20 cm can be correlated with silt sediments at CR-06 with a depth of 0 cm – 179 cm, but cannot be correlated with CR-07 because at a depth 0 cm – 156 cm found fine - coarse sand sediments. CR-06 with silt sediments at a depth of 0 cm -179 cm can be correlated with CR-07 with silt sediments at a depth of 156 cm - 241 cm. This correlation can be interpreted that the further south or towards CR-07, the coarser the sediment is deposited (Figure 11).

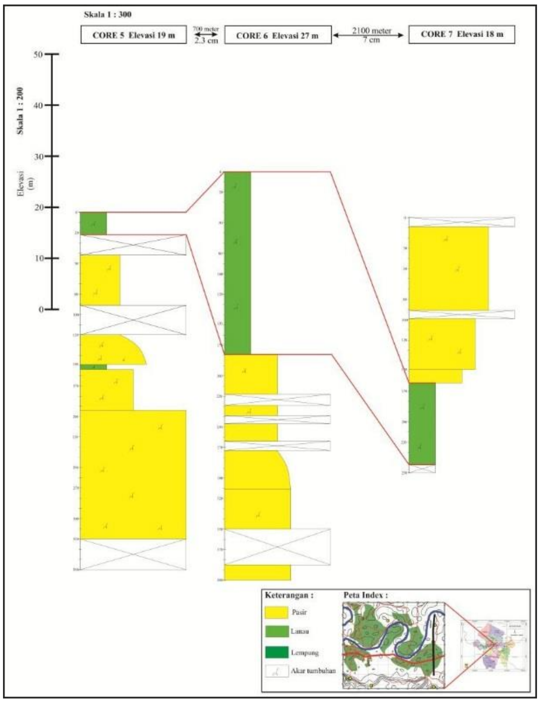

Fig 10. Correlation CR-05,CR-06,CR-07

The sediment deposition pattern on these two correlations can be interpreted as a repetition of the sedimentation pattern smoothing upwards (*Graided Bedding*) then coarse up (*cross bedding*). This pattern was found in CR-01, CR-02 and CR-08. The following is the overall core results from the results of the two correlations.

4.4 Geomorphology and Watershed

Geomorphology and watershed consisting of geomorphological analysis of the Kampar area, division of the Kampar watershed , Rainfall, Relationship of rainfall to Watershed Areas , Relationship of geomorphological conditions to Watershed Areas .

4.4.1 Geomorphological Analysis of Kampar Area

Geomorphological analysis of the Kampar area is interpreted based on the absolute landform based on the difference in elevation according to (Van Zuidam 1985). Where this geomorphology is divided into 4, namely:

1. Lowland Region

Low-lying areas with elevation (of -16 m) - 110 m are shown in dark green, located in the northeastern part of the study area spread from southeast-northwest with a total distribution of 60% having lithology in the form of sediments such as sand, clay, silt, gravel, gravel to lumps. This is based on the regional geological comparison of Pekanbaru.

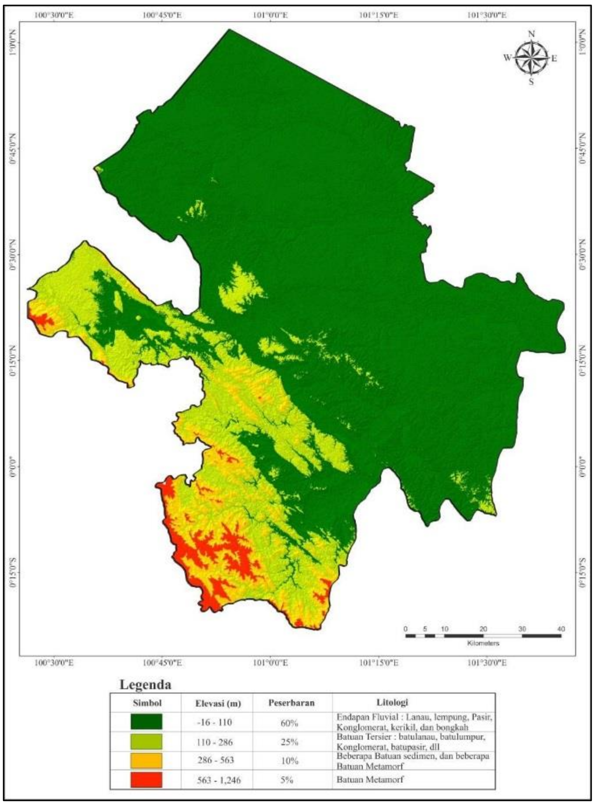

Fig 11. Sedimentation deposition pattern.

2. Low hills area

Low hill areas with an elevation of 110 m - 286 m are shown in light green, located in the middle of the study area spread from the Southeast-Northwest with a total distribution of 25%, there is lithology in the form of sediments of Tertiary age. In the form of mudstone, sandstone, siltstone, conglomerate, glauconite sandstone, and carbonate sandstone. This refers to the regional geological comparability of the Pekanbaru Sheet and the Solok Sheet.

3. Hilly Area

Hilly areas with an elevation of 286 m - 563 m are shown in yellowish-green to yellow colors. Located in the Southwest to the South of the study area spread from Southeast-Northwest with a distribution of 10%. There is lithology in the form of sedimentary rocks and some metamorphic rocks. This refers to the regional geological comparability of the Pekanbaru Sheet and the Solok Sheet.

4. High Hills Area

High hilly areas with an elevation of 563 m to 1,246 m are shown in orange - red. It is located in the southwest part of the study area which is spread from southeast to west with a distribution of 5%. There is a lithology in the form of metamorphic rock.

4.5 Watershed division

In the study area there are 2 large watersheds, namely Kampar and Siak watersheds (Table 7).

Siak watershed is included in Kampar Regency and is a large watershed. Because the headwaters of the Siak River Basin are in the Tapung Hulu District and Tapung District. This watershed has 2 main rivers, namely the Right Tapung River and the Left Tapung River. Where the Tapung Kanan River has a length of 175.60 km and has a dendritic flow pattern, the Tapung Kanan River has the highest elevation at 95.1 m with the lowest point at 4 m.

The Tapung Kiri River has a river length of 123.1 km, has a dendritic flow pattern, the Tapung Kiri River has the highest elevation at 140 m with a lowest point of 8 m. The Siak watershed has an area of 3880.93 km22 or 388,093 Ha with the highest elevation of 158 m and the lowest point of -16m.

Table 7. Watershed characteristics

Characteristics	Name	
	Siak	Kampar
Large (Ha)	388.093 Ha	676.389 Ha
Length of Main River (Km)	175,60 km & 123,1 km	424. 28 km, 77,45 km & 159.62 km
The River Order	5	5
Type of Watering Pattern	Dendritic	Dendritic & Sub Paralel
Type of Lithology	Aluvial Deposit	Sediment & Metamorf

The Siak watershed has an order with several orders of 5 and a large number of tributaries scattered in each left and right lane in the 2 main rivers. it is interpreted that the Siak Watershed is located in a plain area with a relatively flat slope thus the flow rate of river water sent from upstream slows down and accumulates in areas on the plains around the Siak Watershed causing flooding. This flood is the sediment or soil type supply in the Siak watershed (Figure 14, 15, 16).

The Kampar Watershed is a large watershed that has 3 main rivers, namely the Kampar Kant River, the Kampar Kiri River, and the Subayang River. Kampar Kanan River has a length of 424.28 km with a dendritic flow pattern. The Kampar Kanan River has the highest elevation of 857.40m with the lowest point of 1.52m.

The Kampar Kiri River has a length of 277.45 km with a dendritic flow pattern. The Kampar Kiri River has the highest elevation of 125m with the lowest point of 12m.

The Subayang River has a length of 159.62 km with a sub-parallel flow pattern. The Kampar Kiri River has the highest elevation of 1,146 m with the lowest point of 16m. The Kampar Watershed itself has an area of 6730.89 km22 or 676.389 Ha. Where it has the highest elevation of 1,246 m and the lowest point of 1.52 m.

Kampar watershed has 5 river orders, has a large number of tributaries each of the right and left lanes of the main river. This Kampar watershed has sedimentary and metamorphic lithology. This watershed has 2 main river branches that merge the downstream (figure 12, 13, 14).

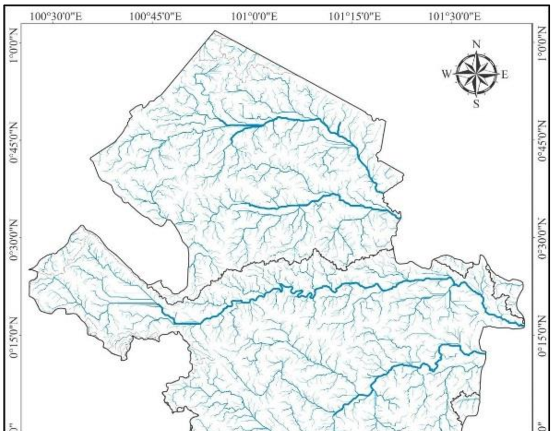

Fig 12. Watersheds map

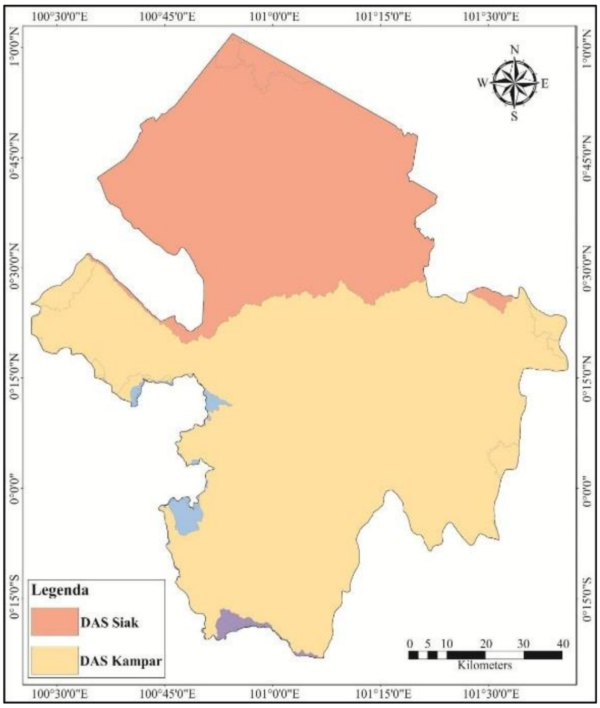

Fig 13. Flow pattern map

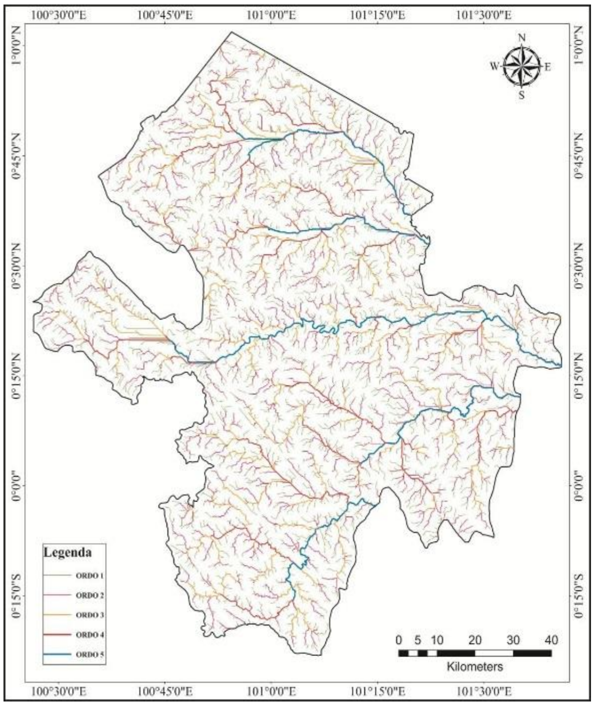

Fig 14. Ordo River Map.

4.6 Rainfall Analysis

1. Location of rainfall data collection

In this rainfall analysis will discuss the watershed rainfall in the study area. Where the data used in the analysis are the results or data continuously at each station.

BMKG rain observations for 5 years and at 6 different stations namely Bangkinang, XII Koto Kampar, Kampar Kiri, North Kampar, Petapahan Raya, and Tambang. This data is presented in graphical form to determine the average monthly rainfall. There are the following results:

1. 2019 rainfall

Table 8. Rainfall Data for 2019

Month	Bangkinang	North Kampar	Left Kampar	Petapahan Jaya	XIII Koto Kampar	Tambang
January	21	19	26	18	8	23
February	20	18	29	12	23	12
March	32	13	20	14	10	16
April	19	27	26	27	17	15
May	20	16	8	45	8	23
June	27	29	63	44	12	23
July	30	22	10	12	13	17
August	14	3	12	45	17	3
September	14	22	15	38	27	12
October	16	18	17	31	10	11
November	27	19	33	29	9	21
December	32	19	26	19	13	28
Average	22.66666 667	18.75	23.75	27.83333 333	13.91 66666 7	17
Average Annual	20.65277 8					

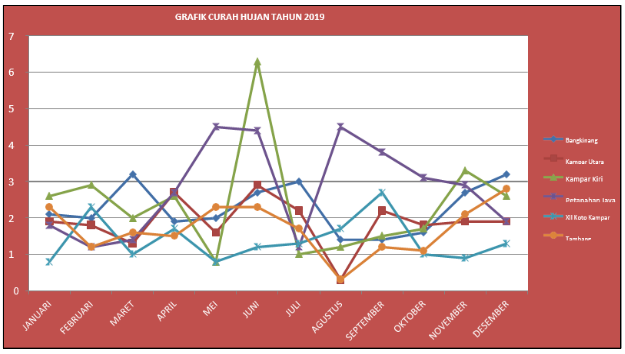

Fig 15. 2019 Rainfall Graph

Based on the analysis of the graph (Figure 15) the shape of the graph fluctuates. Daily rainfall values were obtained from 6 different stations. In each research station area, the average rainfall in 2019 was 20.652 mm a year and the average rainfall intensity at 6 different stations was at Bangkinang Station 22.66 mm a year, Kampar Utara 18.75 mm a year, Kampar Kiri 23, 75 mm a year, Petapahan Raya 27.83 mm a year, XII Koto Kampar 13.91 mm a year, and at the Mining Station 17 mm a year.

2. 2018 Rainfall

Table 9. 2018 Rainfall Data

Month	Bangkinang	North Kampar	Left Kampar	XIII Koto Kampar	Tambang
January	6	0	16	0	18
February	8	0	9	0	8
March	15	0	15	0	21
April	0	0	11	0	11
May	0	15	10	0	26
June	0	18	18	0	17
July	0	11	11	0	13
August	0	14	26	0	11
September	12	12	25	13	15
October	17	19	12	19	17
November	0	26	26	0	28
December	0	19	32	0	16
Average	4.833333333	11.16 66666 7	17.58 33333 3	2.666 6666 67	16.75
Average Annual	10.6				

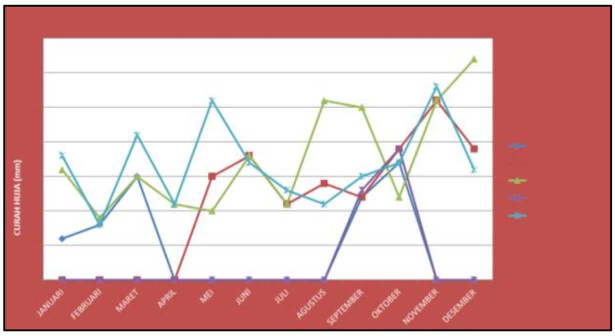

Fig 16. 2018 Rainfall Graph

Where the monthly rainfall intensity value in the Kampar Kiri area is the highest in June with a value of 63 mm/year and the lowest rainfall intensity value is in the North Kampar area in August with a value of 3 mm/year. In the 2019 observation year, the rain intensity was low based on the BKMG classification (Meteorology Climatology and Geophysics Council).

3. 2015-2017 rainfall

Table 10. Rainfall Data for 2015-2017

Month	Kampar - Bangkinang 2015	Kampar – Bangkinang 2016	Kampar – Bangkinang 2017	XIII Koto Kampar 2015	XIII Koto Kampar 2016	XIII Koto Kampar 2017
January	12	28	6	0	8	9
February	5	18	6	9	6	10
March	8	16	6	10	5	11
April	7	19	4	5	3	11
May	4	19	7	3	10	7
June	3	18	4	6	7	4
July	7	10	5	3	7	6
August	8	16	7	7	3	17
September	10	18	7	11	6	27
October	10	20	10	6	2	10
November	12	28	16	10	8	24
December	6	15	9	7	2	13
Average	7.6666666 67	18.75	7.25	6.41666 6667	5.58333 3333	12.416666 67
AverageYear 2015	7.0416666 67					
AverageYear 2016	12.166666 67					
AverageYear 2017	9.8333333 33					
Total Average 3 Years	29.041666 67					

4.

Based on the graphical analysis in (Figure 16) Rainfall in 2015 - 2017 there are 2 rainfall observation stations. It is shown that the shape of the graph is still fluctuating. The intensity of the monthly rainfall varies for each observation station. The total annual average for 2015-2017 was 29.04 mm a year with an average of 7.04 mm a year in 2015, 12.16 mm a year in 2016, and 9.83 mm a year in 2017.

Where the highest monthly rainfall value on the graph is located in the Kampar - Bangkinang area in 2016, in January and December. The lowest monthly rainfall values are in the XII Koto Kampar area in 2015 January with a value of 0 mm a month.

From all the rainfall data it can be concluded that this rain variation occurs due to differences in rain intensity and distribution due to the influence of meteorological factors (climate), the Kampar Watershed has low rainfall, this is seen based on references based on BMKG, because if averaged, the average rainfall for these 5 years will be at a value of 12.05866 mm a year. It can also be seen that areas with sloping on plain to low hilly geomorphology have moderate rainfall intensity, such as the Mining area, Petapahan Raya area, Bangkinang -

Kampar Kiri area compared to XII Koto Kampar area, and North Kampar area.

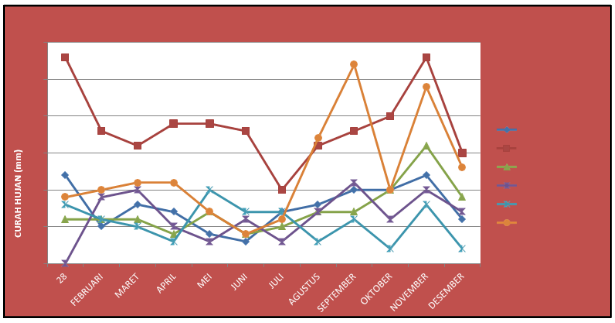

Figure 17. Rainfall graph for 2015-2017

4.7 Relationship between Rainfall and Watershed

From the rainfall data, it is known that from 2015-2019 the average rainfall in the watershed of the study area fluctuated. Rainfall will affect the discharge of the Siak and Kampar watersheds, it is known from the graphical table for the last 5 years that the intensity of rainfall with a high monthly average is from September to December, where high rain intensity will affect the volume of water in the Kampar and Siak watersheds with an area of > 500,000 km2 these two watersheds are classified as large watersheds.

If the rain intensity is high, it will fill the small river (ordo) in the watershed and will continue to flow downstream. The large watershed will be able to accommodate rainwater/rainfall which is quite large (volume). Thus the river discharge will also be the faster and faster supply of the material in this watershed will be increasingly diverse.

However, the Siak and Kampar watersheds are large and elongated watersheds. It is unlikely that water runoff or flooding will occur when rainfall comes, except in the downstream part of the DAS it may occur because it is included in the lowland morphology, such as the Fold of Cloth area, etc.

4.8 Relation of Geology, Geomorphology with DAS

What we already know is that the watersheds in the study area are divided into 2 watersheds, namely the Siak and Kampar watersheds. Where are the geological control and geomorphological shape affect the shape of the watershed?

The Siak watershed has an area of 388,093 ha which has 2 main rivers. Geologically, the Siak watershed is located in the Archipelago Back Arc area. Back art Basin), thus it has a watershed geomorphology, namely lowland areas to low hill areas with an elevation of -16 m to 158 m. Judging from the state of geomorphology, the Siak Basin is a downstream area of the river where the deposition process of sedimentation occurs, this process is influenced by erosional processes from the upstream of the river, where the drainage pattern in the Siak Watershed is a dendritic flow pattern and the main river is a meandering pattern. The type of lithology is in the form of soil and alluvial deposits such as sand, clay, gravel, some other gravel, and peat swamps.

As a downstream area of the river, the Siak Watershed has the potential to utilize the watershed in the form of agricultural land and plantation land. Lahal agriculture can be located not far from the main river in the Siak watershed itself, products that can be developed from this land are rice, chili, corn, and other plants. For plantation land by utilizing the geomorphological conditions of the Siak watershed in the form of alluvial areas, it can be used as oil palm plantation land. Apart from having potential, of course, the Siak Watershed also has a risk of natural disasters in the form of flooding. Due to the geological conditions, it is an alluvial area and the geomorphological position of the Siak Watershed itself is plain, causing the potential risk of flooding to be very large. If the rain intensity is high enough then there will supply the water that flows downstream will get bigger, causing the tamping water to get bigger and it will run over to the area around the plains of the Siak watershed.

The Kampar watershed has an area of 676,389 ha with 3 main rivers. Geologically, the Kampar Watershed, which is located in the Southwestern part, is a Bukit Barisan arc,this section has high hill geomorphological conditions, while the rest of the Kampar watershed is located in hilly to low hill areas with elevations from 158 m to 1247 m. In the Kampar watershed, the high hill areas are the upper reaches of the river, and in the Kampar watershed, the hilly to lowland areas are the transportation areas or the middle to the lower reaches of the river. The upstream area of the river is which area basement is exposed to the surface. The tributary which is in the upper reaches of the river is more dominant in the shape of a "V" due to its geomorphological conditions thus it forms a steep to steep slope.

And produce a sub-parallel type flow pattern. The lithology types in this watershed area are phyllite, quartzite, slate, volcanic rock, and lava flows. The middle to lower reaches of the Kampar watershed area is an erosional route and sediment transport, resulting in a dendritic and meandering drainage pattern. The lithology types are in the form of sedimentary rocks such as sandstone, siltstone, claystone, and conglomerate, while the types of soil and alluvial deposits are in the form of clay, sand, gravel, conglomerate, gravel, and peat swamp.

As an upstream area of the river, the Kampar watershed has the potential to use the watershed as a power plant, tourist attraction, and others. The power plant takes advantage of the shape of the river such as the shape of the letter "V" and the strong river currents are characteristic of upstream rivers. The tourism objects themselves, such as waterfalls and rafting, take advantage of the geological features of the Kampar watershed in the Bukit Barisan area. This watershed area is controlled by a developing structure that produces high hills geomorphology.

On the other hand, the potential for disaster risk in the Kampar watershed is quite large, where excessive land use can cause the loss of water catchment areas, this can result in an even greater discharge of water to be tamped causing erosional processes which are high enough to result in supply sedimentation downstream will be even greater, and large discharges will result in flooding downstream areas.

5. Conclusion

Distribution of geological data is secondary data, namely geological mapping, in the watershed research area there are 10 geological formations from the results of geological mapping, namely: the Sihapas Formation, the Telisa Formation, the bekasap formation, the Bahorok Formation, the Farmer formation, the Manggala formation, the Talang Akar formation, the Upper Telisa formation, Central member of the Palembang formation, Basement, Lower member of the Palembang formation (Air Berakat),

Subsurface geology data collection in the Rumbio Jaya area, Kampar Regency consists of 8 well points. where the Rumbio Jaya area is dominated by sand sediments. Overall the subsurface layer consists of fine sand to gravel, silt, and clay. Some organic materials are found in the form of roots, leaves, and so on in the layer close to the surface. Correlation 1 subsurface geology, namely CR-04, CR-03, CR-01, CR-02, CR-08. And correlation 2 CR-05, CR-06, CR-07. From correlation 1 it can be interpreted that the sediment originates from the south, namely CR-02, and has an elevation of ± 50 m, the further north it is the finer it is and from the 2nd correlation it can be interpreted that the towards the south it will be coarser. From these 2 correlations, it can be seen that the surface geology of the study area is that the pattern of sediment deposition is in the form of a smooth upward loop and then a rough upward one.

The geomorphology of the study area is divided into 4: lowland areas, low hill areas, hilly areas, and high hill areas.

The watersheds in the research area are divided into 2 watersheds: the Kampar and Siak. Watershed rainfall observations in the study area for 5 years from 2015 - 2019 were located at 6 different stations.

The relationship between rainfall and the watershed. If the rain intensity is high, it will fill the small river (order) in the watershed and will continue to flow downstream. The large watershed will be able to accommodate large enough rainwater/rainfall (volume). Thus the river discharge will also be the faster and faster supply of the material in this watershed will be increasingly diverse. However, the Siak and Kampar watersheds are large and elongated watersheds. It is less likely for water runoff or flooding when rainfall comes.

The relationship between geology, geomorphology, and watershed is very important. Where are the geological control and geomorphological shape affecting the shape of the watershed in the study area? Geologically, the Siak watershed is back art basin thus it has a geomorphological condition of the lowland to low hills watershed, the Siak watershed is a sedimentation process and the Kampar watershed is located on the Barisan hill, thus the geomorphological conditions of the hills are high. The Kampar watershed is the upstream part or source of sedimentation.

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