Analysis of velocity groundwater in unconfines aquifer zone using infiltration measurement

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Abstract. The presence of ground water is strongly influenced by the presence of recharge zones. Changes in land use can affect the availability of ground water due to changes in the rate of groundwater flow into the ground. One of the causes of flooding and inundation, this occurs because the reduction in the catchment area is accompanied by a decrease in the infiltration rate coupled with an uneven distribution of rainfall throughout the year, thus triggering inundation problems. In this study by analyzing the value of groundwater flow velocity in the free aquifer zone. The study area has various hydraulic conductivity values with values ranging from 0.69 cm / minute to 0.02 cm / minute. The very high category is in the southern part of the research area with an area of 150 Ha, the high category is in the West, East, South and North research area with an area of 21,355 Ha, and the rather high category is in the northern part with an area of 740 Ha. The study area has various infiltration velocity values ranging from 0.22 cm / minute to 1.41 cm / minute. The fast category is in the South and North parts of the research area with an area of 17,355 Ha, the rather fast category is in the North and West parts of the research area with an area of 4152 Ha. Potential groundwater catchment areas are limited by areas consisting of breccia’s, pasufufaan, or clay tuffs, fast infiltration rates - rather fast, and high hydraulic conductivity - very high. The main groundwater catchment potential zone has an area of 10,417.63 Ha, while the additional groundwater catchment potential zone has an area of 11,673.24 Ha.

1. Introduction
‘Water’ always has been a key resource for humankind but over the period with increasing population and rapid urbanization, water resource is under immense pressure [1]. Groundwater systems can respond to climate forcing and millennial climate shifts more slowly than other components of the hydrologic cycle, making it difficult to reconstruct the influences and responses of groundwater to changing climate [2]. Planning for sustainable groundwater abstraction requires realistic and reliable assessments of groundwater drawdown in aquifers as well as impacted groundwater-dependent terrestrial and aquatic ecosystems [3]. In humid subtropical regions, base flow is mainly governed by aquifer discharges and this dynamic is fed by groundwater recharge [4].

The evaluation of the aquifer system functioning and the water availability are the main issues in water resource management [5]. Groundwater management authorities usually use groundwater budget calculations to evaluate the sustainability of withdrawals for different purposes [6]. With the progressive evolution of industrial sector, agricultural, urbanization, population and drinking water supply, the water demand continuously increases which necessitates the planning of groundwater recharge particularly in
arid and semi-arid regions [7]. Delineation of groundwater catchment zones is very important for the conservation of the quality and quantity of groundwater. To objectively estimate groundwater catchment zones, many field surveys are needed which take time and money [8]. To understand the use of water resources in this basin, the fundamental characteristics and recharge of the groundwater need to be analyzed [9]. Studying the groundwater recharge mechanism in regions with thick unsaturated zone can greatly improve our understanding of hydrological processes since these regions have complex groundwater processes [10].

Based on the hydrogeological cycle, groundwater comes from rainwater. Rainwater that reaches the surface partly flows on the surface. While some of the other rainwater seeps into the ground until it reaches the saturation zone and becomes ground water. Groundwater is the main supplier of clean water that can be directly consumed by humans. About 70% of clean water sources come from ground water. The amount of dependence on ground water is caused by the water which is clear, safe for consumption, and easy to extract.

The existence of ground water is estimated to be more in number than surface water. According to UNESCO in 1988, 98% of all surface water was hidden below the surface of the land. Groundwater can be found at varying depths, ranging from a few meters to hundreds of meters. Ground water is in the soil layer that can drain water. That layer of soil that contains water is called an aquifer. Ground water can come from 2 sources, namely: (1) Rain water that enters the soil through pores or cracks in the soil, (2) Surface water that flows such as rivers or lakes that seep into the saturated strip through the ground.

The existence of ground water and surface water are interrelated. When the dry season arrives, surface water such as rivers can dry out. In some rivers it is found that the source of the flow comes from ground water through springs, and vice versa. Both types of water follow the hydrogeological cycle.

![Establishment of Groundwater](image_url)

2. Method research
Areas of infiltration and percolation are called water catchment areas. Basically, the entire surface of the earth is a place for infiltration, but in relation to groundwater recharging, water catchment areas are areas that absorb water and supply groundwater to certain groundwater basins. Water that seeps into the soil indirectly undergoes a filtering process. This causes groundwater to become cleaner and clearer.

To determine the water catchment area, it is necessary to consider several factors that influence it. Practically, to determine water catchment areas, it is necessary to pay attention to several things, including:

- Matching hydrogeological conditions, including: direction of groundwater flow, presence of water-bearing layers, soil cover conditions, rainfall
- Morphological and topographic conditions. Flat land and high elevation will facilitate the process of water absorption.
- Land use. Areas filled with vegetation will facilitate the infiltration process.

However, according to Freeze and Cherry, determining catchment areas needs to pay attention to [11]:
- Surface water flow and groundwater;
- Rainfall;
- Hydrogeological characteristics;
- Topography;
- Geomorphology.

Apart from the need to pay attention to these points, determining catchment areas can also be done by identifying the following characteristics:
- Having a general direction of vertical groundwater flow;
- Many rock outcrops escaped unsaturated water;
- The chemical content of groundwater is relatively low;
- Body area and peak of the volcanic cone;
- Karst areas that have cracks and dissolving holes;

The outcrop area of rock forming the aquifer is depressed upstream.

3. Results
The infiltration velocity data for each point obtained using the Kostiakov equation is then plotted into the map. Using the triangulation method, the infiltration velocity data is transformed into contour lines. The contour lines are then classified to form a zone based on the classification of Elrick et al., from the results of the work, obtained zoning map of infiltration speed with 4 types of categories, namely fast rather fast, medium and rather slow. The study area is mostly classified into the fast category with infiltration rates above 0.45 cm / min. Using the same method, Ksat values are also plotted into the map to produce a zoning map of saturated soil conductivity [12].

![Figure 2. Map of infiltration zoning velocity.](image)
4. Conclusion
The study area has various hydraulic conductivity values with values ranging from 0.69 cm / minute to 0.02 cm / minute. The very high category is in the southern part of the research area with an area of 150 Ha, the high category is in the West, East, South, and North research area with an area of 21,355 Ha, and the rather high category is in the northern part with an area of 740 Ha.

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The potential groundwater catchment area is limited by areas composed of breccia’s, pasufufaan, or tuffaceous sand, fast infiltration rates - rather fast, and high hydraulic conductivity - very high. The main groundwater recharge potential zone has an area of 10,417.63 Ha, while the additional groundwater recharge potential zone has an area of 11,673.24 Ha.

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