Groundwater Hydrogeochemistry in Bukit Raya and Tenayan Raya, Pekanbaru, Indonesia

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Abstract. Pekanbaru is growing rapidly and one of the largest in industry and commercial sector on Sumatera Island. Hydrogeological mapping and major elements in groundwater samples from protected wells were used to determine hydrochemical facies in Bukit Raya and Tenayan Raya sub-districts in Pekanbaru. A total of 14 groundwater samples were collected in May 2017. A Piper Trilinear diagram was employed to evaluate the hydrogeochemical evolution of groundwater. Results show that water table varies from 7.02 to 46.67 m in depth and flow toward the middle of research area which is Sail River. Based on groundwater table, the relationship between groundwater and river water was effluent. Hydrochemical facies of groundwater in the study area are dominated by sodium chloride, calcium chloride, and calcium bicarbonate water type. Dominance of Na⁺ elements in facies is from the dissolution of Feldspar or Pyroxene in sand, and the Ca²⁺ element in facies is from the dissolution of Feldspar and Plagioclase in sand. The presence of Cl⁻ element in facies is from salt crystals in rainwater, and the HCO₃⁻ element in facies has contact with air and is dominated by rainwater. Lithology conditions in the study area are generally weathered so that the influence of rocks on rainwater is quite high.

Keywords: Hydrogeochemistry

1. Introduction

The main issue of groundwater in the development of a city in Indonesia is the interaction between urbanization and its groundwater system, let alone if that city is above a certain unconfined aquifer system [1]. One of the cities with rapid development in Sumatra Island is Pekanbaru City which had a population of more than one million residents in 2016 and has a reputation as “one of the cleanest and greenest city” in Indonesia [2,3]. Pekanbaru City was predicted, started from 2016 until 2020, to lack groundwater sources because of the increase of population number, industry, and limited land for the conservation of groundwater charging, then it could cause the pattern of safe zonation for the shallow groundwater to tend to decrease [4].

It is important to understand the hydraulic trait and characteristics of hydrochemical groundwater. In the study area, the correlation between the groundwater flow, hydrogeology trait, and hydrochemical is related to the quality of chemistry and lithology. Geological factor, chemical weathering level, types of rocks, and water absorption quality in the ground affect groundwater chemicals [5]. On the other side, there are few research publications which have been done concerning
water table and groundwater chemical in Pekanbaru City. In the end, Bukit Raya and Tenayan Raya sub-districts were selected as the research location. The purpose of this research is to make hydrogeological mapping and to investigate the sources of high ion concentration to characterize hydrogeochemical process.

2. Materials and Methods
Hydrogeological mapping was conducted in May 2017 (normal season) to measure water table by using water level meters and taking fourteen protected wells as samples. The locations of sampling were determined as even as possible in the study as shown in Figure 1. All groundwater from the protected wells were sampled using 1-liter high density polyethylene bottles. Eight samples of even study area were many more than previous research [6]. The samples were then analyzed chemically, with 6 parameters tests conducted in the laboratory of Technical Implementation Unit Public Works and Spatial Service of Riau Province Government and 2 parameters in the laboratory of water quality at the Faculty of Civil and Environmental Engineering in the Technology Institute of Bandung. Among these parameters, Na\(^+\) and K\(^+\) were determined using flame photometer; SO\(_4^{2-}\), Cl\(^-\), HCO\(_3^-\), and CO\(_3^{2-}\) were analyzed using ion chromatography method; and Ca\(^{2+}\) and Mg\(^{2+}\) were determined by spectrophotometry. The chemical results of the main cations and anions from the eight samples determined the groundwater facies and their composition which were plotted on a Piper Trilinear Diagram. Hydrochemical data from unconfined aquifer were then interpolated using spatial analysis and translated into hydrochemical mapping.

3. Results and discussion
The distribution of water table from sea surface was around 7.02-46.67 m, then it was made into a certain distribution map to obtain the flow direction from the groundwater to research location (Figure 1). The groundwater flow at the northwest, northeast, and southeast part of the research location went to Sail River. The position of river water surface was lower than the groundwater (effluent). The data used for determining hydrochemical facies were analysed by counting the content of the main component ions obtained in the water samples such as cations which consist of Ca\(^{2+}\), Na\(^+\), K\(^+\), Mg\(^{2+}\) ions; and anions which consist of Cl\(^-\), CO\(_3^{2-}\), HCO\(_3^-\), SO\(_4^{2-}\) ions. However, the results of laboratory analysis for each ion were in milligram/liter (mg/L) unit, while the unit used for further analysis was milliequivalent/liter (meq/L).

Based on the analysis results by using piper diagram towards the protected wells, the hydrochemical facies at the research location could then be determined and be grouped into 3 (three) facies, which are sodium chloride, calcium chloride, and calcium bicarbonate. The domination of Na\(^+\) element comes from feldspar dissolution or pyroxene that exists in the sand [7] in which this element is jotted in the river’s alluvium contained in clay, sand, pebble, quartzite, and the chunks of igneous rock [8]. The domination of Ca\(^{2+}\) element comes from feldspar dissolution and plagioclase in the sand [7] in which this element is jotted in Minas Formation consisting of sands, pebbles, clay, and silt [8]. The presence of Cl\(^-\) element comes from saltwater crystals (NaCl) which is soluble in the rainwater [9] and HCO\(_3^-\) is from the contact of CO\(_2\) and water (H\(_2\)O) in the atmosphere [6,10]. The slow flow in this low area enabled sufficient interaction between water and stones [11].
Figure 1. Groundwater flow direction and spatial distribution of water types. Sodium chloride water type is dominant in the west (SG 2, SG 5-7, and SG 14), then calcium carbonate is dominant in the middle and the east (SG 1, SG 3, SG 4, and SG 12), while calcium chloride is dominant in the north until southeast.

4. Conclusions
The groundwater hydrogeochemistry from unconfined aquifer through the protected wells in Bukit Raya and Tenayan Raya Sub-districts Pekanbaru City has been mapped and investigated. The distribution of groundwater from the sea surface is around 7.02-46.67 m whose flow follows the topography to Sail River. Based on cations and anions concentration, there are three kinds of water such as sodium chloride, calcium chloride, and calcium bicarbonate. The fact is that the internal factor in spatial distribution of groundwater hydrochemistry facies correlates to geology which causes different hydrochemistry process and the external factor comes from the rainwater. Besides, lithology distribution has a strong influence towards the presence of different groundwater in the study locations.
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