

KARAKTERISASI SISTEM DRAINASE KARST GUA PINDUL DENGAN PENDEKATAN HIDRODINAMIKA DAN HIDROGEOKIMIA

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INTISARI

Sistem Drainase Karst Gua Pindul merupakan sistem karst dengan outlet Gua Pindul. Gua Pindul merupakan salah satu objek wisata *cave tubing* yang secara administratif terletak di Kecamatan Karangmojo, Kabupaten Gunungkidul. Sebagai objek wisata, perlu dilakukan pengelolaan berkelanjutan khususnya sumberdaya air Sungai Bawah Tanah (SBT) Gua Pindul dengan mengetahui karakteristik sistem drainase karst untuk mengetahui perkembangan akuifer karst. Penelitian ini dilakukan dengan tujuan untuk: (1) menganalisis karakteristik hidrodinamika di Sistem Drainase Karst Gua Pindul; (2) menganalisis variasi temporal kondisi hidrogeokimia Sistem di Drainase Karst Drainase Gua Pindul; dan (3) mengkaji hubungan antara hidrodinamika dan hidrogeokimia airtanah di Sistem Karst Drainase Gua Pindul.

Penelitian ini merupakan penelitian berbasis data primer yang dilakukan dengan pengumpulan data selama satu tahun (November 2020 – Oktober 2021). Alat pencatat tinggi muka air (TMA) atau logger dipasang di titik lokasi pemantauan SBT Gua Pindul dengan interval pencatatan setiap 15 menit. Data TMA diolah menghasilkan hidrograf aliran dan dilakukan perhitungan konstanta resesi aliran (*diffuse*, *fissure*, dan *conduit*) serta perhitungan persentase aliran dasar (PAD) untuk menggambarkan kondisi hidrodinamika. Data kimia air yang dikumpulkan sebanyak 51 sampel yang mencakup sampel air bulanan dan sampel air pada tiga kejadian banjir. Pengujian lapangan dan laboratorium menghasilkan data hidrogeokimia air yaitu ion mayor (Na^+ , K^+ , Mg^{2+} , Ca^{2+} , HCO_3^- , Cl^- , K^+ , SO_4^{2-}), suhu, pH, DHL, dan TDS. Pengolahan data kimia tersebut menghasilkan tipe kimia airtanah, hidrokemograf, SI Kalsit, Log PCO_2 , dan proses kimia yang dominan terhadap hidrokimia air, yang dianalisis dengan metode *Principal Component Analysis* (PCA)

Hasil penelitian menunjukkan bahwa kondisi hidrodinamika dan hidrogeokimia bervariasi secara temporal. Sistem Drainase Karst Gua Pindul memiliki tipe pelepasan komponen aliran campuran dengan nilai konstanta aliran *diffuse* (K_c), *fissure* (K_f), dan *conduit* (K_c) masing-masing sebesar 0,996; 0,836; dan 0,429. Nilai PAD memiliki rata-rata yang cenderung tinggi ($\text{PAD} > 80\%$). Nilai konstanta aliran dan PAD ini membuktikan bahwa akuifer karst Gua Pindul memiliki pelorongan yang telah berkembang dengan simpanan airtanah yang masih baik. Kondisi hidrogeokimia di sistem karst Gua Pindul menunjukkan bahwa dominasi aliran *diffuse* pada musim kemarau mempengaruhi kandungan kimia yang tinggi dan stabil akibat proses *water-rock interaction*. Sementara itu, proses *dilution by precipitation* menyebabkan rendahnya beberapa parameter saat kejadian banjir. Hal ini juga dipengaruhi oleh agresivitas air terhadap mineral kalsit di musim penghujan. Oleh karena itu, proses yang dominan berpengaruh hasil dianalisis metode PCA adalah *water-rock interaction* dan *dilution by precipitation*.

Kata Kunci : Karakterisasi Akuifer Karst, Hidrogeokimia, Gua Pindul

CHARACTERIZATION OF THE PINDUL KARST DRAINAGE SYSTEM WITH HYDRODYNAMICS AND HYDROGEOCHEMICAL APPROACHES

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ABSTRAK

Pindul Cave Karst Drainage System is a karst system with the Pindul Cave outlet. Pindul Cave is one of the cave tubing attractions which is administratively located in Karangmojo District, Gunungkidul Regency. As a tourist attraction, it is necessary to carry out sustainable management, especially the Pindul Cave Underground River water resources by knowing the characteristics of the karst drainage system to determine the development of the karst aquifer. This research was conducted with the objectives to: (1) analyze the hydrodynamic characteristics of the Pindul Cave Karst Drainage System; (2) analyzing the temporal variation of the hydrogeochemical condition of the Karst Drainage System in Gua Pindul Drainage; and (3) examine the relationship between hydrodynamics and hydrogeochemistry of groundwater in the Karst Drainage System of Gua Pindul.

This research is primary research conducted with data collection for one year (November 2020 – October 2021). A water-level recording device or logger is installed at the monitoring point for the Gua Pindul SBT at 15-minute intervals recording. The water-level data was processed to produce a flow hydrograph, calculated flow recession constants (diffuse, fissure, and conduit), and calculated base flow percentage (PAD) to describe hydrodynamic conditions. The water chemistry data collected were 51 samples, including monthly water samples and water samples from three flood events. Field and laboratory tests produced hydrogeochemical data on water, namely major ions (Na^+ , K^+ , Mg^{2+} , Ca^{2+} , HCO_3^- , Cl^- , K^+ , SO_4^{2-}), temperature, pH, DHL, TDS. The chemical data processing resulted in the type of groundwater chemistry, hydrochemograph, SI Calcite, Log PCO_2 , and chemical processes that were dominant to water hydrochemistry, analyzed by Principal Component Analysis (PCA) method.

The results showed that the hydrodynamic and hydrogeochemical conditions varied temporally. The Pindul Cave Karst Drainage System has a mixed flow component release type with a diffuse (K_c), fissure (K_f) and conduit (K_c) constant of 0.996; 0.836; and 0.429. PAD values have an average of high (PAD>80%). These flow constants and PAD values prove that the Pindul Cave karst aquifer has a developed tunnel with good groundwater storage. The hydrogeochemical conditions in the Pindul Cave karst system indicate that the dominance of diffuse flow in the dry season affects the high and stable chemical content due to the water-rock interaction process. Meanwhile, the process of dilution by precipitation causes several parameters to be low during a flood event. The aggressiveness of water also influences this to calcite minerals in the rainy season. Therefore, the dominant and influential process analyzed by PCA is the process of water-rock interaction and dilution by precipitation.

Keywords: Karst Aquifer Characterization, Hydrogeochemistry, Pindul Cave