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Geochemistry of Three Spots on Stream Water around Gedongsongo Hot Springs

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ABSTRACT

Study on the physical characteristics, chemical content of water as well as microbiological composition in the area of geothermal hot springs in Gedongsongo have been done. Water samples were collected on the area within streaming water with moderate temperature. The selection was done on the basis of water that will enter into agricultural and residential areas. Water analysis includes physical analysis, such as temperature, water clarity and odor. While the chemical analysis comprised the oxide content of Mg and Ca. Anion analysis was also performed as sulfate, phosphate, bicarbonate and chloride. The microbiological composition performed using SSCP method for community analysis. The results showed a correlation between the temperature and the content of the anions. The higher temperature of water showed the higher level of anions. The existence of the metal oxide is directly proportional to the levels of the anions. The lower acidity of water showed the higher the levels of hydrogen sulfide. Bacterial composition based on SSCP profile showed a slight different of diversity.

INTRODUCTION

Chemical analysis of rocks, water and gas is part of a research that aims to create integrated geo-scientific characteristics of the potential of geothermal systems in the hot springs of Gedongsongo. Hot springs in Gedongsongo is an existing geothermal manifestation around Mount Unggaran (Budiharjo, 1997). According Wahyudi (2006), the heat source is estimated to be a diuretic intrusion. Volcanic rock which cracked the Lower Quaternary and Tertiary age is thought to function as a reservoir rock. Volcanic rocks Upper Quaternary age is thought to function as an impermeable covering rock (cap rocks). Geothermometry based on fumaroles contained in the Gedongsongo, the reservoir temperature estimated at 230°C.

Study of chemical analyzes from geothermal sources is done for the element/compound such as SiO2, Al, Fe, Na, K, Ca, Mg, Li, B , CO_2, NH_3, SO_4^{2}, H_2S, Cl^-, F^-, HCO_3^-. Determination of elements/compounds are needed to verify the classification of the type of water that describes the condition of the reservoir / geothermal sources Gedongsongo based on the concentration of chloride anions (Cl^-), sulfate (SO_4^{2-}) and bicarbonate (HCO^{3-}) and the amount of other elements. In addition to the chemical aspects should also be determined the physical properties such as the degree of acidity (pH), temperature and electrical conductivity values for various points of the hot springs.

Microbial community composition and diversity in terrestrial hot springs have been extensively studied. Most of these phylogenetic studies have used 16S rRNA clone libraries in combination with cultivation methods. The results of these studies have expanded our knowledge of microorganisms that commonly inhabit thermal springs. At temperature suitable for photosynthesis moderately thermophilic and mesophilic Bacteria are important members in terrestrial thermal springs, such as *Cyanobacteria*, *Chloroflexi* and *Proteobacteria*. To better understand microbial ecology and functions in geothermal niches, an increasing number of studies have tried to establish the linkage between microbial community composition/ diversity and physicochemical conditions such as temperature, pH, and water chemistry. Among these environmental conditions, the effect of temperature on microbial community structure has received much attention. In this study, three spots on flowing water around hot springs were chosen to review the extent to which the characteristics of the physical / chemical water may affect the agricultural and / or human health.

MATERIALS AND METHODS

Determination of CO_2 and H_2S, using a gasometrical.

Determination of chloride ions using the gravimetric method and titration argentometry, samples coupled with silver nitrate to obtain solids. In the gravimetric method, the sample is added to the silver nitrate solution with a certain concentration to obtain solids. The solid was washed with dilute HNO_3, filtered with a sintered - glass crucible, then dried to constant weight. In argentometry titration method, a solution of silver nitric with a particular concentration in the column is inserted and used to titrate sample solution suspected of containing chloride.

Determination of carbonate ions

Dilute sulfuric acid solution is added to the test solution. Gases arising captured with a glass rod that has been moistened with calcium hydroxide $Ca(OH)_2$ will occur white patches on the glass rod. If the sample is added concentrated H_2SO_4, gas bubbles are formed and there is a white precipitate on a glass rod moistened with a solution of $Ca(OH)_2$. Sample was added with $BaCl_2$ solution and white precipitate formed ($BaCO_3$). Quantitative determination performed by volumetric methods/acidimetry using hydrochloric acid and PP indicator.

For analysis of salt content of the phosphate, sulfate and carbonate were used Volumetric or gravimetric analysis.

Determination of sulfate carried out by addition $BaCl_2$ solution to the sample and a white precipitate formed (BaCO3).

The cations of Na, K, B, Li, Mg, Ca, Al and Fe performed using atomic absorption spectrophotometer.

Amplification of 16S rRNA gene fragments

PCR was performed with the formula: 1UL DNA samples were placed in 12.5 mL solution was added micro tube mega mix blue, NS1 1 mL, 1 mL GC - Fung and 9.5 mL and 12.5 mL ddH2O mega mix blue solution, 1 mL Com1F, 1 mL and 9.5 mL ddH2O Com2R . Initiation at 95 °C for 4 min , with a 35X cycles, each cycle undergo denaturation step at 95 °C for 1 min, annealing 51 °C for 1 min, extension at 72 °C for 2 min and last extension for 8 minutes .

Analysis by Single Strand Conformation Polymorphism technique

Five microliters of the PCR product was mixed with 15 mL loading solution (95 % formamide, 0.25 % xylene cyanol, 0.25 % bromophenol blue) with variation of NaOH and 20 mM EDTA, and then heated at 100 °C for 5 min and immediately cooled in ice . Samples were loaded into wells of 10% polyacrylamide gel. Samples were electrophoreses in the gel electrophoresis cells with 1X TBE buffer at 200 V for 4 hours at 4 °C. Gel has previously been in pre run for 30 minutes beforehand.

RESULTS AND DISCUSSION

Gedongsongo Geothermal Field

Gedongsongo geothermal field, especially around the Itam crater located on the southern slopes of volcanic geothermal Unggaran show interesting geological phenomena, among which is the presence of fumarola, hot water field, a strong rock alteration and control of geological structures. Item crater appearance at geothermal and surrounding areas, which are bursts of steam (steam discharge), hot springs, hot tubs (hot pool) and steaming ground is very clearly observable on the surface.

Gedongsongo an undulating hilly, narrow and steep valleys that form the letter V. Gedongsongo morphology area controlled mainly by rocks and geological structures that develop in the area. In the southern part of the area showing undulating hills are composed by lava rocks and andesitic breccia laharik. Most breccia laharik experienced changes. These rocks are the result of volcanic activity Unggaran. In the nort , straightness structures trending northeast-southwest recognizable cut the morphology.

Based on Figure 1, hot springs scattered across a large area and small, with a temperature variation ranging 25 °C to 100 °C. Each of these sources also show different characteristics based on turbidity, the smell of sulfur and acidity. The parts are marked on the sampling position entirely a part of the meeting location between pond springs with spring flows from the top mountain. This river is part of the sites that most visited by tourists, especially who want to soak for reasons of skin disease or just unwind. The selection of sampling locations at these points is made to review the extent to which the

characteristics of the physical / chemical water may affect the agricultural and / or human.

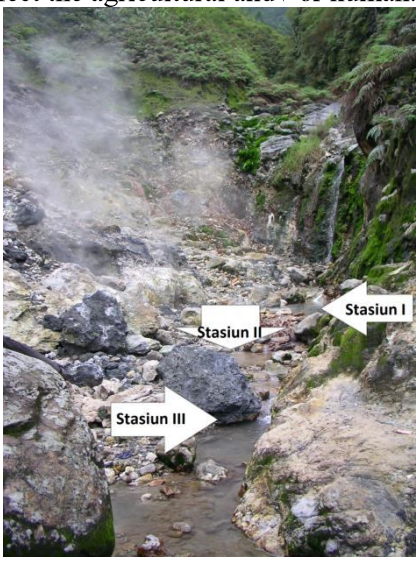

Figure 1. Location Gedongsongo hot springs flow. The arrows indicate the three sampling sites

The results of the analysis of physics at the three locations are presented in the following Table 1.

Table 1. Analysis of Thermal Physics Gedongsongo

Assay Parameter	Stasiun I	Stasiun II	Stasiun III
Temperature (°C)	36 – 37,5	32 – 33	26,5 – 27
Turbidity	Rather turbid	Rather clear	Quite clear
H_2S (smell)	Hard smell	smell	Little smell
pH	3	4 - 5	5 – 6

Table 1 showed the correlation between pH, levels of H2S, water color and water temperature. This is understandable because, hydrogen sulfide is a gas that smells like rotten eggs and weakly acidic. H2S is usually correlated to the content of phosphate anions, sulfate and bicarbonate. Then it is understandable if the higher levels of H2S, will surely further acidify the water and usually the content of phosphate, sulfate and bicarbonate is also higher.

Hot water geochemical studies play an important role in solving various problems developing geothermal resources. Some of them determine the hydrothermal system, valuation and depreciation reserve of energy in the reservoir, power plant design, estimate the level of corrosion and waste disposal design. Geochemical methods came into widespread use after successful exploration geochemistry at Wairakei (Koga , 1978). This method is not only used in the preliminary exploration of the potential of geothermal prospecting, but in almost all stages, during production, testing and utilization further. Koga (1978) also explained that the geochemical studies can be relied upon to carry out a study of the properties of materials derived directly or indirectly from the geothermal reservoir body. From the results of geochemical studies of hot water, the interpretation of the model can be done in a geothermal system geothermal field.

In this study, water chemistry analyzes conducted on the 3-point sources, with each sample volume of approximately 1 liter. Samples were analyzed in two ways which is Chemical Physics analysis. Physical analysis is based solely on the character of physics / physical properties. While the chemical analysis performed by adding a specific chemical reagent or based on the character of the material or the element. The results as shown in the following table 2.

Table 2. Chemical analysis of three hot springs Gedongsongo

Test Parameter	**Stasiun I**	**Stasiun II**	**Stasiun III**
DO	2 – 2,4	2,8 - 3	3 – 3,3
DCO_2	4,6 - 5	3,8 – 4,1	3 – 3,4
Sulfate	406 - 412	110 – 117,6	92,5 – 96,2
Phosphate	0,3 – 0,32	0,04 – 0,05	< 0,001
Bikarbonate	99 - 102	110 – 112,5	92 - 94
Cloride	102 - 104	98 - 101	88 – 95
Mg	200- 204	192- 198	180- 186
Ca	300- 306	290 - 302	286- 296

Table V.2 showed a clear correlation to the content of carbon dioxide (CO_2) in the water with other variables such as the content of Sulfate, Phosphate, bicarbonate, Mg and Ca. According to Barus (2004), the higher content Phosphate

will affect declining oxygen levels and increasing bicarbonate, sulfate and chloride anion, usually accompanied by rising levels of metals capable of forming salts. Faithful (2006) and Rizgi (2010) reported the increasing temperature it is usually also accompanied by rising levels of sulfate and chloride salts. Then the table V.2 gives the real picture that Hot Springs in Gedongsongo show similar things.

Area around the hot spring there is clay. According to Baver (1963), the chemicals / minerals in the clay soil is very diverse, such as: Si_2O_3, Al_2O_3, and Fe_2O_3. Even other oxides were also often found in significant levels, such as CaO, MgO, MnO, K_2O, TiO_2, Na_2O and P_2O_5. The content of the oxide varies greatly depending on the type of clay. According to Grim (1963), the content of oxides in Kaolininites, Illites, Vermecullites and Mormorillonites quite varied .

The composition of the microbial

The composition of microbial communities in terrestrial hot water has been studied extensively. Most of phylogenetic studies using 16S rRNA clone libraries combine with culture method. The results of these studies have expanded our knowledge of microorganisms that commonly inhabit hot water. At the appropriate temperature for photosynthesis, several thermophilic and mesophilic bacteria which is an important member in terrestrial hot springs, such as Cyanobacteria, Chloroflexi and Proteobacteria. To better understand the microbial ecology and function in geothermal recesses, an increasing number of studies have tried to establish the relationship between microbial community composition and physicochemical conditions such as temperature, pH, and water chemistry. Among these environmental conditions, the effect of temperature on microbial community structure has received much attention.

In this study the bacterial composition was analyzed using Single Strand approach conformational polymorphism (SSCP) as a method that can be directly and easily to compare the diversity of the community of microorganisms. The results of SSCP analysis of water samples from the three samples shown in Figure 2.

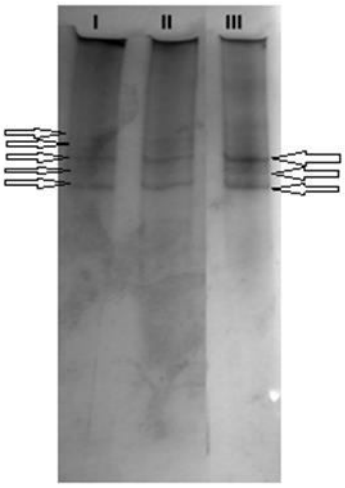

Figure 2. SSCP profiles of bacterial communities at three sampling stations

SSCP profiles in Figure 2 shows that the bacterial diversity in station I and station II are similar, while the third station showed little difference. Microbial diversity in a habitat, closely related to environmental conditions and nutrient content. In the SSCP technique, only the dominant microbes are detected. Based on the results of physical and chemical analysis, the station I and station II have almost similar characteristics so that the diversity of microbes that inhabit both locations has higher possibilities to be similar. While on station III, the relative temperature approaching the temperature environment; therefore the probability of growing microbial diversity tends to be higher.

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