

Characterization of Volcanic Ash of Mount Sinabung Erupting On 29th June 2014 Using XRD, SEM and AAS

Perdinan Sinuhaji^{1*}, Susilawati¹, Nimpan Bangun²

¹Departement of Physics, Faculty of Mathematics and Natural Science
Universitas Sumatera Utara Medan 20154, Indonesia

²Departement Of Chemistry, Faculty of Mathematics and Natural Science
Universitas Sumatera Utara Medan 20154, Indonesia

Abstract: Crystal structure and heavy metal analysis of Mount Sinabung, erupting on 29th June 2014, volcanic ash was carried out using XRD, SEM, and AAS. The sample was taken from Perteguhen, a village of approximately 7 km from the crater. Volcanic ash of Mount Sinabung contains Silicon Oxide/Quartz (SiO₂), 16.71%, hexagonal parameter, lattice constant, $a = 4.9134 \text{ \AA}$ and $c = 5.4052 \text{ \AA}$ with 2.65 gr/cm^3 density (No. ICDD 46-1045), Sodium Calcium, Aluminum Silicate/ Anorthite (Ca, Na) (Si, Al)₄ O₈, 58.12%, triclinic crystal structure, lattice constant, $a = 8.1813 \text{ \AA}$, $b = 12.8740 \text{ \AA}$ and $c = 7.0970 \text{ \AA}$, with a density of 2.72 gr/cm^3 (No. ICDD 41-1481) and Sodium Aluminum Silicate/ Albite high Na (Al Si₃ O₈), 25.17%, triclinic structure, lattice constant, $a = 8.1535 \text{ \AA}$, $b = 12.8694 \text{ \AA}$ and $c = 7, 1070 \text{ \AA}$ with the density of $2,62 \text{ gr/cm}^3$, (No. ICDD 71-1150), with sharp microstructure at the edge. Volcanic ash of Mount Sinabung contain heavy metal : Cu 46,35 ppm, Plumbun (Pb) < LoD ; Arsene (As) < LoD, Mercury (Hg) 0.06 ppm, Zinc (Zn) 0.08%, ash size 100 mesh 82.20%, using Indonesian National Standard, SNI 02.2803.2005. Mount Sinabung ash is not poisonous because it is still in tolerable limit as stated in PerMenKes and SNI 7387:2009 but the ash can result in upper respiratory track disturbances, bronchitis and eye irritation.

Keywords: Volcanic Ash, Heavy Metal, Microstructure, Crystal Structure

1. Introduction

On the 28th June 2014 Mount Sinabung erupted at 02.51 and it erupted again on the 29th June 2014 also at 08.00. Smoke and ash went up to 1,000 m from the crater. The following is the result of the observation of The Center of Vulcanology and Mitigation Geologic Disasters:

Activity on 29 June 2014 at 08.00 West Indonesian Time Zone, with bare eyes, thin white smoke of $\pm 20 \text{ m}$ with weak to medium pressure. Further activity occurred again on 29th June 2014. At 08.00, thundering noise was heard and the Mount Sinabung status changed to warning at 10.00. At present, some of the villagers still stay around to take care of their housings at the danger zone, but they, too, eventually left because all woods around their villages was ruined by volcanic ash [Wikipedia B. 2014],[Wikipedia A. 2014]. The white grayish ash covered woods, villages and agriculture areas around the mountain. This situation inspired the writer to study the hazards of the ash toward people, plants and animals.[Sudryo, 2009]. The writer intended to identify heavy metal, microstructure, and crystal structure of the volcanic ash. To identify the type of component, to see if the composition of heavy metal of Mount Sinabung ash is poisonous or not and also to see crystal structure and microstructure of Mount Sinabung ash.[Liu, Hermanto, 2010]. The scope in this research covers only the analysis of Arsene (As), Cadmium (Cd), Plumbun (Pb), Mercury (Hg), Zinc (Zn), Bronze (Cu).[Nain Felix Sinuhaji, 2010] and crystal structure and microstructure of Mount Sinabung volcanic ash.[Albert Daniel S, 2012] The sample was taken on 30th November 2013 at 15.30 at village of Perteguhen, approximately 7 km from the crater. The

purpose of the research is to identify the type of heavy metal of the volcanic ash of Mount Sinabung like Arsene (As), Cadmium (Cd), Plumbun (Pb), Mercury (Hg), Zinc (Zn) Cuprum (Cu), the size is in accordance with SNI 02.2803.2005 and also to determine crystal structure and micro structure of the volcanic ash. Volcanic ash is fragmented volcanic stone particle; it is hot when it is close to mountain but it becomes cold at certain distance. Volcanic ash varies in appearance depending on the type of mountain. [HTML A, 2010]. Generally heavy metal is classified by its density namely 5 gr/cm^3 . [Liu, Hermanto, 2010]. Basically, all creatures need heavy metals in various amounts. Human beings, for example, need iron, cobalt, copper, manganese, molybdenum and zinc in certain amount. But in excessive amount, heavy metal become destructive. The existence of heavy metals like Ag, As, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Sn, and Ti requires strict control in the environment. [Yudatomo, 2009], [Sudaryo, 2009],[Supriyanto, 2007].

2. Experimental

Volcanic ash is fragmented volcanic stone particle; it is hot when it is close to mountain but it becomes cold at certain distance. Volcanic ash varies in appearance depending on the type of mountain. [HTML A, 2010]. Generally heavy metal is classified by its density namely 5 gr/cm^3 . [Liu, Hermanto, 2010]. Basically, all creatures need heavy metals in various amounts. Human beings, for example, need iron, cobalt, copper, manganese, molybdenum and zinc in certain amount. But in excessive amount, heavy metal become destructive. The existence of heavy metals like Ag, As, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Sn, and Ti requires strict control in the environment.

[Yudatomo,2009], [Sudaryo,2009], [Supriyanto, 2007]. The equipment used in this research is AAS. SEM, XRD, Volcanic Ash of Mount Sinabung. The research was conducted in the AAS Laboratory of Oil Palm Research Center and Service Medan, SEM ITB Laboratory Bandung. XRD Laboratory, Fisika Syarif Hidayatullah Jakarta.

3. Results and Discussion

3.1. Heavy Metal Analysis

The results of the heavy metal composition analysis of Volcanic Ash of Mount Sinabung are shown in the following table 1.

Table 1: The Composition of Heavy Metal of Mount Sinabung Volcanic Ash, erupting on 29th November 2013

Plumbun (Pb) LoD < 50 ppm, Mercury (Hg) LoD < 1 ppm, Cadmium (Cd) LoD < 10 ppm, Cuprum (Cu) LoD < 5000 ppm, Arsene (As) LoD < 10 ppm, Zinc (Zn) LoD = 5000 ppm.

The composition of heavy metal of the ash of Mount Sinabung as shown in Table 1, can be detected that it contains heavy metal like Cuprum (Cu) = 46.35 ppm, Plumbum (Pb) < LoD, Cadmium (Cd) < LoD, Arsene (As) < LoD, Mercury (Hg) = 0.06 ppm and Zinc (Zn) 0.08 %. Limit of Detection (LoD) for heavy metal like Plumbum (Pb) < 50 ppm, Cadmium (Cd) = 10 ppm, Arsene (As) < 10 ppm, Mercury (Hg) < 1 ppm, Cuprum (Cu) < 5000 ppm and Zinc (Zn) < 5000 ppm. Heavy metal like Plumbum (Pb), Cadmium (Cd), Arsene (As) possess smaller composition than Limit of Detection (LoD) The volcanic ash from Mount Sinabung contains Cu,Hg and Zn in very little composition compared to LoD and the composition of heavy metal Pb, Cd, and As is far smaller than LoD. The volcanic ash of Mount Sinabung erupting on 29th November 2013 has 200 mesh size 85.20 % with a distance of approximately 7 km from the crater.

3.2. Crystal Structure Analysis

The crystal structure analysis if volcanic ash of Mount Sinabung as carried out using XRD. $\text{Cu}_{\text{K}\alpha} = 1.540059 \text{ \AA}$, so x-ray diffraction pattern as shown in the following figure 1 can be seen in the following figure

No	Heavy Metal	Unit	Nominal	Method
1	Cuprum (Cu)	ppm	46,35	AAS
2	Pelumbun (Pb)	ppm	< LoD	AAS
3	Cadmium (Cd)	ppm	< LoD	AAS
4	Arsene (As)	ppm	< LoD	AAS
5	Ferum (Fe)	%	4,37	AAS
6	Zinc (Zn)	%	0,02	AAS
7	Mercury (Hg)	ppm	< 0,001	ICP
8	Ash size 100 mesh	%	85,20	SNI

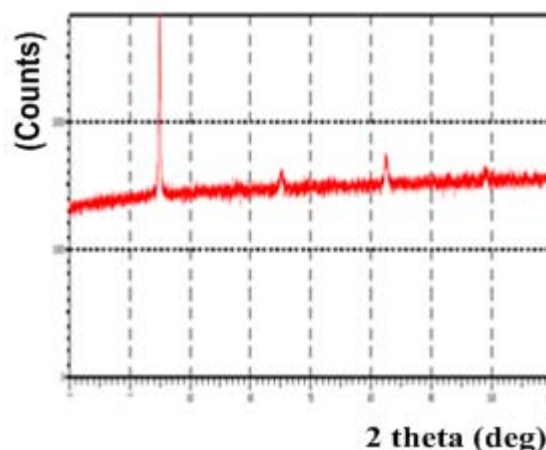


Figure 1: Diffraction Pattern of volcanic ash of Mount Sinabung erupting on 29th June 2014

From the diffraction pattern above the analysis can be concluded that the volcanic ash of Mount Sinabung contains Silicon Oxide / Quarts (SiO_2), 16.71 % , hexagonal structure, lattice constant $a = 4.9134 \text{ \AA}$ and $c = 5.4052 \text{ \AA}$, with density of 2.725 gr/cm^3 , (No. ICDD 46-1045), Calcium Aluminum Silicate / Anorthite ($\text{Ca}_2\text{Al}_2\text{Si}_2\text{O}_8$) 58.12 % , Triclinic structure, Lattice constant $a = 8.1813 \text{ \AA}$, $b = 12.8740 \text{ \AA}$ and $c = 7.0970 \text{ \AA}$, with the density of 2.725 gr/cm^3 (No. ICDD 41-1481) and Sodium Aluminum Silicate (Albite high) $\text{Na}(\text{AlSi}_3\text{O}_8)$, Triclinic crystal structure. Lattice constant $a = 8.1535 \text{ \AA}$, $b = 12.8694 \text{ \AA}$ and $c = 7.1070 \text{ \AA}$, with the density of 2.615 gr/cm^3 , No. ICDD 71-1150 and (JCPDS - International Center for Diffraction Data, 2002)

3.3. Microstructure

Microstructure analysis of mount Sinabung with 3000 times enlargement can be seen in the following figure 2.

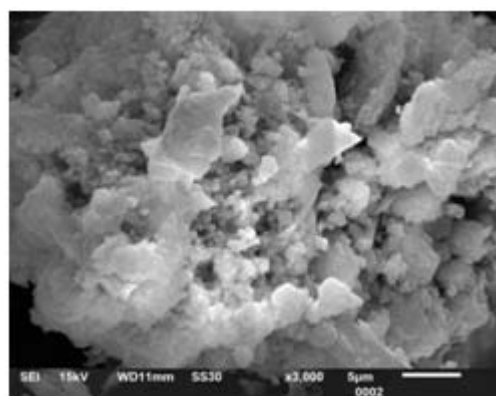


Figure 2: Microstructure of Mount Sinabung Ash Erupting on 29th November 2013

From picture 1 above an analysis, it can be concluded the volcanic ash of Mount Sinabung possesses sharp microstructure with irregular edge like broken glass. If the ash is inhaled into the lung, respiratory track infection may occur and it goes into the eye, it may cause irritation.

4. Conclusion

After the analysis and observation of microstructure and crystal structure of volcanic ash of Mount Sinabung it can conclude that.

1. Volcanic ash of Mount Sinabung contains 0.08 % Zinc, 46.35 ppm Cuprum
2. Volcanic ash of Mount Sinabung also contains 16.71 % Silicon Oxide / Quartz SiO₂ Hexagonal crystal structure, lattice constant $a = 4.9134 \text{ \AA}$ and $c = 5.4052 \text{ \AA}$, with density of 2.725 gr/cm³ (No.ICDD 46.1045). 58.12 % Sodium Calcium Aluminum Silicate/ Anorthite (CaNa) (Si,Al)₄O₈, with 2.72 gr/cm³ density (No ICDD 41.1481). Triclinic crystal structure, lattice constant $a = 8.1813 \text{ \AA}$, $b = 12,8740 \text{ \AA}$ and $c = 7.0970 \text{ \AA}$ with 2.725 gr/cm³ density, (No.ICDD 71-115) and Sodium Aluminum Silicate / Albite Hih,Na (Al Si₃ O₈),25.17 %,Triclinic Crystal Structure, lattice constant $a = 8.1535 \text{ \AA}$, $b = 12.8694 \text{ \AA}$ $c = 7.1970$ with the density of 2.615 gr/ cm³, No.ICDD 71-1150)
3. Microstructure of Mount Sinabung volcanic ash possesses sharp edges like broken glass that it can cause eye irritation, bronchitis and respiratory track infection.

5. Acknowledgments

Acknowledgments addressed to all parties who have helped. Especially to Prof. Timbangan Sembiring, MSc. who directed and guided until this research works.

References

- [1] Wikipedia A. Mountain Eruption, ([http://id.wikipedia.org/wiki/ Mountain Eruption](http://id.wikipedia.org/wiki/Mountain_Eruption)) accessed on 17 September 2013
- [2] HTML A, Volcanoes. USGS. Gov, diakses pada tanggal 17 September 2010, <http://volcanoes.usgs.gov/ash/properties.html>
- [3] HTML A. Volcanoes USGS Gov., accessed on 17 September 2010 ([http://volcanoes.usgs.gov/ash/properties, html](http://volcanoes.usgs.gov/ash/properties.html))
- [4] Yudatomo, 2009. Heavy Metal, PT.YTL, East Java,Paiton 2009, Ministry of Health Regulation No.416/MEN.KES /PER/IX/1990 regarding Requirements and Control on Drinking Water Quality
- [5] Indonesian National Standard of Maximum Limit Containment of Heavy Metal in Food, SNI 77387: 2009, ICS 67.220.20
- [6] Sudaryo, Metal Identification and Classification on Volcanic Land in Area around the Mountain in Sleman Regency Using the Method of Rapid Neutron Activation Analysis, STTN, Batan Yogyakarta
- [7] Supriyanto, Heavy Metal Contamination Analysis Pb,Cu, and Cd on Plain Fish Water Using the Method of Flame Spectrofotometri Atomic Absorbtion,Yoyakarta, 2007
- [8] Ikrob, Didik, Hazardous Volcanic Ash, Joglo Daily, Com, 2010