Studies on Ejecta from Gallungung Volcano, West Java, Indonesia, Referring to Its Effects on Crop Growth

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Abstract

Eight samples from ejecta deposits from Gallungung Volcano, West Java, Indonesia. were collected. The thick deposits of ejecta caused serious damage to the agriculture around the volcano.

In this study, apart from the direct damage, the ejecta (volcanic ash, scoria etc.) was examined with special attention paid to its nutritional status.

All the samples were found to contain considerable amounts of available (common extractants soluble) nutrients : i.e. N, P, K, Ca, Mg, Na). Especially, the occurrence of soluble N was noticeable because primary magma contains almost no nitrogen compounds. These nutrients are, of course, effective to crop growth.

Most of the samples contain more or less of a secondary crystalline mineral, smectite, which is capable of retaining larger amounts of H_2O and nutrient cations as exchangeable ones.

In the tropics, the soils in volcanic zones are thought to be fertile. The fertilities are partially attributable to the fresh ash falls which have the nutritients found here.

Key Words:Gallungung Volcano, Nutrients in volcanic ash, Nitrogen in volcanic ejecta, Smectite.

Introduction

In 1982,Gallungung Volcano became violently active and erupted much ejecta. Deposits as thick as several meters were found around the volcano and caused serious damage to the agricultural activities. The volcanic ashes reached Jakarta, about 200km from Gallungung.

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The main eruptions occurred 3 times in April, 3 times in May, 6 times in June, 7 times in July, 6 times in August and 1 time in Septembar ("Gallungung, Letusan dan Penanggulangan" A pamphlet, in Indonesian).

OBA et al.(1983) investigated these volcanic products lithologically and geochemically, classifying them into pyroclastic flow and volcanic ashes.

Heavy falls of the volcanic ejecta caused the vegetation to wither and die. Thick deposits also make germination of buried seeds difficult.

While the ejecta (volcanic ash, sand and scoria etc.) was confirmed to be effective for crop growth when added to and mixed with soils, because of mainly nutritional elements retained in the volcanic materials (MIYAUCHI and NAGATA, 1983).

The soils of volcanic zones in the tropics are known to be generally fertile compared with other non–volcanic soils.This may be partially attributable to the above–mentioned nutritional effects of the volcanic ejecta.

Here, apart from the direct damages to crop growth by the thick deposit, the ejecta from Gallungung was studied with special attention to its nutritional status.

Materials and Methods

Eight samples were collected from the foot of Gallungung (about 50km south–east of Bandung).

Samples 1 ~ 3 were taken from an upland field covered with volcanic materials. They were taken from one profile: No.1 from 0 ~ 3cm depth, sandy (scoria), No.2 from 3 ~ 11cm, loamy ash and No.3 from below 11cm, sandy. Sample 4 was fine–textured ash collected from a rooftop in the same area.

Samples 5 ~ 8 were taken from surface deposits near the dam side where secondary debris flow of the volcanic ejacta occurred.

These samples were considered to correspond to the mud flow and to the lapilli and ash (air fall) after the OBA et al.'s classification (1983).

The samples were examined for the following items: pH measurement, particle size fractionation, X–ray and thermal analyses and available (soluble) nutrients determination.

The pH of the sample was measured with the suspension of the solid/water ratio of 1/2.5.

The particle size fractionation of the sample was made after sonic treatment (20kHz for 10 minutes) to ensure the complete dispersion of particles in slightly alkaline water.,

Rather larger amounts of clay fractions were prepared as Mg– and K–saturated ones and were X–ray analyzed. The diffraction patterns were obtained for the Mg– and K–clays. The changes of d(001) spacings after ethylene glycol solvation for Mg–clay and heating to 350°C and 550°C for K–clay were also tested, using the RAD–RB system of

Rigaku Denki Co. Thermal analyses (DTA and TG) of the clay fractions were carried out at the elevation rate of 20°C per minute.

The available N in the sample was extracted with 2N–KCl, which consisted of both NH_3– and NO_3–N. All the extracted N was converted to ammonia form by Devarda's alloy (NO_3–N was reduced to NH_3–N) and then determined by titration, using a Conway unit.

The available P was extracted with $(NH_4)_2SO_4$–H_2SO_4 buffer of pH 3.0 (Truog–P) and determined by spectrophotometer, developing molybdate blue color.

The water soluble and exchangeable K, Ca, Mg and Na were extracted with lN NH_4–acetate solution of pH 7.0. Each cation was determined by a Hitachi 170–10 atomic absorption spectrophotometer.

Results and Discussion

The mechanical compositions (particle size distribution) of the samples is shown in Table 1. It is apparent that the sizes of ejecta is quite variable. The coarse sand fractions in the samples ranged from 5.2% to 90.6% and the finest ones (clay fractions) from 0.0 to 3.8%.

Such difference in particle size have been observed in many cases as reported in Sakurajima's ash fall (MIYAUCHI and NAGATA, 1983) and suggests various ways of influences on the living environment.

Table 1. Particle size distribution of the samples

Sample No.	coarse sand (2 - 0.2mm)	fine sand (0.2-0.02mm)	silt (0.02-0.002mm)	clay (- 0.002mm)
1	60.5	26.9	3.6	0.0
2	10.0	64.8	24.0	1.2
3	90.6	6.9	2.5	0.0
4	5.2	66.4	27.4	1.1
5	25.9	53.5	20.0	0.8
6	66.6	27.0	6.2	0.2
7	26.1	52.2	20.6	1.1
8	10.8	62.9	24.8	1.5

% on oven-dry basis

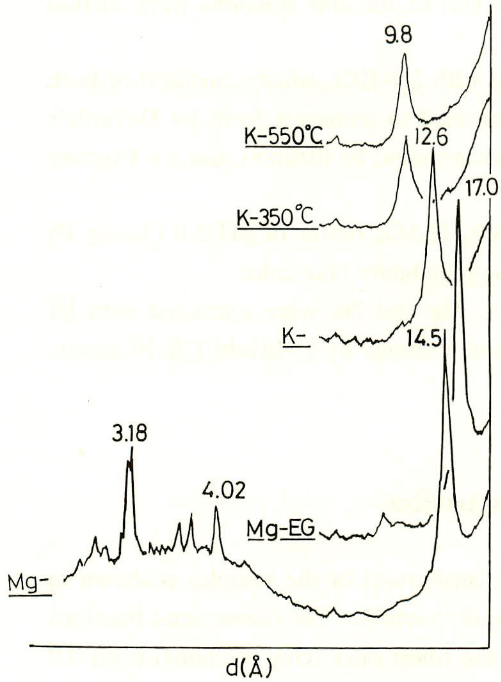

Fig. 1. X–ray diffraction patterns for the clay fraction of sample No.8, showing the changes of d(001) spacing with each treatment. EG: ethylene glycol solvation.

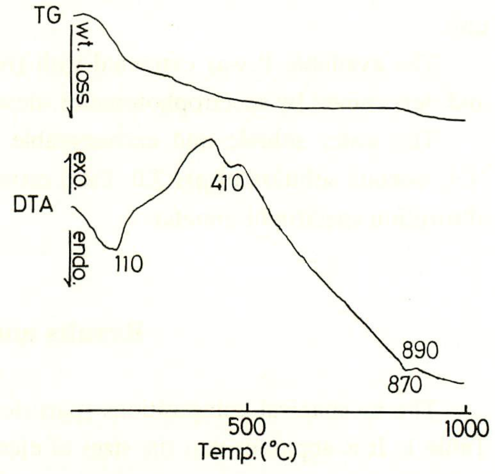

Fig. 2. Thermal analyses curves for the clay fraction of sample No.8. TG: thermogravimetry. DTA: differential thermal analysis. Exo– and endo– indicate exo– and endo–thermic peak, respectively.

The fact that most samples contain some clay size particles was noticeable because, in most cases, fresh ash contains no secondary minerals (clay minerals) and so they were presented to X–ray and thermal analyses.

As shown in Figs.1 and 2, the existence of clay mineral smectite is apparently shown: i.e. a sharp peak at 14.5Å for Mg–specimen swells to 17.0Å with ethylene glycol solvation, contracted to 12.6Å with K saturation and further to 9.8Å after heating at 350°C and at 550°C, indicating the characteristic basal spacing changes of smectite. The diffraction peaks of primary mineral feldspar (4.02, 3.18Å etc.) are also observable. Thermal figures also correspond to that of smectite except the endothermic peak and slight weight loss near 410°C which is attributed to gibbsite.

The occurrence of crystalline clay minerals in fresh volcanic ash have been reported in Usu, Japan (KONDO et al., 1978) and in the 1883's pyroclastic flow of Krakatau, Indonesia (MIYAUCHI et al., 1986), though the formation mechanism of them are still not clear.

Table 2. Some environmental factors of the samples for crop growth

Sample No.	pH	Available nutrients (mg/100g)					
	(H_2O)	N	P	K	Ca	Mg	Na
1	4.4	0.78	0.64	4.96	19.2	5.6	7.2
2	6.4	1.16	1.69	8.30	55.2	17.2	27.2
3	4.3	1.68	0.67	3.40	41.8	17.2	21.6
4	7.4	1.27	0.88	4.80	38.8	5.6	7.6
5	6.7	1.98	2.28	2.92	44.4	7.4	8.5
6	4.6	1.16	0.89	3.04	27.0	7.2	5.8
7	6.1	1.49	2.42	4.88	42.4	9.4	6.0
8	7.2	1.72	1.89	5.64	35.6	6.6	6.0
	(5.5-6.5)	(10-15*)	(5<)	(12-24)	(160<)	(12<)	

( ) : Desirable values for Japanese field conditions (YOKOI et al., 1979)
* In the case of paddy field

The occurrence of smectite in these samples mean that the ejecta are capable of retaining the nutritional cations as exchangeable ones and also of retaining larger amounts of H_2O and therefore they are beneficial to crop growth.

The chemical aspects are shown in Table 2. The pH values vary from 4.4 to 7.4. Among the samples, coarser (less content of clay) ones seem to have a lower pH. Samples showing pH below 5 are not good foe vegetation.

All samples contain considerable amounts of soluble or available nutritional elements. Especially, the existence of extractable nitrogen, even if the amount is small, seems quite interesting, because the magma itself is considered to contain no nitrogen compounds. The extracted N might be formed at the moment of eruption from N_2 gas in the air or in the volcanic gas similar to mechanism of thunder generation. The contents of nutrients in these ejecta alone are not sufficient for crop growth based on desirable values for cultivated field (Table 2). However, if added to soils, volcanic ash may be an adequate fertilizer.

In Japan, mainly the detrimental effects of ash falls on vegetation has been investigated, but the above–mentioned positive nutritional effects should be also considerable hereafter.

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