LAPORAN AKHIR

RISET KEMITRAAN INTERNASIONAL
PROGRAM DESENTRALISASI

REMEDIATION OF VOLCANIC ASH SOILS IN MANAGING AND IMPROVING THEIR SUSTAINABLE PRODUCTIVITY IN THE AGRICULTURAL AREA

Oleh :

Dr. Rina Devnita, Ir., M.S., M.Sc
Rida Hudaya, Ir., M.S.
Ir. Mega Fatimah Rosana, M.Sc., Ph.D

dan

Professor D.Sc. Hiroharu MATSUEDA
(HOKKAIDO UNIVERSITY – JAPAN)

DIBIAYAI OLEH :

DANA DIPA BLU UNIVERSITAS PADJADJARAN
TAHUN ANGGARAN 2012
SESUAI DENGAN SURAT KEPUTUSAN REKTOR UNIVERSITAS PADJADJARAN
Nomor : 1039/UN6.RKT/KP/2012
Tanggal : 2 PEBRUARI 2012

KEMENTERIAN PENDIDIKAN DAN KEBUDAYAAN
UNIVERSITAS PADJADJARAN
FAKULTAS PERTANIAN
OKTOBER, 2012

IDENTITY AND VALIDATION OF FINAL REPORT
RISET KERJASAMA INTERNASIONAL (RiKI)
DESENTRALISATION PROGRAM
FUNDED by DP2M DIKTI KEMDIKBUD 2012

1.	Title	:	**Remediation of Volcanic Ash Soils in Managing and Improving Their Sustainable Productivity in the Agricultural Area**

2.	Principal Investigator		
	a. Full Name	:	Dr. Rina Devnita, Ir., M.S, M.Sc.
	b. Gender	:	Female
	c. Position/Rank/NIP/NIDN	:	Lektor Kepala / IV. a / 19631222 198903 2 001 / 0022126309
	d. Function	:	Pembina
	e. Faculty/Department	:	Agriculture / Agro Technology/ Soil Science
	f. Research Centre	:	Padjadjaran University
	g. Field of the Research	:	Soil Science
3.	Number of the Researchers	:	3 (three)
	Member 1	:	Ridha Hudaya, Ir., M.S.
	Member 2	:	Ir. Mega Fatimah Rosana, M.Sc., Ph.D
4	Location of the Research	:	- Lembang, Horticultural Research Institute - Laboratory of Physic and Chemistry Padjadjaran University. - Hokkaido University, Sapporo, Japan
5.	In case this research is a collaboration with other institution		
	a. Instiution, Person	:	Hokkaido University, Prof.Hiroharu MATSUEDA
	b. Address	:	The Hokkaido University Museum & Natural History of Science Hokkaido University - Japan 060-0810
6.	Duration of the research	:	8 months, from February till October 2012
7.	Cost approved	:	Rp 160.000.000 (one hundred and sixty million rupiahs)
	Cost (first year)	:	Rp. 160.000.000,-
	Second year (in proposing)	:	Rp. 200.000.000,-

Jatinangor , October 31th, 2012

Approved by,
The Dean of Faculty of Agriculture
Padjadjaran University

Prof. Dr. Benny Joy, Ir., M.S
ID. 19520707 198503 1 002

Principal Investigator

Dr. Rina Devnita, Ir., M.S., M.Sc.
ID. 19631222 198903 2 001

Approved by,
The Head of Research and Community Service Institute of Padjadjaran University

Prof. Dr. Wawan Hermawan, M.S
ID. 19620527 198810 1 001

Abstract

Volcanic ash soils (VAS) are among the most productive soils in the world. But they were regarded as impoverished soils because of high variable charge and P-retention with low available P. The objectives of this research were to manage and improve the productivity of VAS for having their sustainable productivity. The incubation of 2 kg of soil with the remediation material of slag steel and bokashi of husk in the combination of 0, 2.5, 5.0, and 7.5 of weight percentage were done for four months to know the influence of those materials in reducing pH_0 and P-retention and in increasing pH, CEC and availbale P. The result showed that the remediation treatments increased the soil pH, available P, CEC and decreased the pH_0 and P-retention. The treatment of 7.5% of slag steel combined with 7.5% of bokashi of husk gave the best result in increasing pH from 5.1 to 5.7, available P from 4.8 to 7.2 mg kg^{-1}, CEC from 14 to 30 cmol kg^{-1}, and in reducing pH_0 from 4.2 to 3.8, P- retention from 96 to 86%. Slag steel and bokashi of husk can be considered as remediation materials for improving some chemical characteristics of VAS.

Key words: variable charge, P retention, slag steel, bokashi of husk

Abstrak

Tanah abu vulkanik termasuk salah satu tanah paling produktif di dunia, namun dianggap mengalami kemerosotan/pemiskinan karena mempunyai muatan variabel, sehingga mempunyai retensi P tinggi dan ketersediaan P rendah. Tujuan penelitian ini adalah untuk mengelola dan meningkatkan produktivitas tanah abu vulkanik untuk memperoleh produktivitas tinggi yang berkelanjutan. Inkubasi 2 kg tanah dengan material remediasi terak baja dan bokashi sekam padi dengan kombinasi 0, 2.5, 5.0, and 7.5 (persen berat) dilakukan selama empat bulan untuk mengetahui pengaruh material tersebut dalam mengurangi pH_0 dan retensi P serta meningkakan pH, kasitas tukar kation (KTK) dan ketersediaan P. Hasil penelitian menunjukkan bahwa perlakuan remediasi ini meningkatkan pH tanah, ketersediaan P dan KTK, serta menurunkan pH_0 dan retensi P. Perlakuan 7.5% terak baja berkombinasi dengan 7.5% bokashi sekam padi memberkan hasil terbaik dalam meningkatkan pH dari 5.1 menjadi 5.7, ketersediaan P dari 4.8 menjad 7.2 mg kg^{-1}, KTK dari 14 menjadi 30 cmol kg^{-1}, dan menurunkan pH_0 dari 4.2 menjadi 3.8, retensi P dari 96 menjadi 86%. Terak baja dan bokashi sekam padi merupakan material remediasi yang dapat digunakan untuk memperbaiki sifat kimia tanah abu vulkanik.

Kata kunci: muatan variabel, retensi P, terak baja, bokashi sekam padi

PREFACE

Volcanic ash soils from the elevational transect at Mt. Tangkuban Parahu in West Java, Indonesia were studied to characterized their physico-chemical and mineralogical properties, and treated with slag steel combined with bokashi of husk to improve the chemical characteristics. The soils are developed under udic soil moisture regime and isohyperthermic soil temperature regime. They have dark epipedons with high organic carbon content but less than 20%, low bulk densities (< 0.9 g cm^{-3}), high P-retention (> 85%), and aluminum plus half of iron extracted with acid ammonium oxalate are more than 2%, made they be classified as Andisols.

As others volcanic ash soils, these soils are productive, except for the P-retention and available P point of view. Their high P-retention and low available of P content are due to the high variable charge of their noncrystalline mineralogical content like allophane, imogolite and ferrihydrite. It could make they be impoverished if not be managed as their natural characteristcs. Therefore, management of these soils are focused on reducing the high P-retention by adding the materials with high negative charge like silicate and organic matter that could block the positive charge of volcanic ash soils for increasing their negative charge and pH, and releasing the available P.

The treatments with slag steel as silicate materials and bokashi of husk as organic matter as the remediation materials, were expected to release a huge amount the negative charge as they were incubated with volcanic ash soils for four months. The result showed that the remediation materials increased the soil pH**,** available P, and CEC and decreased the pH_0 and P-retention. The treatment of 7.5% slag steel combined with 7.5% of bokashi of husk gave the best result in increasing pH from 5.1 to 5.7, available P from 4.8 to 7.2 mg kg^{-1}, CEC from 14 to 30 cmol kg^{-1}, and in reducing pH_0 from 4.6 to 4.0, P- retention from 96 to 86%. Slag steel and bokashi of husk can be considered as remediation materials for improving some chemical characteristics of volcanic ash soils.

The authors thank to many people and institution that made this research happened from the begining of the purpose, till the end of the writing report. The geratest thanks are due to The Head of Soil Science Department, The Dean of Faculty of Agriculture, The Head of Research and Community Service Institute and The Rector of Padjadjaran University include the institution as well for

permitting the authors doing the research. The authors also thank to The Head of Laboratory of Natural Science of Hokkaido University, Japan for his permission to do some mineralogy analyses there. The special thank is addressed to The Directorate General of Higher Education, Ministry of Education and Culture for funding this reseach.

Lastly, the authors wish that this report as the conclusion of the research could contribute things to the knowledge and application on agriculture, especially soil science.

Jatinangor, October 31, 2012

Authors,

Rina Devnita
Ridha Hudaya
Mega Fatimah Rosana

CONTENTS

		Page
I.	**INTRODUCTION**	1
	1.1 Background of the Research	1
	1.2 Prolems	2
	1.3 Purpose of the Research	3
	1.4 Schedule of the Research	5
	1.5 The Personels	6
	1.6 Location and Object of the Research	6
II.	**LITERATURE REVIEWS, CONCEPTUAL FRAMEWORKS AND HYPOTHESIS**	7
	2.1 Literature Reviews	7
	2.2 Conceptual Frameworks	10
	2.3 Hypothesis	11
III.	**MATERIALS AND METHODS**	12
	3.1 Materials and Equipments	12
	3.2 Experimental Designed	14
	3.3Data Analyses	15
IV.	**RESULTS AND DISCUSSIONS**	16
	4.1 Physical Environment	16
	4.2 Parent Materials and Mineralogy of the Sand Fraction	17
	4.3 Clay Mineralogy	18
	4.4 Changer in Soil Properties after Incubation	20
V.	**CONCLUSSIONS AND SUGGESTIONS**	23
	REFERENCES	24
	APPENDIX	

Tables

No.	Tables	Page
1.	The combination treatments of slag steel and bokashi of husk	5
2.	The geographical position of the profiles	16
3.	The day of rain, rainfall, air and soil temperature in the research area	17
4.	The composition of the minerals in the sand fraction in the upper horizon	18
5.	Quantitatively result of allophane, imogolite and ferryhydtrite in the clay fraction	19
6.	Selected chemical properties of upper 20 cm the studied soil	20
7.	Effect of the remediation treatments of slag seel and bokashi of husk to slected soil parameters	21

FIGURES

No.	Figures	Page
1.	The reflection of XRD on silt and clay fraction	19

CHAPTER I
INTRODUCTION

1.1 Background of the Research

Volcanic ash soils are dominated by short-range-order minerals such as allophane, imogolite, metal-humus complexes and ferrihydrite. These minerals contribute to active Al and Fe, and give a significant effect on physical and chemical properties to the soils (Shoji et al, 1993). These minerals are also the genuine of variable charge, make the soil colloids largely depend on the pH and the electrolyte concentration on soil solution (Van Wambeke, 1992). Volcanic ash soils exhibit high point of zero charge and low nutrient holding capacity (Nanzyo et al, 1993). High rainfall and rolling topography in mountainous region also make the cations are easily leached out and soil fertility deteriorate faster.

Allophane is the most active component in volcanic ash soils, and it strongly retains phosphate (Van Ranst, 1995). The available P, applied as fertilizer is quickly decreased and only 10% could be utilized by crops (Egawa, 1977). This constraint can be alleviated by blocking the positive charge of allophane by adding the high negative charge materials. The high negative charge materials are functioned as inorganic or organic remediation. Silicate, phosphate, and organic matter with high negative charge can be used for blocking the positive charge of volcanic ash soils (Qafoku et al, 2004). Slag steel as silicate material and bokashi of husk as organic matter are the potential remediation materials.

The objectives of blocking the positive charge are for releasing the P-retention, and increasing the negative charge by decreasing the pHo or increasing the pH. Devnita (2010a) found that the addition of silicate, phosphate and organic matter can reduce the P retention from 99% to less than 90%. The reductions of pHo were also found in 0.4-0.8 point. Fiantis (2000) found that the addition of Ca-silicate from 2.5, 5.0, and 7.5% weight of soil in pot can reduce the pHo from 4,0 to 3.0. Boniao (2000) found that the remediation with peat reduce the pHo up to 0.3 point, meanwhile remediation with Ca-silicate reduce the pHo to 0.5 point.

The reducing of pHo will increase the negative charge of the soils, for the P-retention can be reduced and available P can be increased. Devnita (2010b) found that the reducing of pHo increased the available P. Boniao (2000) found the the reducing oh pHo increased the height and biomass of corn.

1.2 Problems

The main problems of volcanic ash soils are related to their variable charge, causes their charge are dependng on the pH, and their P-retention are extremely high. P-retention in volcanic as soils are more than 85%, and in some cases can be more than 95%, even almost 100%. Consequently the availble P is really low. Only about 10% of P fertilizer giving to these soils can be available for plants. Phosphorus can be act as the limiting factor in increasing the producvity in volcanic ash soils.

Maintaining the P problem in volcanic as soils can not be as simple as giving P fertilizer, because once the fertilizers applied, they will immediately retain by the positie charge of allophane, imogolit and ferrihydrite for no longer available for plant growth. The main problem of P-retention have to be solved first. This only can be done by blocking the positive charge of the soil colloid with materials that have a high of negative charge. Previous researches mentioned that silicate and organic matter are the materials with high negative charge. Slag steel as the silicate and bokashi of husk as the organic matterial are the materials that have high negative charge when they weathered and decomposed in the soils. These charges are expecting to block the positive charges of the noncrystalline minerals, for the P-retention is expected to be released and available for plant growth.

The others advantages of giving the silicate and bokashi of husk as the remediation materials,they could increase the CEC, pH and some basi cations, and they could decrease the pH_0 . These conditions are the favorable conditions for many plants, for they could having almos all of the nutrients that will be used for they growth.

1.3 Purpose of this Research

The purpose of this research is to manage and improve the sustainable productivity of volcanic ash soils. This is an important exertion, since volcanic ash soils are one of most productive soils which supports the need of food, fiber and forage, but have the tendency to impoverish because of high amount of active aluminum, very low content of available phosphate due to the very high phosphate retention, low concentration of exchangeable bases and strong acidity.

The optimization the usage of slag steel and bokashi of husk is also the special purpose of this research. Slag steel is a byproduct in the steel manufacture. This material is potential be used as a remediation due to the high content of silicate, but have not much been applied in agricultural area. Husk is also a byproduct in the rice mill processing. As the organic matter, husk has two advantages if used as remediation materials. Firstly due to its high negative charge as an organic matter, and secondly due to the silicate content in husk releases available Si which will be used by some crop. Husk that has been decomposed by microorganism to be the bokashi of husk will be more efficient to be used in the soils.

It will be a big challenge to overcome the problem in volcanic ash soils with the materials that can be found in Indonesia. Slag steel can be gained from PT. Krakatau Steel. The heap of husk is easily found during rice mill processing. Using these byproduct materials as the valuable remediation materials overcome not only the problem in the soils, but also in processing of steel and rice mill

The information on the characteristics of volcanic ash soils, their main constraints on crop production, and the rational management for optimizing and increasing their productivity is practically the basic need to maintain their sustainable productivity. As one of most productive soils which serve food, fiber and forage, volcanic ash soils have always to be maintained properly. The lack of knowledge on soil characteristics, culminate in exploitation of this soils without gaining more additional yield. Giving an excessive fertilizer, especially phosphorus, will only result in frustration because instead of gaining the increasing yield, the production tends to leveling off. Therefore, understanding the characteristics of this soil is an important aspect to plan the rational management.

Blocking the positive charge is the idea in managing this soil. Giving the remediation with high negative charge anion, will firstly fulfill and cover all positive charge site and secondly built the negative charge site. Remediation material like silicate and organic matter is the ideal material due to their ability to contribute the negative charge in the soil.

Create the negative charge in this variable charge soils has some advantages in improving soil characteristics. Being a negative charge soil, the P-retention will be reduced in the significant amount. The cation exchange capacity will also increase, make the soil have more capability to retain nutrient like Ca, Mg, K and other cations. Losing of these cations to the subsurface horizon due to leaching therefore can be diminished. Increasing the availability of P, Ca, K, Mg and other micro elements will in turn improve the productivity of the soils.

1.4 Schedule of the Reseach

Activities \ Months	Febr	Mrch	April	May	June	July	Agst	Sept	Oct
Preparation of some working permisssion, working group of the students, tools for doing survey									
Preparation of soil survey from available map									
Pre Survey to the areal of volcanic ash soil, to determine the site location									
Survey in the selected location in the Balitsa Sukarami									
Profile description, soil sampling from the identifiable horizons for soil characteristics & classificaion, soil sampling from upper horizon for treated with the remediation materials									
Soil caharateristics analyses: Physical, chemical, and preparation for mineralogical analyses									
Visiting PT. Krakatau Steel< Cilegon for taking sla steel									
Presentation in Hokkaido University, Japan									
Mineralogical analyses in Hokkaido University, Japan									
Grinding the slag steel to to pass the sieve of 50mesh									
Preparation / making of bokashi of husk									
Prepartion of incubation with slag steel and okashi of husk									
Treated the soil (2 kg) with slag steel and bokashi of husk in accordance with the treatments of 0, 2.5, 5.0, and 7.5 of weight percetage									
Incubation periode for four months									

Checking of water content during the incubation periode. If the water content reduce from the field capacity, some water adeded.									
Analyses of soil chemical and physical characteristics after incubation periode									
Making Reports and Scientific Article									

1.5 The personels

No.	Personel	Incumbency
1	Dr. Rina Devnita, Ir., M.S., M.Sc.	Chairman of the research
2	Ridha Hudaya, Ir., M.S	Member of the research
3	Ir. Mega Fatimah Rosana, M.Sc., Ph.D	Member of the research
4	Prof. DSc. Hiroharu MATSUEDA	Research collaborator (Hokkaido University)
5	Ovin S	Student
6	Esfen Girsang	Student
7	Adrino	Student
8	Ichsan	Student

1.6. Locations and Object of the Research

Locations of the research were distributed in some spots:

a. Horticulture Research Institute in Lembang, West Java, for profile description, soil sampling, and analyses of some physical, chemical, and preparation of mineralogical characteristic

b. Labratory of Natural History of Science, Hokkaido University, Japan for mineralogical analyses

c. Laboratory of Soil Physic of Faculty of Agriculture, Padjadjaran University to place the incubated soil for four months, and for analyses some soil physical characteristic ater incubation

d. Laboratory of Soil Chemistry of Faculty of Agriculture, Padjadjaran University for analyses some chemical characteristic ater incubation

CHAPTER II

LITERATURE REVIEWS, CONCEPTUAL FRAMEWORKS, AND HYPOTHESIS

2.1. Literature Reviews

Volcanic ash soils are distributed exclusively in regions where active and recently extinct volcanoes are located (Shoji et al, 1993). The soils cover only 0.84 % of the world's land surface, but they represent a crucial land resource due to their productivity support the need of food, fiber and forage. This soils support 10 % of the world's population, including some of the highest human population densities attributed to their natural fertility. However, this is true only in part. This account addresses to the specific feature and genesis of the volcanic soil, and how they are abused in various global environmental settings.

Volcanic soils have a very important role in Indonesia, where low input farming is common, weathering of soil materials advanced, and leaching of soil nutrients intensive (Arifin, 1994). Their agricultural production potential strongly depends on their chemical and physical properties. Accurate and detailed information on these properties is necessary to identify and to minimize the constraints for improving and sustaining agricultural productivity (Devnita, 2010). One of the most important properties, responsible for nutrient availability, is surface charge. Volcanic ash soils commonly have colloids with extreme variable charge. The peculiar behaviour of these soils is largely influenced by organic and inorganic active constituents.

Volcanic soil is a soil developed from volcanic ejecta such as ash, pumice, and cinder. The clay minerals that weather from the ash (i.e., allophane and imogolite) are poorly crystallized and thus amorphous in structure and have an extremely large amount of surface area per unit of volume. These soils contain very large amounts of organic matter in the surface "horizon" (soil layer); 13– 28 percent total organic matter is a common range. As Andisols become more weathered, they have a tremendous water-holding capacity. They are considered light soils because they have a low bulk density (0.4–0.8 g cm^{-3}) and therefore they are generally easy to cultivate. The combination of good physical properties (low bulk density, stable soil aggregates, high water holding capacity and good drainage) coupled with their naturally high organic matter content makes Andisols generally highly productive soils. However, the aluminum and iron clay minerals in Andisols have a very strong capacity to adsorb phosphorus (P, one of the essential plant nutrients) and make it unavailable for plants; this process is especially pronounced in the Andisols that occur in wet environments . more than 60 inches of rainfall (Egawa, 1977).

These soils are found in areas where volcanic vents were once active. Andisols that are found in areas receiving less than 60 inches of annual rainfall are some of the most fertile and productive. These are moderately weathered loamy soils high in organic matter and plant nutrients such as calcium (Ca) and potassium (K), where they support extensive vegetable production. Where rainfall exceeds 60 inches per year, the Andisols are more weathered and less fertile. The higher amount of rainfall has leached much of the plant nutrient content (i.e., Ca, and K) from the surface horizons, and the remaining aluminum and iron minerals have a tremendous capacity to bind soil P. With proper management, however, these soils can be made productive for a wide range of food crops (Hingston, 1972).

Soils formed in volcanic ejecta have many distinctive physical, chemical, and mineralogical properties that are rarely found in soils derived from other parent materials. These distinctive properties are largely attributable to the formation of noncrystalline materials (e.g., allophane, imogolite, ferrihydrite) containing variable charge surfaces, and the accumulation of organic matter. Formation of noncrystalline materials is directly related to the properties of volcanic ejecta as a parent material, namely the rapid weathering of glassy particles. The composition of the colloidal fraction forms a continuum between pure Al–humus complexes and pure allophane/imogolite, depending on the pH and organic matter characteristics of the weathering environment. For soil management purposes, volcanic soils are often divided into two groups based on the colloidal composition of the surface horizons: allophanic soils dominated by allophane and imogolite, and nonallophanic soils dominated by Al–humus complexes and 2:1 layer silicates. Volcanic soils exhibit a wide range of agricultural productivity, depending on the degree or intensity of pedogenic development and the colloidal composition of the rooting zone (Van Wambeke, 1992).

The soils developed from volcanic ash are characterized by the accumulation of humus, fixation of phosphate, leaching of bases and formation of aggregates with micropores, which closely related to the nature and properties of the clay-size minerals, particularly the noncrystalline minerals like allophane, imogolite, ferryhydrite and metal-humus complexes. They either reflect the presence of volcanic ejecta such as ash, pumice cinders or lava in the soil, or they indicate the properties of amorphous clays that characterize volcanic ashes that weather rapidly in humid or perhumid climates (Nanzyo et al, 1993) .

The absence of well-defined crystallize minerals in the clay fraction typifies as a genuine variable charge soils, which the charge of soils colloids are largely dependent on the pH and the electrolyte concentration of the soil solution. The charges in volcanic ash soils are contributed by active Al, Si and Fe. Volcanic ash soils exhibit high point of zero charge and low nutrient holding capacity. The development of negative and positive charges on allophane and imogolite is influenced by pH, the nature and concentration of cations and anions in solutions and temperature. Consequently, they will have high pHo and low cation exchange capacity (CEC), resulting in a limited ability to retain cations and worst excessive losses of cations at certain soil pH (Shoji et al, 1993).

Allophane is considered as the most active components in the volcanic ash soils. Since allophane has hollow structure and positive charge sites, it strongly retains phosphate and organic matter. The availability of soluble phosphorus applied as fertilizer to plants is quickly decreased and only 10 % of the applied phosphorus is utilized by most crops. Phosphorus deficiency is the most important agronomic problem in volcanic ash soils. This constraint can be relieved by blocking the positive charge and hollow site of the allophane. Theoritically, these losses of cations can be prevented according to the literature (Van Ranst, 1995, Qofaku et al, 2004) by developing negative surface charges and thus creating additional cation exchange capacity. This can be achieved either by raising the pH, increasing the electrolyte concentration in the soil solution, or lowering the pHo. Adding materials that mask or block the effect of positive adsorption sites does this. Among the most recommended materials in the literatures are silicate, phosphate and organic matter. Thus, this study was initiated taking into consideration these recommendations trough slag steel and bokashi of husk.

2.2. Conceptual Frameworks

The surface charge also depends on the electrolyte concentration (η), the dielectric constant (ε), and the counterion valenze (z), The relationship between surface charge density (σ_0) and these parameters has been expressed mathematically by Gouy-Chapman and later by Nernst. Wann and Uehara (1978) combined these two equations as follow:

$$\sigma_0 = (2\ \eta\ \varepsilon\ K\ T\ /\ \pi)^{1/2} \sinh 1.15\ z\ (pH_0 - pH)$$

where pHo is the pH at which the net charge of the potential determining ions is zero. K is the Boltzman constant and T is the absolute temperature. The relationship shows that the surface charge density can be changed by varying several parameters such as η, ε, z or (pHo – pH), but it is the electrolyte concentration (η) and the difference between actual soil pH and pHo (pHo-pH) that can be practically manipulated in the field. The η value can be changed by applying fertilizer. The increasing of electrolyte concentration causes an increasing in surface charge. The (pHo-pH) can be made more negative by increasing the soil pH or by decreasing the pHo. Soil pH can be increasing by liming (Gilman, 1980). The pHo value can be reduced by introduction of high valency anions such as silicate, phosphate and organic matter, which will strongly bond to mineral surface (Hingston, 1972). It is therefore, reasonable to assume that applications of silicate material and organic matter to volcanic ash soil would have combined effect of raising pH and at the same time lowering the pHo.

Phosphate sorption capacity in volcanic ash is related to large specific areas of soil components. Although total amounts of native phosphorus are quite hugh in volcanic ash soils, their available forms are quite low. Phosphorus added as fertilizer is immediately sorbed onto metal oxide surfaces, rendering it less available to plants (Qafoku et al, 2004a). The affinity of the short range order minerals for phosphates is very strong because of the density of active aluminum on the colloidal fraction. The possibility of decreasing pHo and P fixation, and at the same time increasing the cation exchange capacity of volcanic ash soils are important factors to obtain optimal agricultural production (Qafaku et al., 2004b).

The cation exchange capacity of the top soil is almost entirely attributable to organic matter. Thus the loss of organic matter trough oxidation when the soils are cultivated, or through erosion not only reduce the phosphorus availability but also its ability to retain cations in a ready available form.

Slag steel as the source of the silicate and bokashi of husk as the source of oganic matter will block the positive chareg of the volanic ash soils, for releasing the phosphorus and making them availabl4e for plant growths. In other part, it will also make the chargen and CEC increase for preventing the cations leach out from the soil surface.

2.3 Hypothesis

a. Slag steel and bokashi of husk will decrease the pH_o and P-retention.

b. Slag steel and bokasi of husk will will increase the pH, CEC, available P, and available basic cations.

CHAPTER III.
MATERIALS AND METHODS

3.1. Materials and Equipments

The volcanic ash soils for this research located in the agricultural area in Lembang, along the southern slope of Mt. Tangkuban Parahu. This is an area of volcanic ash soils (Arifin, 1994; Devnita et al, 2010a) developed from an andesit parent material from the Holocene age and is is made up of volcanic deposit of tuff, hornblende crystal, reddish weathered lahar, and layer of breccias and lapilli of Mt Dano and Mt. Tangkuba Parahu symbolized with Qyd (Silitonga, 2003). The soils has udic soil moisture regime, that never dry 90 days cumulatively every years. The rainfall is about 2637-5369 mm/year and has an isohyperthermic soil temperature regime, with the average of temperature between 18-22 ^{0}C and the difference between the highest and lowest temperatures are not more than 6 ^{0}C.

The area previously has been investigated for their physiographic and environmental setting. Soil profiles were made for having soil morphology data and for taking soil samples. Soil samples were taken from profiles, which were dug along the slope on lower, middle and upper slope respectively. Profile description followed the guidelines proposed by National Soil Survey Centre (2002), and the horizon designation followed the symbols given in Soil Taxonomy (Soil Survey Staff, 2010). From each profiles, the bulk samples for routine physic-chemical analyses were done. The undisturbed soil samples for bulk density were also taken.

The soils in every horizon were analyzed for pH, organic carbon, CEC, Alo and Feo, bulk density and P-retention. The pH was determined in deionized water (H_2O) and 1 M potassium chloride (KCl) in 1:2.5 solid/liquid ratio; the equation of Δ pH (pH KCl –pH H_2O) was used to characterize charge. The pH of NaF (sodium chloride) 1 M was determined in a suspension of 1 g soil in 50 mL NaF soutio after 1, 2, and 24 hour. The organic carbon was determined by Walkley and Black procedure. The CEC was determined with 1 M ammonium acetate at pH 7. The leachate was used to determine the exchangeable bases and be measured by using atomic absorption spectrophotometry (AAS) The adsorbed ammonium ion (NH_4^+) was displaced with acidified 1 M KCl and the NH_4^+ ions in the leachate were then measured to determine the CEC. The Alo and Feo were determined with some steps. An extraction of 0.1 M sodium pyrophosphate solution (1:100) during one night to estimate the aluminum (Alp) and iron (Fep). Oxalate-extractable Alo, Feo, and silicon (Sio) were determined by extraction with 0.2 M ammonium oxalate for 4 h at pH 3 (Van Reeuwijk, 1992). Mineralogical analyses of sand and silt fractions were conducted by using polarizing microscope. The sand and silt particles were mounted with Canada balsam on a glass slide and cover with a cover glass. The minerals were mounted according to the line method. The mineralogical analyses of clay and also silt fractions were conducted by using X-ray diffractometer of Philips X'pert System, Philips Analytical Inc., operating at at 40 kV using nickel (Ni) filtered copper (Cu)-Kα radiation, scanned from 3 to 45^o 2Θ at 1^o/min. range.

3.2. Experimental Designed

Soils on the surface horizon were taken compositely for using in the pot experiment. This experiment were done for investigating the influence of slag steel and bokashi of husk as the remediation material in volcanic ash soils. A 4 x 4 factorial experiment in a completely randomized block designed in double replication will be set up. The experiment consist of 4 levels of slag steel (S_0, S_1 , S_2, and S_3), and 4 levels of bokashi of husk (B_0, B_0, B_0, and B_0). The rates for slag steel and bokashi of husk were 0, 5, 10 and 15% of weight of soil respectively. The slag steel and bokashi of husk will be mixed with 200 g of volcanic ash soils in pot, and watered until reach the field capacity. The well mixed moist sample will be stored on a sealed plastic to prevent drying out. Prior to incubation, the soils will be analyzed for pH, pHo, CEC, P retention, available P and basic cation. After 4 months of incubation, some samples were taken and retained to determined soil pH, pHo, CEC, P-retention and available P. The data will be analysed with analyses of variance with SAS software. Duncan's multiple range test was used for mean separation when anova is significant ($P \leq 0.005$).

Soils on the surface horizon be taken compositely for using in the plastic bag experiment. This experiments were done for investigating the influence of slag steel and bokashi of husk as the remediation material in volcanic ash soils. A 4 x 4 factorial experiment in a completely randomized block designed in double replication will be set up. The experiment consist of 4 levels of slag steel (S_0, S_1 , S_2, and S_3), and 4 levels of bokashi of husk (B_0, B_0, B_0, and B_0). The rates for slag steel and bokashi of husk are 0, 5, 10 and 15% of weight of soil respectively. The complete treatments are presented in Table 1.

Tabel 1. The combination treatments of slag steel and bokashi of husk

Slag Steel	**Bokashi of Husk**			
	b_0	**b_1**	**b_2**	**b_3**
s_0	s_0b_0	s_0b_1	s_0b_2	s_0b_3
s_1	s_1b_0	s_1b_1	s_1b_2	s_1b_3
s_2	s_2b_0	s_2b_1	s_2b_2	s_2b_3
s_3	s_3b_0	s_3b_1	s_3b_2	s_3b_3

S = slag steel
B = bokashi of husk
0 = without slag steel or bokashi of husk
1 = 2.5 % (weight of soils) slag steel or bokashi of husk
2 = 5.0 % (weight of soils) slag steel or bokashi of husk
3 = 7.5 % (weight of soils) slag steel or bokashi of husk

The laboratory analyses were done in the Laboratory of Soil Science, Faculty of Agriculture, and Laboratory of Geology Padjadjaran University. Some analyses like mineralogy analyses of sand, silt and clay fraction will be done in the Laboratory of Hokkaido University Museum, Japan.

3.4 Data Analyses

After incubation period, soils from the plastic bags were taken for chemcal and physical analyses. The data were analysed with analyses of variance (anova) with SAS software. Duncan's multiple range test was used for mean separation when anova is significant ($P \leq 0.005$).

CHAPTER IV.
RESULTS AND DISCUSSIONS

4.1 Physical Environment

The soils of this research developed from andesite parent material of the Holocene age Mt. Tangkuban Parahu, in the area of an intensive farming in Balitsa (BLS), Lembang District, West Java Province, Indnesia. Three profiles were made and the data of the geographical position of the profiles are presented in Table 2.

Tabel 2. The geographical position of the profiles

Location	Profile	Coordinate	Elevation
	BLS 1	107°65’57.0” - 06°68’30”	1280
BLS	BLS 2	107°65’51.9” - 06°68’83”	1282
	BLS 3	107°65 ’54.9” - 06°68’17.8”	1284

The location of the profiles were at the southern slope of. Mt. Tangkuban Parahu, developed from tuff, hornblend crystal and reddish weathered lahar, layered of lapilli and breccias of Mt. Dano and Mt.Tangkuban Parahu, smbolyzed with Qyd (Silitonga, 2003). The land use is an intensive farming area, planted with tomato, potato, cabbage and corn intermittently. The soil temperature regime is isohyperthermic, the annual average of temperature is more than 22^0 C and the difference of summer and winter temperature is not more than 6^0 C. The rainfall within the last ten years (Schmidt-Fergusson,1951), the area was classified to the climate type B. The rainfall is 2637-5369 mm/year. The average of dry month is 1-2 month/year and the wet month is 8 month/year. Some climatic data is presented in Table 3.

The measurement of soil temperature in the upper horizon during the research show the difference between both location (BLS and CKL) compare to the average temperature in in Tangkuban Parahu. The average temperature in BLS was 22.1 $^{\mathbf{0}}$C, and in CKL was 19.8 $^{\mathbf{0}}$C. The difference about 2.4 $^{\mathbf{0}}$C between both locations was assumpted as the increasing of global warming which was about 1.6 $^{\mathbf{0}}$C according to United Nation Convention on Climate Change (2007)

Tabel 3. The day of rain, rainfall, air and soil temperature in the research area.

	Tangkuban Parahu (1365 m dpl)

Month	dor	rf (mm)*	at (^{0} C)**	st (^{0} C)
January	15	382	20.6	23.1
February	15	762	20.7	23.2
March	13	580	20.9	23.4
April	16	692	21.5	24.4
May	14	484	21.3	23.8
June	7	117	21.8	24.3
July	8	125	23.1	25.6
August	0	0	23.8	26.3
September	10	201	22.9	25.4
October	8	148	22.8	25.3
November	19	395	21.9	24.4
December	19	610	21.6	24.1
Sum	144	4496	262.9	292.9
Average	12.0	374.7	21.9	24.4

Note:
dor = day of rain; **rf**= rain fall; **at** = air temperature; **st** = soil temperature

*Lembang Climatology Station (1998 - 2008) Stasiun Klimatologi Lembang

**Conversion of Van Wambeke, 1985

4.2 Parent Materials and the Mineralogy of the Sand Fraction

The parent materials of Mt. Tangkuban Parahu was tuff with coarse hornblend crystall and weathered andesitic lahar, from the eruption of Mt. Dano and Mt Tangkuban Parahu (Van Bemmelen, 1949) of the Holocene age, symbolized by Qyd in Silitonga (2003). The presence of volcanic ash was not revealed in the geology map, but the analyis of sand fraction showed the existence of volcanic glass, which reflected the existence of volcanic ash as the parent materials, erupted during the volcanic eruption. The volcanic glass later on weathered to short ranged order minerals like allophane, imogolite, ferrihydrite, which can not be found in the sand fraction of soil that not developed from volcanic material (Mikutta, et al., 2002).

The analysis of the sand fraction showed that the heavy minerals like hornblend, hypersthene and augite as well as the light minerals like quartz, feldspar, colour and colourless volcanic glass found in different percentage (Table 4). Heavy minerals in BLS (27 %) were more than in CKL (20 %). This was the indication that the difference of the temperature for a long periode gave the difference composition of the heavy and light fraction, emphasized that the temperature could influence the weathering of heavy minerals.

Table 4. The composition of the minerals in the sand fraction in the upper horizon

Profile	Heavy Minerals (%)					Light Minerals (%)					Total %	HV %	LV %
	Op	**Hor**	**Aug**	**Hip**	**Oli**	**Clgv**	**Cgv**	**Fel**	**Qua**	**RF**			
BLS 1	7	7	8	5	0	20	4	30	4	15	100	27	73
BLS 2	3	8	13	4	0	15	7	30	5	15	100	28	72
BLS 3	6	5	14	2	0	15	7	26	3	22	100	27	73

Notes

Op = Opaque

Hor= Hornblende

Aug = Augite

Hyp = Hypersthene

Oli = Olivine

Clgv= Clear glass volcan

Cgv=Colour glass volcan

Fel = Feldspar

Qua = quartz

RF = Rock frackment

4.3 Clay Mineralogy

The quantitative analyses with acid ammonium oxalate and phyrophosphate indicate the presence of allophane, imogolite and ferryhdrite (Table 5). Silica, aluminum, and iron which had been extracted, symbolized with Sio, Alo, Feo, Sip, Alp dan Fep. The percentage of allophane, imogolite and ferryhydrite were calculated base on Shoji et al. (1988). The percentage of allophane = % Sio x 7.14; percentage of imogolite = % (Alo – Alp) x 1.7; and percentage % ferihidrit = % Feo x 1.7 The existence of allophane, imogolite, ferryhydrite and Al-humus complex showed an allophanic Andisol, Andisol with the Al and Fe active group as a non crystalline materials (Shoji *et al.*, 1985), with the average of Alo > 3.5 % (Parfit dan Wilson, 1985).

Table 5. Quantitatively result of allophane, imogolite and ferryhydtrite in the clay fraction

Profile	Hor	Sio	Alo	Feo	Fep	Alp	Alo + ½ Feo	al	im	fer
		%	%	%	%	%		%	%	%
BLS 1	Ap1	1.08	4.48	1.58	0.24	0.69	5.3	8	6	3
	Ap2	0.74	2.93	0.84	0.37	0.68	3.4	5	5	1
	Ap3	0.86	3.09	0.72	0.28	0.72	3.5	6	5	1
BLS 2	Ap1	0.77	2.9	1.27	1.76	1.72	3.5	5	3	2
	Ap2	0.85	3.3	1.15	1.23	1.59	3.9	6	3	2
	BA	1.33	4.85	1.1	0.37	0.81	5.4	9	5	2
BLS 3	2 Ab1	1.38	3.99	1.43	0.12	0.44	4.7	10	4	2
	2 Ab2	1.49	4.58	1.38	0.21	0.52	5.3	11	5	2
	2 CB	1.41	4.03	0.95	0.02	0.32	4.5	10	4	2

al = allophane   im = imogolite   fe = ferryhydrite

Qualitatively, analyses of the silt and clay fraction with XRD indicated that the soils have the quite similar result wih the analyses in the sand fraction which consist of some feldspar (0.376, 0.363, 0.321, 0.315 nm), crystoballite (0.405, 0.252 nm), gibbsite (0.485, 0.438 nm), ferrihydrite (0.212, 0.195 nm) and quartz (0.425, 0.334 0. 245, 0.228, 0.181, 0.154 nm). These reflections can be seen in the Figure 1.

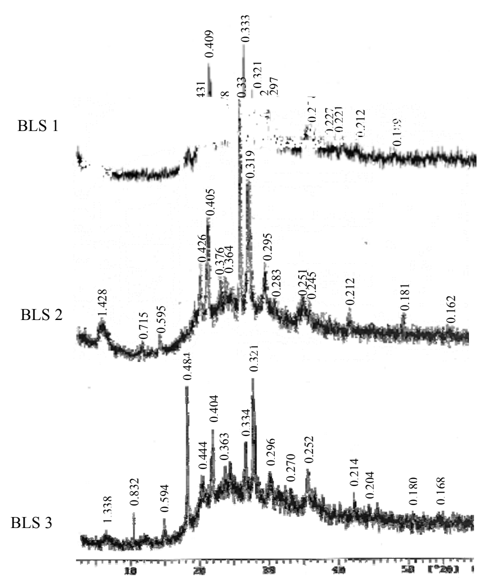

Figure 1. The reflection of XRD on silt and clay fraction

4.4 Changes in Soil Properties after Incubation

General properties of the soil from the 0-20 cm prior to incubation, presented in Table 6. In general the soil is slightly acid with the pH H_2O is 5.1.

This is a soil reaction characteristics of a relaively young soil developed from andesitic volanic materials. The Δ pH (pH KCl – pH H_2O) is close to zero indicates that the net charge of the soil is very close to zero. The pH_0 is quite high (4.6) result in low CEC (14 cmol kg^{-1}) indicating the relatively poor fertility. P-retention is extremely high (96%), corresponding with low availble of P (4.8 mg kg^{-1}).

Table 6. Selected chemical properties of upper 20 cm the studied soil

Soil Characteristics	**Value**
pH H_2O	5.10
pH KCl	4.65
Δ pH	-0.45
pH_0	4.2
CEC	14 cmol kg^{-1}
P-retention	96 %
Availble P	4.8 mg kg^{-1}

After the incubation periode, the combination of remediation treatments of slag steeel and bokashi f husk, had the significant effect in increasing the soil pH**,** available P, and CEC, and also had the significant effect in decreasing the pH_0 and P-retention. The slagsteel treatmens alone (with no bokashi or b_0) also gave the significant effec as well as the bokashi treatments alone (with no slag steel or s_0). The treatment of 7.5% slag steel combined with 7.5% of bokashi of husk gave the best result in reducing pH_0 from 4.2 to 3.8, reducing P retention from 96% to 86%, increasing pH from 5.1 to 5.7 and increasing available P from 4.8 mg kg^{-1} to 7.2 mg kg^{-1} and CEC from 14 to 30 cmol kg^{-1}. Slag steel and bokashi of husk can be considered as remediation materials for improving some chemical characteristics of volcanic ash soils. Table 7 shows the influence of the treatments to selected soil parameters.

Table 7. Effect of the remediation treatments of slag seel and bokashi of husk to slected soil parameters

	pH H_2O	**CEC cmol kg^{-1}**	**Availble P mg kg^{-1}**	**pH_0**	**P-retentiom %**
s_0b_0(control)	5.10a	14,0a	4.8a	4.2a	96a
s_1b_0	5.10a	17.5ab	5.1ab	4.2a	90c

s_2b_0	5.17a	14.6a	4.9a	4.2a	93b
s_3b_0	5.23ab	14.4a	5.3ab	4.1a	90c
s_0b_1	5.21ab	20.1b	5.4ab	4.0a	91c
s_1b_1	5.21ab	16.0ab	4.9a	4.0a	86d
s_2b_1	5.30b	24.0b	4..8a	4.1a	87d
s_3b_1	5.27ab	17.2ab	6.5b	4.1a	90c
s_0b_2	5.49c	14.8a	6.2b	3.9b	89c
s_1b_2	5.32b	19.0b	5.7ab	4.0a	90c
s_2b_2	5.20ab	28.0c	5.1ab	3.8b	95a
s_3b_2	5.62c	16.2ab	7.1c	4.1a	95a
s_0b_3	5.30b	21.0b	6.0b	4.0a	90c
s_1b_3	5.24ab	27,3c	5.9ab	4.1a	90c
s_2b_3	5.70d	18.0ab	7.0c	3.8b	85d
s_3b_3	5.70d	30,0c	7.2c	3.8b	86d

Values followed by the same letter are not statistically different ($P<0.05$)

Slag steel as the source of silicate in their weahering during the incubation periode, result in the brakdown of Si-O-M (M=cation). This process released SiO^- anion which subsequently hydrolses, producing alkalinity. This is made possible by the fact that H_4SiO_4 is a very weak acid (pKa = 9.5), and when hydrolyses reactions happened, a huge amount of OH^- will be released to the soil (Sanchez, 1976)

Bokashi of husk as the organic matter plays in charge characteristics from the ability of cetain functional group on particle surfaces to accept or donate protons. The organic matter itself has a low pH_0 (about 3.5), and therefore can lowering the soil pH_0 by sorption of large organic anions onto particle surfaces, thereby maskingsome positive charge. This process result in increasing pH, CEC and available P and decreasing pH_0 and P-retention (Van Ranst, 1995).

The increasing or decreasing the soil parameters in some cases do not follow the clear pattern with the increasing the dossage of slag steel or bokashi of husk. But, there is an increasing or decreasing of the parameters compare to the control. In these cases, we can say that slag steel and bokashi of husk have the signifiant effect in increasing the soil pH, CEC, and available P. Slag steel and bokashi of husk also have the significant effect in decreasing the pH_0 and P-retention.

Overall, however, the dosage of 7.5% of slag steel with 7.5% of bokashi of husk consistently in giving the best result in incrasing pH, CEC and available P, and in deceasing pH_0 and P-retention.

CHAPTER V.

CONCLUSSIONS AND SUGGESTIONS

In conclusion, the result of this study indicated that the slag steel and bokashi of husk can be considered as a soil remediation agent in volcanic ash soils for improving soil characteristics. The effectiveness of slag steel and bokashi of husk application was the highest at the combination of application dose of 7.5% (weight percentage) of both.

We suggest to do further research in the field with crop, to see the crop responses to the improving of soil characteristics after the treatments with slag steel and bokashi of husk.

REFERENCES

Arifin, M. 1994. Pedogenesis Andisol Berbahan Induk Abu Volkan Andesit dan Basalt pada Beberapa Zona Agroklimat di Daerah Perkebunan Teh Jawa Barat. Disertasi Doktor. Institut Pertanian Bogor. 202 hal.

Broquen, P., J. C. Lobartini, F. Candan and G. Falbo. 2005. Allophane, Aluminum, and Organic Matter Accumulation Across a Bioclimatic Sequence of Volcanic Ash Soils of Argentina. Geoderma. 129 : 167-177. E-Journal on-line. http://www.elsevier.com/locate/geoderma (20/09/06)

Devnita, R. 2010. Kajian Karakteristik Mineralogi dan Ameliorasi Anisol di Jawa Barat. Disertasi. Progam Pascasarjana Universitas Padjajaran. 192 hal.

Mikutta, C., M., M. Kleber and R. Jahn. 2002. Mineralogical Properties of German Andosols. COST 622 Meeting : Soil Resources of European Volcanic System in Manderscheid/Vulkaneifel. 23-25.

Nanzyo, M. 2002. Unique proprties of volcanic soils. Available online at http://www.aires.or.jp/publication/ger/pdf/06-2-11,pdf

Neall, V. E. 2006. Volcanic soils. Land Use and Land Cover. Vol VII. Encyclopedia of Life Support System (EOLSS)

Scoffin, T.P. 1987. An Introduction to Carbonate Sediments and Rocks. Chapman and Hall, New York. 274.

Shoji, S. M. Nanzyo and R. Dahlgren. 1993. Genesis of Volcanic Ash Soils. In Shoji, S., M. Nanzyo and R. Dahlgren (Editors). *Volcanic Ash Soil – Genesis, Properties and Utilization*. Hal. 37-71 Developments in Soil Science 21. Elsevier, Amsterdam.

Silitonga, P. H. 2003. Peta Geologi Lembar Bandung. Departemen Energi dan Sumber Daya Mineral

United Nation Convention on Climate Change. 2007. International meeting of climate change. Brazil, 190 p.

Van Reeuwijk, L. P. 1992. Procedure for Soil Analysis. Fourth Edition. ISRIC. Wageningen. The Netherland. 56 p