International Journal on Advanced Science Engineering Information Technology

Vol.8 (2018) No. 5
ISSN: 2088-5334

The Role of *Sub-bituminous* Coal Powder with Sodium Hydroxide (NaOH) to Improve Chemical Properties of Ultisols

Herviyanti [#], T.B. Prasetyo[#], Juniarti[#], S. Prima[#], and S. Wahyuni[#]

[#]*Department of Soil Science, Faculty of Agriculture, Andalas University Limau Manis, Padang, West Sumatra, Indonesia*
Email : evi.64.faperta@gmail.com

***Abstract*— This research was conducted in soil chemical laboratory, Faculty of Agriculture, Andalas University, Indonesia from December 2016 until May 2017. The purpose of this research is to determine the level of activeness of powder of Sub-bituminous coal with Sodium Hydroxide (NaOH) and to determine the appropriate dosage of the mixture in improving the chemical properties of Ultisols. This research was conducted in 2 stages: first stage study with 10 treatments (1% to 10% (w/w) NaOH) and the second stage study on soil using 15 treatment combinations (3 doses of powder Sub-bituminous coal with 5 doses of NaOH). The results of the first stage of research are the addition of NaOH in Sub-bituminous could increase the activity of powder Sub-bituminous coal with parameters of pH, CEC, and increases the number of O-H, C=O, and CH_3 groups. The results of stage II study is the provision of a mixture of 20 ton.ha^{-1} of Sub-bituminous coal powder and 10% of NaOH were able to increases the pH of H_2O, CEC, organic-C, Available-P, and Total-N Ultisol each of 1.49 units, 28.08 me.100g^{-1}, 1.63 % C, 2.37 ppm P, 0.06% N, and decreases Al-exch Ultisol by 1.17 me.100g^{-1} and , SAR Ultisol by 0.03, and ESP Ultisols by 0.82 % compared to natural soil.**

Keywords : **NaOH; sub-bituminous; ultisols; chemical properties; sodium hydroxide.**

I. INTRODUCTION

Indonesia is the largest coal producer after China, America, India and Australia. Coal production in Indonesia reaches 470.8 million tons in 2014. Indonesia is the world's largest exporter of coal from 2011 to 2013 [1]. Coal is grouped into four levels, namely (a) *Lignite* (b) *Sub-bituminous* (c) *Bituminous* (d) *Anthracite. Anthracite* and *Bituminous* has a high calorific value is > 5,700 kcal (kg)$^{-1}$ so widely used as a fuel. *Sub-bituminous* and *Lignite* contain a low calorific value, so they are not suitable as fuel. *Sub-bituminous* type has traits not clot, contains a calorific value of 4,165 kcal (kg)$^{-1}$ to 5,700 kcal (kg)$^{-1}$ (ASTM, 2006; *cit* [2]. Ref. [3] reported that *sub-bituminous* which is taken from Pasaman, West Sumatra can be used as a source of organic material because it contains humic substances as much as 31.5% (21% of humic acid and 10.5% of fulvic acid). The humic acid content of *Sub-bituminous* (21%) was higher than the percentage of humic acid contained from other organic materials, such as municipal solid waste compost (1.4%), manure (1.6%), rice straw compost (5%), and peat soil (9.2%) [4]. Therefore, *Sub-bituminous* as a source of humic substances can be used as soil organic matter to improve soil fertility.

Soil organic matter is the source of organic compounds that can be absorbed even in small amounts [5]. Organic matter acts as a contributor to the amounts of nutrients ions available which are the result of the mineralization processes of the decomposable parts of the organic material. Because of its large specific surface area of about 800-900 m^{2}g^{-1}, the Cation Exchange Capacity (CEC) of soil organic matter becomes high that is about 150 - 300 cmol / kg. High CEC on soil organic matter is able to absorb many cations so that both micro and macronutrients can be met [6].

The humic material is a component of organic material that can perform the rapid reaction, most active in soil with electric charge and CEC higher than clay minerals (Tan 2003 in [3]. It also works as Al and Fe toxicity control and increases P availability with the provision of a humic material may occur through the formation of complex organo-metallic compounds or chelates, so that the activity of Al and Fe metals which generally bind P in the soil may be reduced, and no toxic to the plant. Humic materials can directly improve soil fertility by changing the physical, chemical, and biological soil conditions. Humic materials can modify growing plant media that enhance soil structure formation, increase the soil water holding capacity and CEC [7].

The presence of humics in soil is necessary for sustainable agriculture, due to their ability to condition the soil, enhance its stability and increase its resistance to erosion, ensure enhanced biological activity and obtain higher crop yields. The humics also have the ability to sequestrate soil pollutants and may be used in soil remediation. Among many other roles, solid humic substances (HS) act as pH buffers and metal binders, and they are places to sequester plant hormones, fertilizers, nutrients, pollutants, and soil toxics [8].

Organic materials component that plays a vital role in improving the chemical properties of soil is humic substances [6]. Humic substances are the end result of decomposition of organic matter in the soil which can be obtained by dissolving the organic material with a inorganic solvent such as hydrochloric acid (HCl), fluoride acid (HF), boric acid (H_3BO_3), sodium hydroxide (NaOH), sodium carbonate (Na_2CO_3), sodium fluoride (NaF), sodium polyphosphate ($Na_4P_2O_7$), sodium-EDTA (Na_2-EDTA), and sodium tetraborate ($Na_2B_4O_7$). From various solvents that have been used, NaOH is the most effective solvent and has the ability to separate quantitative humid material in soil [9].

Sub-bituminous utilization can be applied easily by the farmers. Ref [10] have examined the use of *sub-bituminous* in two forms, *sub-bituminous* powder and humic substances were extracted from *sub-bituminous.* The results explain that the ability of *sub-bituminous* powder similar to the ability of humic substances in improving soil chemical properties and soil fertility. So, the use of sub-bituminous powder is more practical than the use of humic material which is extracted with 0.5 N NaOH.

NaOH can be used as a chemical agent of *Sub-bituminous* powder. It will improve the chemical properties of the *Sub-bituminous* powder. The research has proven that NaOH can increase pH, CEC, C-organic, N-total, P-available and lower exch-Al [10]. The *Sub-bituminous* powder can improve the chemical properties of marginal soil. It can be concluded, the use of powdered *sub-bituminous* more practical to improve chemical properties marginal soil such as Ultisol.

Ultisol is one type of soil in Indonesia which has an area of about 45,794,000 ha equals to 24.3 % of the total land area of Indonesia. Ultisol with a large coverage area has the potential to be used as an agricultural area in Indonesia. For example, the Ultisol in Dharmasraya District which has an extensive potential to be used as agricultural land. However, its utilization is faced with several characteristics that can inhibit the growth of plants [11]. Some of the common obstacles in Ultisol are low pH (<4.5), high Exchangeable Aluminum (Al-exch) (2.94 $me.100g^{-1}$, poor macronutrient content, especially Phosphorus (P), 52-60% P is absorbed by Al, CEC, Potassium (K), Calcium (Ca), Magnesium (Mg), and low organic matter. Such characteristics may affect plant growth and production so that intolerant crops will be hampered by growth and productivity [12].

The objective of this research is to determine the level of activeness of powder of Sub-bituminous coal with Sodium Hydroxide (NaOH) and to determine the appropriate dosage of the mixture in improving the chemical properties of Ultisols.

II. Material and Method

This research was conducted in December 2016 until May 2017 at Soil Laboratory, Faculty of Agriculture, Andalas University, Padang consisting of 2 stages. The first stage experiment aims to select the treatment to be used in the soil experiment (stage II). This study used the Completely Randomized Design (CRD) method with 10 treatments and 2 replications, The treatments are: A = 1% of NaOH; B = 2% of NaOH; C = 3% of NaOH; D = 4% of NaOH; E = 5% of NaOH; F = 6% of NaOH; G = 7% of NaOH; H = 8% of NaOH; I = 9% of NaOH; J = 10% of NaOH/100 g *sub-bituminous*).

Second stage trial used a selected mixture of powder *subbituminous* from first stages and tested in CRD with 15 treatments and 2 replications. The treatments are: A= 10 $tons.ha^{-1}$ *Sub-bituminous* + without NaOH; B= 10 $tons.ha^{-1}$ *Sub-bituminous* + 2.5% of NaOH; C = 10 $tons.ha^{-1}$ *Sub-bituminous* + 5% of NaOH; D = 10 $tons.ha^{-1}$ *Sub-bituminous* + 7.5% of NaOH; E = 10 $tons.ha^{-1}$ *Sub-bituminous* + 10% of NaOH; F= 20 $tons.ha^{-1}$ *Sub-bituminous* + without NaOH; G= 20 $tons.ha^{-1}$ *Sub-bituminous* + 2.5% of NaOH; H = 20 $tons.ha^{-1}$ *Sub-bituminous* + 5% of NaOH; I = 20 $tons.ha^{-1}$ *Sub-bituminous* + 7.5% of NaOH; J = 20 $tons.ha^{-1}$ *Sub-bituminous* + 10% of NaOH; K= 30 $tons.ha^{-1}$ *Sub-bituminous* + without NaOH; L= 30 $tons.ha^{-1}$ *Sub-bituminous* + 2.5% of NaOH; M = 30 $tons.ha^{-1}$ *Sub-bituminous* + 5% of NaOH; N = 30 $tons.ha^{-1}$ *Sub-bituminous* + 7.5% of NaOH; O = 30 $tons.ha^{-1}$ *Sub-bituminous* + 10% of NaOH.

Sub-bituminous was taken from the District of Pasaman, West Sumatra and then crushed into a powder and sieved with a hammer mill of 125 µm sieve. Ultisol was taken from Dharmasraya. NaOH was given aquades of field capacity and then mixed into *Sub-bituminous* coal powder, then incubated for 10 days. After that, the mixture was analyzed in the laboratory. The results of the analysis stage I was chosen mixture. It is obtained 5 dosages, they are 0%, 2.5%, 5%, 7.5%, and 10% NaOH respectively and mixed with *subbituminous* powder with appropriate treatment dose and incubated for 10 days. After that, the mixture of *subbituminous* powder and NaOH is blended with soil, (Ultisol, 500 g) in each treatment pot, mixed and incubated for 10 days and then analyzed in the laboratory.

The parameters were observed in the trial of stage I: (1) pH (H_2O); (2) CEC; (3) analysis of functional groups by FTIR spectroscopy *(Fourier Transform Infra Red)* using the correlation table of infrared spectra of coal by [13] *cit* [14]. The parameters were tested in stage II: (1) Organic-C *(Walkley and Black),* (2) Total-N *(Kjeldahl)* (3) CEC *(leaching with NH_4OAc)* (4) Al-exch *(volumetric),* (5) Available-P *(Bray II)* (6) pH H_2O (*electrometric*) (7) *Sodium Adsorption Ratio* (SAR), the *Exchangeable Sodium Percentage* (ESP), and (8) Electrical Conductivity (EC). The data obtained were analyzed statistically using the F test if F calculated is more significant than F Table at 5% level, it will be followed by LSD test at 5% level.

III. Results and Discussion

A. Results of Stage I Research Analysis

1) pH H_2O (1:1), and CEC of powder *Sub-bituminous :* Effect of NaOH on pH H_2O (1:1) and CEC of *Sub-bituminous* powder that has been incubated for 10 days is presented in Table 1.

Table 1 showed that NaOH is able to increase the pH H_2O (1:1) of S*ub-bituminous* powder. Giving NaOH at 10% (w/w) is the best treatment in increasing the pH powder S*ub-bituminous* amounting to 7.31 units compared without NaOH. Increasing pH occurred with increasing doses of

NaOH are given in *subbituminous* powder caused by NaOH which is an alkaline compound that can donate hydroxide ions (OH^-) so that the concentration of OH^- in *Sub-bituminous* powder increase and result in the pH increases.

TABLE 1
EFFECTS OF NAOH ON PH AND CEC OF *SUB-BITUMINOUS* POWDER

NaOH (%)	pH (H_2O)	CEC
	Units	me.$(100g)^{-1}$
0	5.34	24.39
1	7.14	39.22
2	7.82	57.48
3	9.41	67,76
4	9.83	91.43
5	10.34	102.60
6	10.54	110.08
7	11.16	119.88
8	11.88	128.34
9	12.45	135.46
10	12.65	148.20

Table 1 also showed that with the aexchition of NaOH in S*ub-bituminous* powder cause CEC value also increased. NaOH at a dose of 10% (w/w) was able to increase the CEC value by 123.81 me.$(100g)^{-1}$ compared without NaOH. CEC of S*ub-bituminous* powder increased due to the humic acid contained in the powder *subbituminous* undergo deprotonation, namely the release of H^+ ions functional groups of humic acid at pH 9 will lead to the release of H^+ ions from a phenolic hydroxyl group thus increasing the negative charge which results in increased CEC of S*ub-bituminous* powder [8].

2) *Spectrum FTIR of Sub-bituminous Powder* : FTIR results showed that *Sub-bituminous* Powder has a significant absorption band at 3300 cm^{-1} numbers (OH), on the wave of 1637 cm^{-1} (C = O) conjugated strong, at a wavelength of 996 cm^{-1}(aliphatic ethers, alcohols). FTIR results on *Sub-bituminous* coal powder and 3% NaOH (blue), similar in functional groups than the FTIR results of *Sub-bituminous* coal powder, but the provision of 6% NaOH in *Sub-bituminous* powder resulted in higher absorption intensity at a wavelength of 3350 cm^{-1} and 1635 cm^{-1} which is becoming identifier OH groups and C = O. The appearance of an absorption band at a wavelength of 1388 cm^{-1} become identifier of CH_3.

Giving a 9% NaOH uptake of *Sub-bituminous* coal powder, OH, C = O, and CH_3 increasingly intense that characterize

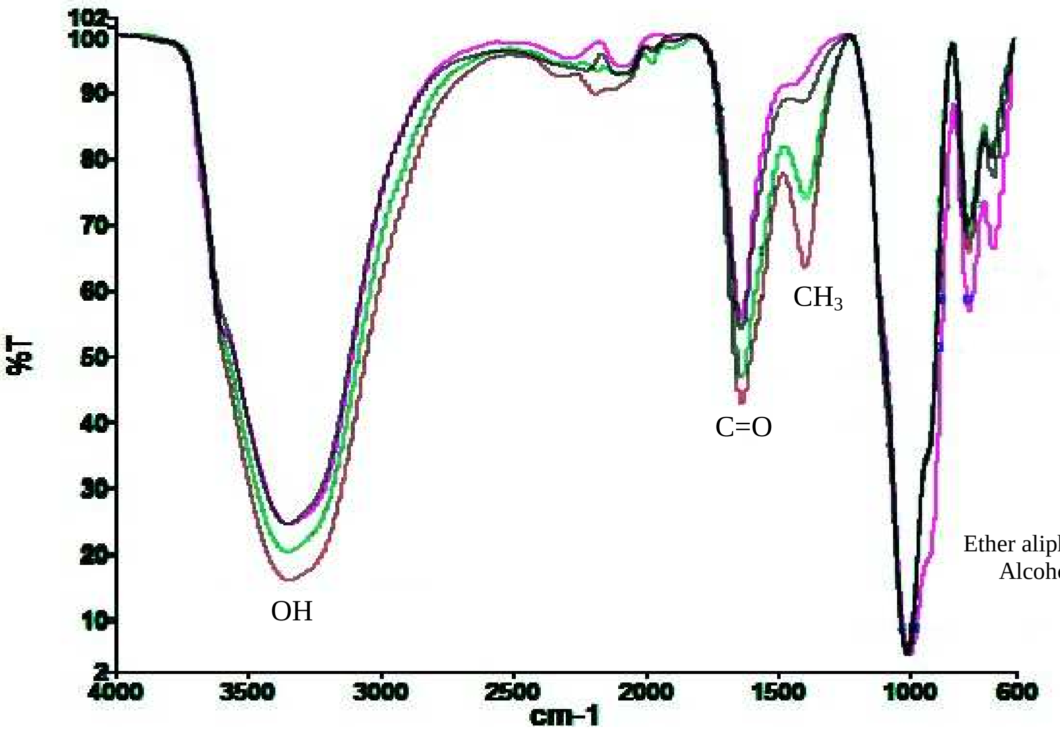


Fig.1. FTIR of powder coal *Sub-bituminous* (purple), 3% of NaOH + powder coal *Sub-bituminous* (blue), 6% of NaOH + powder coal *Sub-bituminous* (green), and 9% of NaOH + powder coal *Sub-bituminous* (red)

the increased activity of *Sub-bituminous* coal powder . It is also characterized by an increase in pH and CEC of *Sub-bituminous coal powder*. According to Ref. [15], the emergence or increase the absorption intensity group containing a double bond or oxygen-containing group indicates that there has been an increase in the absorption capacity of *Sub-bituminous* coal powder. Increased absorption occurs the group C=O and OH which is a group that is active in chemical reactions in the soil.

B. Soil Analysis Result

TABLE II
THE ANALYSIS RESULT OF CHEMICAL PROPERTIES OF ULTISOL NAGARI KAMPUNG SURAU, PULAU PUNJUNG, DHARMASRAYA, WEST SUMATERA INDONESIA

Chemical characteristics	Value	Criteria
pH	4.36	Very acid*
Al-exch(me.100g^{-1})	2.26	-
CEC (me.100g^{-1})	11.34	medium *
Total N (%)	0.03	Very low *
Organic C (%)	0.95	Very Low *
Available P (ppm)	9.74	low *
Na-exch(me.100g^{-1})	0.11	low *
Ca-exch(me.100g^{-1})	0.15	Very low *
Mg-exch(me.100g^{-1})	0.12	Very low *
SAR	0.31	normal ***
ESP (%)	0.66	Very low **
EC (dS.m^{-1})	1.02	Very low **
pH	4.36	Very acid*
Al-exch (me.100g^{-1})	2.26	-

*) Source : Staf Pusat Penelitian Tanah. (1983, *cit* Hardjowigeno, 2003)
**) Source : Balai Penelitian Tanah (2012)
***) Source : Sparks (2013)

Table 2 showed that Ultisols have low fertility soil with pH parameters are very acid, CEC is included in the moderate criterion, Total-N, Organic-C, Ca-exch, Mg-exch, very low ESP and EC, Available low P as well as low Na-exch. This is due to the high rainfall which resulting in leached alkaline minerals and decomposition of aluminium silicate in the form of Al^{3+} ions are free to be sequestered in the soil colloids and hydrolysed so that it will donate H^+ ions. This causes the soil becomes acidic. The high Al saturation level in Ultisol also causes P-available in the soil to become low due to the occurrence of P fixation by Al. The content of N-total and organic-C in the soil is shallow because leached N in the form of NO_3^- (nitrate) caused by rainfall quite high during the formation of soils resulting in leached of bases cations intensively [16].

C. Soil Analysis After Incubation

1) *pH H_2O (1:1) and Al-exch Ultisol* : Giving of powder coal *Sub-bituminous* that was mixed with NaOH provides a highly significant effect on pH H_2O (1: 1) and Al-exch of Ultisol. In general, the more powder coal *Sub-bituminous* and NaOH so higher pH of the soil and the lower Al-exch of soil. The provision of 30 tons.ha^{-1} of S*ub-bituminous* and 10% of NaOH is the best treatment that can improve the pH value of 1.84 units and decreased Al-exch of 1.27 me.100 g^{-1} compared with the provision of treatment to 10 tons.ha^{-1} of S*ub-bituminous* without NaOH. Results of Ultisol chemical analysis results are presented in Table 3.

Based on the stage I trial, the addition of NaOH increase the pH *sub-bituminous* powder of up to 7.31 units so that the pH *sub-bituminous* becomes 12.65 units for their cargo OH^- which increase the pH. With the provision of materials that have an alkaline pH will undoubtedly increase the soil pH. Ultisol pH increase also caused due to the use of powdered *sub-bituminous* which produce organic acids (humic acid and fulvic acid) which can form complexes with Al^{3+} and hydroxide ions (OH^-) derived from the ionization process of NaOH were able to neutralize the hydrogen ions (H^+) so that the pH soil increases.

TABLE III
EFFECT OF POWDER COAL *SUB-BITUMINOUS* AND NAOH TO PH AND AL-EXCH OF ULTISOLS

Sub-bituminous Powder + NaOH	pH (unit)	Al-exch (me.100g^{-1})
10 ton.ha^{-1}+ 0%	4.60 j	1.90 a
10 ton.ha^{-1}+ 2.5%	5.09 hi	1.45 abcd
10 ton.ha^{-1}+ 5%	5.25 gh	1.35 abcde
10 ton.ha^{-1}+ 7.5%	5.33 fgh	1.14 bcde
10 ton.ha^{-1}+ 10%	5.67 def	0.93 de
20 ton.ha^{-1}+ 0%	4.60 j	1.79 ab
20 ton.ha^{-1}+ 2.5%	5.32 fgh	1.35 abcde
20 ton.ha^{-1}+ 5%	5.80 cde	1.03 cde
20 ton.ha^{-1}+ 7.5%	6.03 bcd	0.93 de
20 ton.ha^{-1}+ 10%	6.09 abc	0.73 de
30 ton.ha^{-1}+ 0%	4.69 ij	1.67 abc
30 ton.ha^{-1}+ 2.5%	5,56 efg	1.25 abcde
30 ton.ha^{-1}+ 5%	6.15 abc	0.93 de
30 ton.ha^{-1}+ 7.5%	6.21 ab	0.73 de
30 ton.ha^{-1}+ 10%	6.43 a	0.63 e
CV	1.80 %	15.59%

The numbers followed by the same lower case are not significant at the 5% level according to LSD

The addition of *sub-bituminous* powder which has been mixed with NaOH has a significant effect on the content of exch-Al Ultisol. The best treatment was administered 30 tons / ha of *Sub-bituminous* powder mixed with 10% NaOH will reduce exch-Al by 1.28 me.100 g^{-1}. The decrease in exch-Al content is caused due to humic acid contained from the *Sub-bituminous* powder of Al ion fixation so that Al is no longer soluble, as the following reaction :

$$Al^{3+} + RCOO^- \rightarrow Al(RCOO)_3$$

The reaction shows that Al^{3+} ions can be fixed by organic material so that Al^{3+} ion does not dissolve and settle.

2) *Organic-C and Total-N of Ultisols :* Table 4 shows that the effect of the dose of powder and NaOH *sub-bituminous* is very significant to the content of soil organic C, but no significant effect on soil N. It is seen that the 20 ton / ha *sub-bituminous* powder and 10% NaOH is the best treatment to improve the content of organic C of soil where an increase of 1.63% compared with the provision of 10 ton.ha^{-1} of *Sub-bituminous*. The treatment of 10 ton.ha^{-1} of *Sub-bituminous* and 7.5% NaOH has been able to give a significant influence on soil organic C.

The provision of 20 ton.ha^{-1} *subbituminous* and 10% of NaOH higher to produce Organic-C than other treatments because the *sub-bituminous* powder that contains carbon elements have been decomposed during the incubation period. Based on Ref. [3], the provision of *sub-bituminous* powder at doses of 0.5; 1,0; and 1.5 % (10, 20, and 30 ton.ha^{-1}) which was activated by urea increased the content of soil organic C. This increase is due to higher amounts of Urea ingredients, then the contribution to C-organic ingredients also high. Likewise with higher amounts of *sub-bituminous* powder that has been activated with urea resulted in more C-organic donations. This is because the *sub-*

bituminous Powder contains organic-C > 30%. According to Ref. [17], coal comes from consolidated plants between other rock strata and altered by a combination of heat and pressure effects over millions of years to form a coal seam. The situation creates the carbon content of coal getting higher. Humic acid is usually rich in carbon ranging between 41% and 57% and is capable of providing organic C that is readily absorbed by plants [10,18].

TABLE IV
EFFECT OF POWDER COAL *SUB-BITUMINOUS* AND NAOH TO ORGANIC C AND TOTAL N OF ULTISOLS

Sub-bituminous Powder + NaOH	Organic-C (%)	Total-N (%)
10 $ton.ha^{-1}$+ 0%	1.95 c	0.16
10 $ton.ha^{-1}$+ 2.5%	2.25 bc	0.17
10 $ton.ha^{-1}$+ 5%	2.40 bc	0.19
10 $ton.ha^{-1}$+ 7.5%	2.75 abc	0.19
10 $ton.ha^{-1}$+ 10%	3.01 abc	0.20
20 $ton.ha^{-1}$+ 0%	2.34 bc	0.17
20 $ton.ha^{-1}$+ 2.5%	3.16 ab	0.17
20 $ton.ha^{-1}$+ 5%	3.19 ab	0.17
20 $ton.ha^{-1}$+ 7.5%	3.21 ab	0.19
20 $ton.ha^{-1}$+ 10%	3.58 a	0.22
30 $ton.ha^{-1}$+ 0%	2.36 bc	0.17
30 $ton.ha^{-1}$+ 2.5%	2.68 abc	0.17
30 $ton.ha^{-1}$+ 5%	2.70 abc	0.19
30 $ton.ha^{-1}$+ 7.5%	2.73 abc	0.20
30 $ton.ha^{-1}$+ 10%	3.07 ab	0.21
CV	9.80%	7.46%

The numbers followed by the same lower case are not significant at the 5% level according to LSD

The application of *Sub-bituminous* with NaOH have no significant effect on N-total in Ultisol. This is presumably because the incubation period is only 10 days resulted in unperfect *Sub-bituminous* coal powder, so the element N contained in *sub-bituminous* is still small. According to research conducted by Ref. [19], the *Sub-bituminous* treatment with 0.25 N NaOH mixing ingredients only able to increase 0.01% N-total soil on a 2 week incubation period and an increase of 0.02% total N soil compared to a powder of *Sub-bituminous* coal.

According to Ref. [20], the application of organic matter affected the soil total-N and Organic-C significantly. Increases in rates of organic matter application caused enhancement of soil chemical properties. Enhancement of chemical properties occurred due to the content of organic material. The organic addition could cause organic carbon accumulation on the topsoil [21].

3) Available P and CEC of Ultisols : The application of *Sub-bituminous* coal powder with NaOH has a non-significant effect on the content of available-P of Ultisols, but the significant impact to CEC of Ultisols. It is suspected that the organic acid has not been effective in releasing fixation P in the soil. But, from Figure 1. it can be seen that the increase in line with the increased application of doses of *Sub-bituminous* coal powder and NaOH compared to *Sub-bituminous* coal powder.

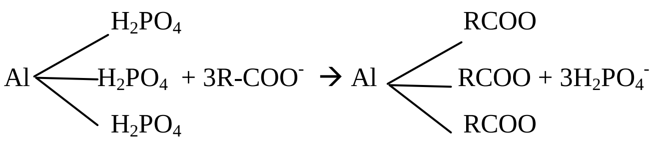
TABLE V
EFFECT OF POWDER *SUB-BITUMINOUS* AND NAOH TO AVAILABLE-P AND CEC OF ULTISOLS

Sub-bituminous Powder + NaOH	Available P (ppm)	CEC ($me.100g^{-1}$)
10 $ton.ha^{-1}$+ 0%	7.83	19.76 f
10 $ton.ha^{-1}$+ 2.5%	8.18	34.04 bcdef
10 $ton.ha^{-1}$+ 5%	8.22	36.89 abcde
10 $ton.ha^{-1}$+ 7.5%	8.65	40.94 abc
10 $ton.ha^{-1}$+ 10%	10.02	48.79 a
20 $ton.ha^{-1}$+ 0%	9.03	24.51 ef
20 $ton.ha^{-1}$+ 2.5%	9.68	35.70 abcde
20 $ton.ha^{-1}$+ 5%	9.71	41.89 abc
20 $ton.ha^{-1}$+ 7.5%	9.82	44.03 abc
20 $ton.ha^{-1}$+ 10%	10.20	47.84 abc
30 $ton.ha^{-1}$+ 0%	8.06	25.94 def
30 $ton.ha^{-1}$+ 2.5%	9.17	33.80 cdef
30 $ton.ha^{-1}$+ 5%	9.41	34.98 abcde
30 $ton.ha^{-1}$+ 7.5%	9.74	39.51 abcd
30 $ton.ha^{-1}$+ 10%	11.73	48.32 ab
CV	0.13%	9.70%

The numbers followed by the same lower case are not significant at the 5% level according to LSD

The application of *Sub-bituminous* powder with NaOH has not shown any significant effect on P-available of Ultisol. This is due to an incomplete humic acid derived from *Sub-bituminous* powder in binding Al^{3+} ions that fix P in the soil. However, judging by the number has increased along with increased doses of *Sub-bituminous* powder and NaOH compared with *Sub-bituminous* powders without NaOH.

According to Ref. [13], P-available in acidic soil is fixed by Al and Fe ions. Al and Fe ions that fix the element P in the soil become difficult to dissolve so it can not be used by plants. Therefore, soil repair material is needed to increase P available soil to increase soil fertility as in the following reaction:



The provision of 30 $ton.ha^{-1}$ of *sub-bituminous* and 10% of NaOH was able to increase a CEC of Ultisols by 29.03 $me.100g^{-1}$ compared with coal powder of *Sub-bituminous*. Based on the stage I trial, it is shown that the CEC of *Sub-bituminous* coal powder is increasing the dose of *Sub-bituminous* and NaOH with the highest value of 148.20 $me.100g^{-1}$. The CEC of *Sub-bituminous* coal powder is also increased CEC of Ultisols. According to Ref. [22], the humic acid derived from *Sub-bituminous* could influence the value of CEC in the extreme. Ref. [23] proved that the treatment of *sub-bituminous* powder and 0.25 N NaOH in Ultisol could increase CEC by 15.27 me / 100 g.

4) SAR (Sodium Absorption Ratio) and ESP (Exchangeable Sodium Percentage) of Ultisols : Giving *Sub-bituminous* coal powder and NaOH significantly influence the value of SAR and ESP, but no significant effect on EC of Ultisols. Giving *Sub-bituminous* coal powder and NaOH has a fluctuating effect on the value of SAR of soil. In the treatment of 10 and 30 $ton.ha^{-1}$ of powder coal *Sub-*

bituminous mixed with NaOH fluctuations in the value of SAR. It is seen that the use of powdered *sub-bituminous* as much as 10 and 20 ton / ha has a SAR value of 0.37 and 0.30 and impaired SAR when the powder coal *Sub-bituminous* is mixed with NaOH then increasing again. This is due to the use of powdered *Sub-bituminous* is capable of binding exchangeable Na ions in the soil thus reducing the SAR value compared to soil early. Similarly, the SAR value on providing *Sub-bituminous* powder and 2.5% of NaOH lowering the SAR value because of increased CEC of *Sub-bituminous* coal powder suspected Na of soil can still be bound by *Sub-bituminous* coal powder. But along with the aexchition of NaOH, the SAR value increased again allegedly due to increased Na ions in the soil due to the aexchition of NaOH and mixed *Sub-bituminous* powder already saturated by so many Natrium accumulated in the soil.

In the treatment of 20 ton.ha^{-1} of *Sub-bituminous* powder an increase in SAR values along with the aexchition of NaOH. This is thought to be due to the increased Na content when given NaOH and does not change the status of existing Mg and Ca ions. The soil SAR value after NaOH did not increase the SAR value is very high and is still standing, so there is no dispersion on the soil.

The application of *Sub-bituminous* coal powder and NaOH treatment have very significant effects on the value of ESP Ultisol. Ultisol ESP value decreases with the use of powdered *subbituminous* and NaOH. This is because NaOH will donate OH ions so that the pH of *Sub*-bituminous is also increased. Ref [22] stated that at a relatively high pH (concentration of H^+ is low) will increase the concentration of COO^- which can function as ligands on humic acid. The reason is what causes many Na ions are bound by powder coal *Sub-bituminous* functional groups such as COO^- so the exchangeable Na ions are reduced.

The SAR and ESP values of soil after treatment were still reasonable so that not to harm the soil and the plants. According to Ref. [23] soil belonging to alkaline soils having SAR values of more than or equal to 13 and ESP values of more than or equal to 15.

The electric conductivity of soil after treatment gives different effects were not statistically significant. EC value of soil changed significantly due to the use of powdered NaOH and *Sub-bituminous* coal, but the increased alkalinity did not increase the value of DHL. This can be attributed to the value of ESP that the presence of alkaline in soil does not change significantly.

TABLE VI
EFFECT OF POWDER COAL *SUB-BITUMINOUS* AND *NAOH TO* SAR, ESP AND EC OF ULTISOLS

Sub-bituminous Powder + NaOH	SAR	ESP (%)	EC (dS.m^{-1})
10 ton.ha^{-1}+ 0%	0.37 abcd	1.27 a	0.087
10 ton.ha^{-1}+ 2.5%	0.23 d	1.01 ab	0.081
10 ton.ha^{-1}+ 5%	0.31 abcd	0.81 bc	0.082
10 ton.ha^{-1}+ 7.5%	0.34 abcd	0.63 bc	0.084
10 ton.ha^{-1}+ 10%	0.40 abcd	0.60 bc	0.086
20 ton.ha^{-1}+ 0%	0.34 abcd	0.60 bc	0.094
20 ton.ha^{-1}+ 2.5%	0.37 abcd	0.57 c	0.074
20 ton.ha^{-1}+ 5%	0.42 abc	0.53 c	0.078
20 ton.ha^{-1}+ 7.5%	0.46 ab	0.51 c	0.085
20 ton.ha^{-1}+ 10%	0.48 a	0.51 c	0.087
30 ton.ha^{-1}+ 0%	0.30 bcd	0.50 c	0.088
30 ton.ha^{-1}+ 2.5%	0.27 cd	0.49 c	0.086
30 ton.ha^{-1}+ 5%	0.24 cd	0.48 c	0.089
30 ton.ha^{-1}+ 7.5%	0.29 bcd	0.47 c	0.090
30 ton.ha^{-1}+ 10%	0.34 abcd	0.45 c	0.091
CV	12.92%	15.64%	7.97%

The numbers followed by the same lower case are not significant at the 5% level according to LSD

EC soils exceeding 4 dS.m^{-1} or more are categorized as saline soils, and EC values do not reach a value by 2.0, so it can be stated that the treated Ultisols were normal and did not affect the crop [23]

IV. CONCLUSION

The results of the first stage of research are the addition of NaOH in *Sub-bituminous* could increase the activity of *Sub-bituminous* coal powder with parameters of pH, CEC, and increases the number of O-H, C=O, and CH_3 groups, i.e. pH of 7.31 units and CEC amounted to 123.81 me.(100 g)$^{-1}$ compared to without NaOH application. The increase in the provision of NaOH increased pH and CEC powdered *sub-bituminous*, so from that 0% to 10%, NaOH becomes 0 %, 2.5%, 5%. 7.5% and 10% for treating the soil in core research. The results of stage II studies is the provision of a mixture of 20 ton.(ha)$^{-1}$ *Sub-bituminous* coal powder and 10% of NaOH were able to increase the pH of H_2O, CEC, organic-C, Available-P, and Total-N Ultisol each of 1.49 units, 28.08 me.(100g)$^{-1}$, 1.63 % C, 2.37 ppm P, 0.06% N, and decreases Al-exch Ultisol by 1.17 me.100g^{-1} and SAR Ultisol by 0.03, and ESP Ultisols by 0.82 % compared to natural soil.

ACKNOWLEDGEMENTS

We would like to thank the Rector and Chairman of the Institute for Research and Community Service of Andalas University Padang, the Ministry of Research Technology and the Higher Education Republic of Indonesia, the financial support of this research through professorship research grants of the fiscal year 2017.

REFERENCES

[1] World Coal Association (WCA). (2016). Coal facts 2015, London. [Online] Available: www.worldcoal.org, [5 April 2016].

[2] J. T. Riley. Routine Coal and Coke Analysis: Collection, Interpretation, and Use of Analytical Data. ASTM International. The USA. 104 p. 2007.

[3] Herviyanti, T. B. Prasetyo, Juniarti, and D. Rezki. Activation Unproductive Coal Powder with Urea to Improve Chemical Properties of Ultisols. International Journal on Advanced Science, Engineering and Information Technology, Vol. 7 No. 3, pp: 957-963, Juni 2017.

[4] Herviyanti, T. B. Prasetyo, M. Harianti, A. Saidi. and Ismon. The potency of humate material from Sub-bituminous and how to do Incubation with Fosfor-Fertilizer to Increase Upland Rice Production at Acidic Mineral Soil. Greener Journal of Agricultural Sciences. 2 (8) pp: 351-361. 2012.

[5] K. A. Hanafiah. Dasar-Dasar Ilmu Tanah. Rajawali Press. Jakarta. 359 hal. 2007.

[6] D. L. Sparks, Environmental Soil Chemistry. Second Ed. Academic Press: USA. pp : 76-77. 2013.

[7] G. Fiorentino, R. Spaccini, and A. Piccolo. Separation of molecular constituents from a humic acid by solid-phase extraction following a transesterification reaction. Talanta 68, pp: 1135-1142. 2006.

[8] E. A, Ghabbour, G. Davies, Jr. Daggett. JL, C. A. Worgul, A. Wyant, M. M Sayedbagheri. Measuring the humic acid contents of commercial lignites and agricultural topsoils in the National Soil Project. Annals of Environmental Science, 6: 1-12. [Online]. Available: www.aes.neu.edu. 2012.

[9] K. H. Tan. Principles of Soil Chemistry. CRC Press Taylor and Francis Group. 362 pp. 2011.

[10] Herviyanti, Azwar, dan Yusnaweti. Kajian Stabilitas Bubuk Tidak Produktif Dan Bahan Humatnya Yang Diekstrak Dengan Pupuk Buatan Untuk Meningkatkan Efisiensi Pemupukan Dan Produktifitas Ultisol Dan Oxisol. Laporan Hasil Kegiatan penelitian KKP3N . 60 hal. 2014.

[11] B. H. Prasetyo dan D. A. Suriadikarta. Karakteristik Potensi dan Teknologi Pengelolaan Tanah Ultisol Untuk Pengembangan Pertanian Lahan Kering di Indonesia. Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian dan Balai Penelitian Tanah. Bogor. Jurnal Litbang Pertanian 25 (2) hal: 39 – 47. 2006.

[12] S. Hardjowigeno. Ilmu Tanah. Akademi Persindo. Jakarta. 268 hal. 2003.

[13] P. C. Painter, M. Starsinic, M. M. Coleman. Determination of Functional Groups In Coal by Fourier Transform Interferometry. In Fourier Transform Infrared Spectroscopy. Ferraro, J.R., Basile, L.J., Eds.; Academic Press: New York, NY, USA; pp. 169–240. 1985.

[14] Y. Chen, C. Zou., M. Mastalerz, S. Hu, C. Gasaway, dan X. Tao. Applications of Micro-Fourier Transform Infrared Spectroscopy (FTIR) in the Geological Sciences—A Review.Int. J. Mol. Sci. 16 pp: 30223–30250. MDPI, Basel, Switzerland. 2015.

[15] G. Yuliani, G. G.Grandistan., dan A. T. Mursito. Karakterisasi Adsorpsi Batubara Muda Termodifikasi Hidrogen Peroksida Menggunakan Metode Kontinyu Terhadap Metilen Biru. Chimica et Natura Acta Vol.3 No.1 hal: 21-24. April 2015.

[16] N.C. Brady and R.R. Weil. The Nature and Properties of Soils. 13th ed. Pearson Education, Inc., New Jersey, USA. 2002.

[17] World Coal Institute (WCI). The Coal Resource: A Comprehensive Overview Of Coal. https://www.worldcoal.org/sites/default/files /coal_resource_overview_of_coal_report (03_06_2009).pdf. [5 April 2016]. 2005.

[18] B. Saito and M.M. Seckler. Alkaline Extraction of Humic Substances From Peat Applied To Organic-Mineral Fertilizer Production. Brazilian Journal of Chemical Engineering. Vol. 31, No. 03, pp: 675 – 682. 2014.

[19] N. W. Shelly. Pengujian Tingkat Keaktifan Campuran Bubuk subbituminous dengan Urea, KCl, NaOH dan NaCl Terhadap Beberapa Ciri Kimia Oxisol. Skripsi Fakultas Pertanian. Universitas Andalas. Padang. 60 hal. 2014.

[20] H. Junedi, Zurhalena, I. A. Mahbub. Short-Term Effect of China Violet Compost on Soil Properties of Ultisol and Peanut Yield. International Journal on Advanced Science, Engineering and Information Technology, Vol. 3 No. 31, pp: 50-53. 2013.

[21] P. Mantovi, G. Baldoni, and G. Toderi, Reuse of liquid, dewatered, and composted sewage sludge on agricultural land: effect on longterm application on soil and crop,"Water Research, vol. 39, pp. 289-296. 2005.

[22] Olivas, John. Where Does Humic Acid Come From?. Bioscientific. 2010.

[23] D. P. Ariyanto. (2016) Artikel Ikatan Asam Organik Tanah dengan Logam. Fakultas Pertanian Universitas Sebelas Maret Surakarta. [Online]. Available: http://ariyanto.staff.uns.ac.id/files/2009/06/artikel-ikatan-asam-organik-dengan-logam.pdf. September 2016].