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Abstract—Global temperature had increased by about 0.5°C over the past century, increasing temperature leads to a loss or a decrease of soil organic matter (SOM). Whereas soil organic matter in many tropical soils is less stable than that of temperate soils, and it will be easily affected by climate change. Therefore, conservation of soil organic matter is urgent issue nowadays. This paper presents the effect of different doses (5%, 15%) of Ca-type zeolite in conjunction with organic manure, applied to soil samples from Philippines, Paraguay and Japan, on the decomposition resistance of soil organic matter under high temperature. Results showed that a remain or slightly increase the C/N ratio of soil. There are an increase in percent of humic acid (PQ) that extracted with Na2P2O7. A decrease of percent of free humus (H) after incubation was determined. A larger the relative color intensity (RF) value and a lower the color coefficient (AlogK) value following increasing zeolite rates leading to a higher degrees of humification. The increase in the aromatic condensation of humic acid (HA) after incubation, as indicates by the decrease of H/C and O/C ratios of HA. This finding indicates that the use of zeolite could be beneficial with respect to SOM conservation under global warming condition.

Keywords—Global warming, Humic substances, Soil organic matter, Zeolite.

I. INTRODUCTION

The average facade temperature of the globe has augmented more than one degree Fahrenheit since 1900 and the speed of warming has been almost three folds the century long average since 1970 (IPCC, 2007). There is a general expectation that increasing temperature leads to increase in both net primary productivity which provides the input to soil organic C, and the rate of soil organic matter decomposition which determines the loss of soil organic C. Increased temperature may lead to more rapid breakdown of soil organic matter and even small increases in temperature may prompt large releases of C from soils (Richard T. Conant et al., 2008) [8]. Schimel et al., 1994 summarize modeling and data-based predictions of C release (11.1 to 33.8 Pg C) from SOM for a 1°C increase in global mean annual temperature [10]. Hence, it seems likely that soil organic C will decrease with increasing temperature due to climate change. In addition, organic matter decomposition rates in tropical soils are generally faster than in temperate soils because decay of nonlabile fraction is generally faster (Sheila M.Ross, 1993) [9]. Thus, the effects of climate change on the rate of soil organic matter decomposition in high latitudes are expected to be much larger.

SOM plays essential role, without SOM, the Earth’s surface would be a sterile mixture of weathering minerals. Focusing on understanding the significance and learning how to enhance the quality and quantity of SOM may lead to sustainable agriculture. Besides increasing soil organic matter, the ways to reduce its decomposition rate needs to be understood. One of the measures considered highly effective, biologically justified and environmentally safe, especially on degraded and other soils having unfavourable productive traits for crop cultivation, is the use of natural zeolite mineral (Polat et al., 2004; Beqiraj et al., 2008) [7].

Zeolite’s component are SiO2, Al2O3 and Fe2O3. One measure of this property is the cation exchange capacity (CEC). The application of zeolite to soils increases their E.C and as a result, it increases nutrient retention capacity. Futhermore, the adition of zeolite usually increase pH levels (Ming.DW and Boettinger) [6]. Hence, zeolite acts as a slow release fertilizer, giving the plant access to water and nutrients for longer, which results in a significant saving in water resources and reducing the amount of fertilizer to be applied. Natural zeolites are characterized by negatively charged frameworks, with a high cation exchange capacity and specific cation selectivity (Colella, 1996), it is important to recognize that interactions of zeolitic tuffs with humic substances depend on the features of the bridge cation [2]. Thus, the hypothesis is given a complexation between oxy of zeolite components and organic acid that take form organo-metallic when zeolite is applied to the soil. And, whether organo-metallic is a decomposition resistance of soil organic matter, hence the research was performed in order to investigate the effect of its on the decomposition resistance of organic matter in tropical soils under global warming condition.

II. EXPERIMENTAL METHODS

The experiment was carried out with soil samples from Philippines (Ph), Paraguay (Pa) and Japan (J). The chemical characterististics of the soil are shown in Table 1. Ca-zeolite was used for the study and relevant properties are shown in Table 2. Different doses (5%, 15%) of Ca-zeolite type in conjunction with 25% organic manure (OM) was applied to soil samples. The experiment was consisted of 18 treatments. Sample codes for treatments as follow: S1, S2, S3, SO1, SO2, SO3 (S: soil;...
O: organic manure; 1, 2, 3: 0, 5, 15% zeolite, respectively). The incubation was carried out in a soil flask for durations of 1, 3 and 6 months all with a temperature of 40°C and relative humidity of 65 to 70%. During the incubation period, soil treatments were irrigated every three days depending on the vapo-transpiration value which was measured gravimetrically. Soil samples were collected after 1, 3, and 6 months, air dried, crushed and pass through a 0.5-mm mesh sieve and then used in the laboratory analyses.

### III. RESULTS AND DISCUSSION

#### A. Effect of Zeolite application on Carbon to nitrogen (C/N) ratios

The changes in the C/N ratios of soil reflect the rate of decomposition of organic matter and this results in the release (mineralisation) or immobilization of soil nitrogen. A decrease in the C/N ratio from 0 month to 6 months for the untreated soil samples at significant levels. That is a result of decomposition of soil organic matter quickly during incubation time under high temperature. Because the organic molecules in organic matter were broken down into simpler organic molecules. Meanwhile, there was a general higher in the C/N ratio with 5 and 15% zeolite application compared with untreated soil samples after 6 months incubation (Fig.1). The treatment applied 15% zeolite gave the highest of C/N ratios at 18.2 (Ph3) and 10.8 (PhO3); 16.4 (J3) and 9.1 (J03); and 15.0 (Pa3). It means that nitrogen contents were much mineralized during decomposition process, while there was a gradual carbon condensation for the soil by the combination of zeolite and organic matter become stronger than before that made the decomposition of soil organic matter slow down.

#### B. Effect of Zeolite application on soil humic substances

In Fig. 2 can be observed that the treatments applied zeolite combine with organic manure of all soils studying gave a higher carbon contents of HA than the treatments applied only zeolite. The carbon contents of HA from 5 to 15% zeolite application were all higher than that of HA from untreated soil samples after 6 months of incubation. Addition of 5% and 15% zeolite to soils significantly increased “combined” form of HA (HA extracted by NaP2O5), conversely, “free” form of HA (HA extracted by NaOH) was decreased. According to Kumada and Ohta (1965), humus extracted with NaOH

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### Table I

<table>
<thead>
<tr>
<th>Property</th>
<th>Philippines soil (Ph)</th>
<th>Paraguay soil (Pa)</th>
<th>Japan soil (J)</th>
<th>Organic manure (O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total C (%)</td>
<td>2.44</td>
<td>2.06</td>
<td>5.82</td>
<td>5.64</td>
</tr>
<tr>
<td>Total N (%)</td>
<td>0.15</td>
<td>0.17</td>
<td>0.38</td>
<td>1.62</td>
</tr>
<tr>
<td>C/N</td>
<td>16.30</td>
<td>12.10</td>
<td>15.30</td>
<td>3.50</td>
</tr>
<tr>
<td>Na (me/100 g soil)</td>
<td>110.86</td>
<td>15.95</td>
<td>3.26</td>
<td>550.81</td>
</tr>
<tr>
<td>K (me/100 g soil)</td>
<td>119.22</td>
<td>22.52</td>
<td>32.40</td>
<td>1436.46</td>
</tr>
<tr>
<td>Mg (me/100 g soil)</td>
<td>1584.10</td>
<td>141.49</td>
<td>33.74</td>
<td>990.76</td>
</tr>
</tbody>
</table>

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### Table II

<table>
<thead>
<tr>
<th>Property Value</th>
<th>CEC cmol (+)/kg</th>
<th>pH2O</th>
<th>Na cmol (+)/kg</th>
<th>K cmol (+)/kg</th>
<th>SiO2 %</th>
<th>Al2O3 %</th>
<th>CaO %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca-Zeolite type</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>CEC cmol (+)/kg</td>
<td>257.9</td>
<td>10.0</td>
<td>109.4</td>
<td>16.5</td>
<td>46.5</td>
<td>24.0</td>
<td>12.0</td>
</tr>
</tbody>
</table>

Source: Based on Maeda corporation (2005)
presents a very weakly combined form with polyvalent cations or free form, whereas the humus extracted with Na₂P₂O₇ presents a strongly combined form with polyvalent cations and clay minerals [5]. In addition, the humus extracted with Na₂P₂O₇ is supposed to be more stable than that extracted with NaOH (Kumada et al., 1981). Therefore, an increase "combined" form of HA in humus fractions means the formation of organic-metal-mineral complexes is more stable in soils that make the decomposition of humic substances will slower.

Addition of zeolite to soils significantly increased PQ₂ (the HA value of "combined" form of HA extracted by Na₂P₂O₇), conversely, PQ₁ (the HA value of "free" form of HA extracted by NaOH) was decreased following raising zeolite rates after 6 months incubation (Fig. 3).

This results suggested that the relative proportion of HA increased while FA decreased with increasing dose of zeolite. As we know humic acid, which is the most resistant fraction to microbial degradation of the organic matter in soil, are complex polymeric HA with a wide range of molecular weights. Therefore, an increase amount of HA contents in humus fraction will resist the decomposition of humic substance by stable organic clay with zeolite complexes.

![Fig. 2 Relationship of “combined” form of humic acid and “free” form of humic acid in soils studying after 6 months of incubation](image2)

![Fig. 3 Relationship of percent of humic acid in extracted humus by NaOH (PQ₁) and Na₂P₂O₇ (PQ₂) in soils studying after 6 months incubation](image3)

![Fig. 4 Relationship of RF₁ and ΔlogK₁ with zeolite rates in soil studying after 6 months incubation (HA extracted by NaOH)](image4)

![Fig. 5 Relationship of RF₂ and ΔlogK₂ with zeolite rates in soil studying after 6 months incubation (HA extracted by Na₂P₂O₇)](image5)

The ΔlogK and RF have been used as indexes for the degree of humification of HA (Kumada, 1987) [4]. As for alkali-extractable humic acids, when zeolite rates were increased from 0 to 15%, the ΔlogK₁ of HA increased, whereas, RF₁ of HA decreased in both of groups without and applied organic manure with a correlation at \( r = 0.65 \) and \( r = 0.73 \), respectively (Fig.4). This indicates the HA formed during humification process of soil organic matter has a lower humification degree in 5 and 5% zeolite application to soils. However, the reverse was observed as to pyrophosphate-extractable humic acids, the decrease of ΔlogK₂ and the increase of RF₂ compared with those of control soils with a correlation at \( r = 0.54 \) and \( r = 0.67 \), respectively (Fig.5). The highest percent of humic acid in "combined" form of HA (PQ₂) was obtained in treatments applied 15% zeolite wherein the lowest mean average values of ΔlogK₂ was also obtained.
in this study. According to the results, humus composition may be concluded that part of the free humus, particularly the humic acids which have a higher degree of humification were transformed into calcium-combines forms, and that the extent of the the transformation decreased in soils (Ryosuke Shiroya and Kyoichi Kumada, 1976). Therefore, when ΔlogK decrease and RF increase, soil organic matter has a higher humification degree that means organic matter will decompose slowly.

According to Baranciková et al. (1997) the diagram of H/C atomic ratio versus O/C atomic ratio may be considered as a graphical-statistical-representation which indicates the changes in properties occurring during coalification reactions such as oxidation, dehydrogenation, dehydration, demethanation and decarboxylation [1]. At treatments applied zeolite in soils studying, the diagram of atomic O/C versus H/C with incubation time (Fig.6) shows a general tendency that a decrease in O/C and H/C of HA extracted by NaOH and Na2P2O7 are observed in both of groups without and applied organic manure with a correlative at r² = 0.63 and r² = 0.62, respectively, whereas treatments without zeolite were in the opposite direction from 1 to 6 months of incubation. This results agrees well with the reported previously of Minori H/C and O/C ratio during the decomposition process of HA respectively, whereas treatments without zeolite were in the opposite direction from 1 to 6 months of incubation. The O/C ratio is also a representative of the degree of humification. A decrease of this ratio commonly suggests an increase in the aromatic condensation. The value of H/C ratios show the degree of maturity in humic substances (Gonzales-Villa et al., 1992, 2000) since indirectly it reflects the existence of more condensed aromatic ring or substituted ring structure [3]. Therefore, a decrease in atomic H/C and O/C at most of soils studying proved that application of zeolite can resist the decomposition of organic matter.

We found that the carbon accumulation of humic fractions as well as the degrees of humification and acromatica of HA increase by the application CaNzeolite to the soil. These results affirmed that there are a complexation between oxy of zeolite components and organic acid that take form organo-Nmetallic. And this complexes made the humic acid decomposition process such as oxidation, decarboxylation and demethanation will happen slower than the humic acid decomposition process of the soil without zeolite. These results proved that soil amendment with CaNzeolite could resist the decomposition of organic matter under high temperature. In addition, we recognized that there were not only tropical soil (Philippines and Paraguay) but also subtropical soil (Japan) have been affected on the decomposition of soil organic matter by global warming.

IV. CONCLUSION

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REFERENCES


