# CHANGES IN SOIL PHYSICAL CHARACTERISTICS ON THE SOIL CRUST PROCESS THROUGH THE USE OF CHICKEN MANURE AND POLYACRYLE AMIDE UNDER INTENSE RAINFALL

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## ABSTRACT

*Soil crust is a soil suface layer which is more compact, harder, and brittle when it is drier than underlaying material. The soil physical characteristics such as aggregate stability, bulk density and soil permeability rate are closely related to this soil crust process. An experiment was conducted to evaluate the effects of chicken manure doses and certain chicken manure with PAM (Polyacrile Amide) to soil aggregate, bulk density and soil permeability rate. The result of this research, were: 1) An incremental addition of chicken manure into soil increased soil aggregation percentage, soil stability and soil permeability rate, and 2) The combined incremental additions of chicken manure with PAM were found to be more effective than only an incremental additions of chicken manure, increasing the aggregation percentage, soil aggregate stability, from the soil one day drainage process, but another case in decreasing the bulk density permeability rate from the soil with the same process.*

***Key words** : Aggregate, bulk density, chicken manure, crust, PAM, permeability*

## INTRODUCTION

Soil crusts are layers which are more compact, hard and brittle when it is drier than underlaying material. The term has been used to describe layers of reduced permeability under intense rainfall or dense layers resulting from irrigation. Surface crusts can hinder agriculture by impeding seedling emergence or decreasing infiltration capacity (Bryan, 1973).

The consequences of soil crusts are quite severe sometimes. Several time replanting must be carried out due to failure of seedling to emerge through the surface crust. Another case, if soil crusts were formed, the infiltration capacity is decreased, so it may generate a surface water layer during rainfall which can influence soil erosion and decreasing water storage in the roots zone.

The formation of soil slacking and crusting are mainly attributed to the following factors:

a. Poor soil structure, particularly for soils those are under continuous cultivation.
b. Low organic matter.
c. Heavy rainfall.
d. Soil management with heavy machinery.
e. A critical clay/fine sand ratio.

For controlling soil slaking and crusting, various practices and soil treatments have been used:

a. On land covered by vegetation a large proportion of the raindrops are intercepted by the plants and loose most of their kinetic energy before reaching the soil surface.
b. Slaking and crusting of soils can be controlled by surface mulches, which protect the soils from the impact of raindrops.
c. For soils in humid regions the simple flocculation effects might be considered as the worst possible condition which can be improved by organic matter addition.
d. In arid regions the reclamation of dispersed soils by the use of gypsum, which establish the flocculated condition.
e. Certain artificial soil conditioners have been successfully used for preventing and reducing soil slaking and crusting by producing a stable aggregation.

In this way the aim of this work is to study the changes in soil aggregate, bulk density and soil permeability rate as the indicators of soil crusts process through the use of chicken manure and chicken manure with **Polyacrylamide** (PAM) under intense rainfall with one day drainage process.

## MATERIALS AND METHODS

An incubation experiment was conducted in the laboratory of Department of soil Science Resources, Faculty of Agriculture. Bogor Agricultural University. The soil sample was taken from the upper 5 cm layer, having loamy sand soil texture class. Organic matter used was chicken manure, and soil conditioner used was **Polyacrylamide (PAM).** The physical and chemical compositions of the soil sample and chicken manure are presented in Table 1 and Table 2, respectively. The soil conditioner (PAM) used in the present work was an organic polymer solution of polyacrylamide (PAM). The physical properties of PAM are :

| | |
|---|---|
| Viscosity | : 200 to 2000 cps at 25$^0$C |
| Molecular weight | : 250.000 (normal range 200.000 to 1.000.000) |
| Concentration of Active material | : 16% by weight |
| Content of monomer | : less than 0.05% |

Table 1. The physical and chemical compositions of soil sample

| No | Kinds of analysis | Value | Explanation |
|---|---|---|---|
| 1 | Sand (%) | 70.2 | Loamy sand |
| 2 | Silt (%) | 24.4 | Texture class |
| 3 | Clay (%) | 5.4 | |
| 4 | pH – $H_2O$ | 5.27 | |
| 5 | pH – KCl | 4.03 | |
| 6 | Organic matter (%) | 1.62 | |
| 7 | $CaCO_3$ (%) | 0.00 | |
| 8 | E 1/5 (mS. $Cm^{-1}$) | 0.049 | |
| 9 | N – Total (mg N/100 g DS) | 90 | |
| 10 | $NO_3^-$ - N (ppm) | 3.8 | |
| 11 | P – Total (mg/kg DS) | 510 | |
| 12 | $P_{ext.}$ (mg/kg DS) | 68.8 | |
| 13 | K – Total (mg/kg DS) | 1000 | |
| 14 | $K_{ext.}$ (mg/kg DS) | 100 | |

Table 2. The physical and chemical compositions of chicken manure

| No | Kinds of analysis | Value |
|---|---|---|
| 1 | Fraction (% air dry): | |
| | Diameter (mm) | |
| | 8 – 4.76 | 6 |
| | 4.76 – 2.83 | 11 |
| | 2.83 – 2.00 | 18 |
| | 2.00 – 1.00 | 29 |
| | 1.00 – 0.50 | 17 |
| | 0.50 – 0.297 | 8 |
| 2 | Moisture (% oven dry weight) | 13 |
| 3 | Total N (%) | 5.0 |
| 4 | $P_2O_5$ (%) | 3.0 |
| 5 | $K_2O$ (%) | 1.5 |
| 6 | CaO (%) | 5.0 |
| 7 | MgO (%) | 2.0 |
| 8 | $SO_3$ (%) | 1.5 |

The experiment was completely randomized design with the treatments different percentages of chicken manure as organic matter with and without PAM. The percentages of organic matter (chicken manure) as follow:

T1 = soil with 0.2 % organic matter/(chicken manure)

T2 = soil with 0.8% organic matter/(chicken manure)

T3 = soil with 1.8% organic matter/(chicken manure)

T4 = soil with 3.0% organic matter/(chicken manure)

T5 = soil with 5.0% organic matter/(chicken manure)

The other set of this experiment was applied on soil, the same as percentage of chicken manure above but with additional of PAM with the consentration of 2/1000 air dry soil. Air dry soil samples were put into the rings with 8 cm diameter and 4 cm height. The weight of each soil sample is based on the bulk density of each treatment. Five replications were used for each treatment in these experiments. All treatments were incubated for three weeks, at $27^0$C temperature. The water contents were kept at field capacity during the incubation.

**Organic matter destruction.** Organic matter was destructed by $H_2O_2$. The result of the destruction was checked by the measurement of the organic – Carbon with the Walkley and Black Method (Cottenie and Verloo, 1982).

**Determination of field capacity.** To determine which time at field capacity will be achieved, a soil sample was subjected to an evaporation under laboratory condition.

**Determination of the aggregate stability.** The dry and wet sieving were carried out according to the method described by De Leenheer and De Boodt (1967).

Approximately 500 g of air dry soil (diameter less than 8 mm) was sieved on a set of sieves with mesh widths of 8, 4.76, 2.83, and 2 mm. Shake gently by hand to devide these dry aggregates into the different fractions, without breaking the aggregates. The fraction less than 2 mm is discarded, and the fractions 8 to 4.76, 4.76 to 2.83, and 2.83 to 2 mm respectively were weighed and placed in nickel cups. The fractions were brought to field capacity and incubation one night before wet sieving. The mean weight diameter of respectively the dry and the wet stable aggregates, was calculated using the following formula:

$$\Sigma \left[ \frac{\text{mass \% soil x } \dfrac{\text{Greatest diameter + smallest diameter}}{2}}{100} \right]$$

The difference between the dry and wet mean weight diameter gives the instability index. The soil is easy to erode, if it has high instability index.

$$\text{Instability Index} = \frac{1}{\text{Stability Index}}$$

The Soil Stability Quotient = % Aggregation x Stability Index

**Determination of the bulk density.** The bulk density was calculated as the ratio the mass of oven dry soil to the bulk volume of the soil (volume of soil particles plus pore spaces).

**Raindrop impacts.** The rainfall simulator utilizing nozzles operating under pressure has been developed, by means of which rain characteristics can be controlled with a fairly wide range. The controlables are intensity, drop size distribution, and drop velocity distribution. The rainfall intensity was 42 mm per hour, and samples were placed under the rain for a period of 10 minutes.

**Determination of water permeability of the saturated soil.** The water permeability of the saturated soil was determined in accordance to the method described by Verplancke (1983). It was calculated with the following equation :

$$K_W = - \frac{Q_W}{A \, . \, t} \times \frac{\Delta z}{\Delta \psi_h}$$

$K_W$ = water permeability (cm/hour)
$Q_W$ = quantity of water, that flow for each measurement (ml)
A = wide of soil surface
t = time (hour)
$\Delta z$ = distance measured in vertical direction/thickness of soil (cm)\
$\Delta \psi_h$ = difference in hydraulic potential between two points (cm)

## RESULT AND DISCUSSION

### Aggregation Percentage

The total amount of aggregates greater than 2 mm, is measured in percentage and can easily be determined using dry sieving. The aggregation percentage of the soil treated with organic matter (chiken manure) and a mixture of organic matter (chicken manure) with PAM is graphically presented in Figure 1.

From this results we can conclude that, the aggregation percentage of organic matter in combination with PAM is higher than that of organic matter, due to the more effectiveness of PAM to form aggregates. The addition of more organic matter to the soil seems to increase the aggregation percentage, however, no significant differences could be observed. The reason is probably due to during the incubation period was not sufficiently in order to a reaction of organic matter with the soil (Khaled, 1982).

### Soil Stability Quotient

Figure 2 showed that the stability quotients of organic matter in combination with PAM were higher than that of organic matter treatments, due to the more effectiveness of PAM in increasing the aggregate stability than that of by organic matter.

An increase of the stability quotient is established when PAM is added in combination with organic matter at the rate of 1.8%. However, the addition of higher amounts of organic matter decreased the stability quotient (Figure 2). The reason was due to PAM is partly adsorbed by the organic matter when high amounts of organic matter are present. The Fact that PAM is a long chain molecule, some links of molecules exist between the soil aggregates.

### Bulk Density (BD)

Average values of bulk densities on each treatment is shown in Figure 3. A lower bulk density wass observed when organic matter was added in combination with PAM. The same reason can be stated that PAM is more effective to form aggregates with diameter more than two milimeter.

Higher amounts of organic matter seems to increase bulk density, due to the low particle density of organic matter. Besides, organic matter increases the pore spaces.

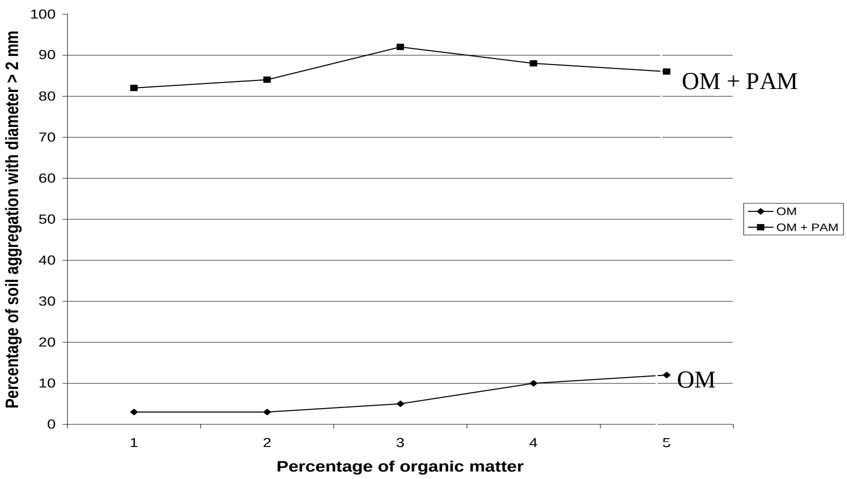


Figure 1. Changes of soil aggregation through the use of organic matter/Chiken manure (OM), mixture of organic matter/chiken manure and PAM (OM + PAM)

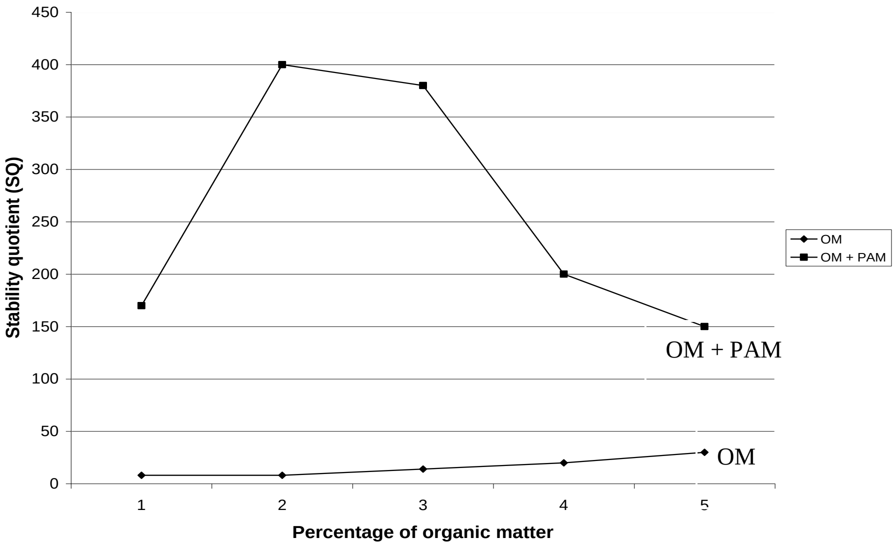


Figure 2. Changes of soil stability quotient through the use of organic matter/ chicken manure (OM), mixture of organic matter/chicken manure and PAM (OM + PAM)

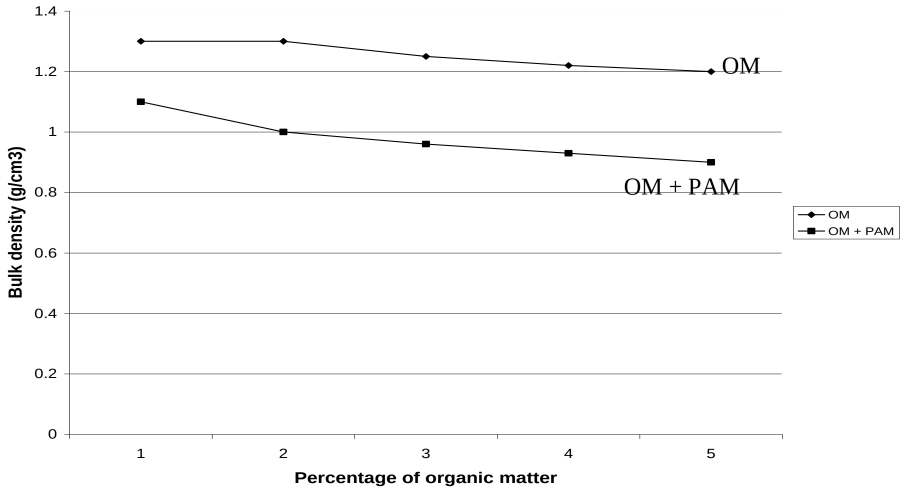


Figure 3. Changes in soil bulk density through the use of organic matter/ chicken manure (OM), mixture of organic matter/chicken manure and PAM (OM + PAM)

**Permeability Rate**

Figure 4 illustrates that the organic matter did not significantly influence the permeability rate. However, the combination of organic matter with PAM results in an increase on two percent of organic matter content and consequtively after that a decrease of the permeability rate.

Hence, by referring to the two previous parameters, it can be concluded that the permeability rate pattern (Figure 4) shows the similar curve with that of the stability quotient (Figure 2). Consequently, the permeability rate of OM + PAM treatment was higher than OM treatment.

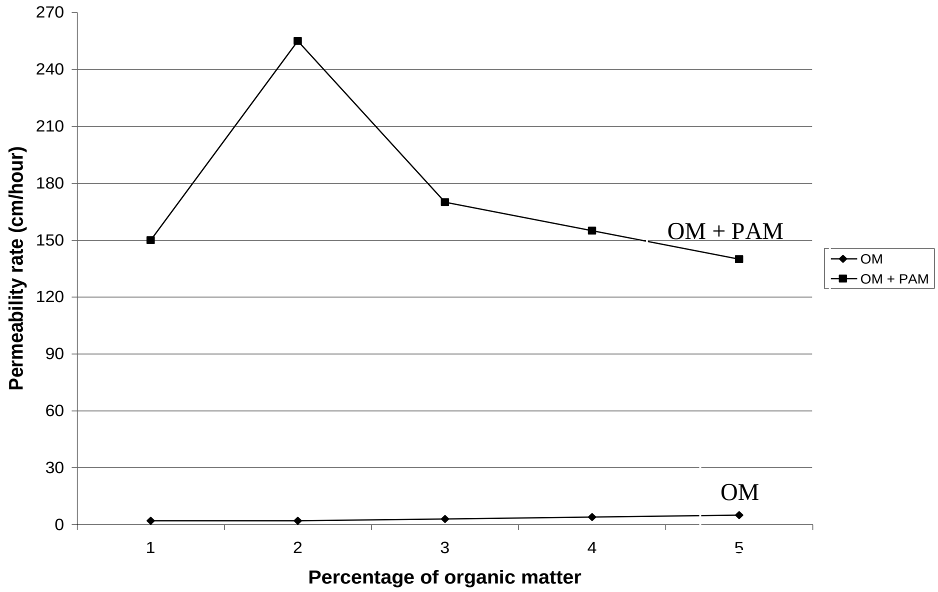


Figure 4. Changes in soil permeability rate through the use of organic matter/chicken manure (OM), mixture of organic matter/chicken manure and PAM (OM + PAM)

## CONCLUSION

The preceding study and its supporting documentations support the conclusions that an incremental additions of organic matter (chicken manure) into a soil increased their aggregation percentage, soil stability, permeability rate of the soil which have been taken up immediately after the rainfall with one day drainage process. Moreover, their increments decreased the bulk density of the soil which have been taken up after having a one day drainage process.

The combined incremental additions of the organic matter with PAM were found to be more effective than only an incremental additions of organic matters, in increasing the aggregation percentage, soil stability, permeability rate from the soil with one day drainage process, but another case in decreasing the bulk density from the soil with the same process.

Based on the result of this experiment, it is suggested all treatments should be incubated in more than three weeks duration.

## ACKNOWLEDGEMENT

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