Fractionation distribution of metal Al, Fe, Mn, and microbial population in acidic soil horizon

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Abstract. Acidic mineral soil generally has mild acidic to high acidic reaction or pH ≤ 5.5, with very low exchangeable bases that can exchanged and rich in oxide as well as Al and Fe hydroxides. Acidized soil can lead to increased toxicity from aluminum, iron, and manganese element to the plants and deficiency of phosphorous, alkaline cation (calcium, potassium, and magnesium), and molybdenum element as well as soil microbial population. This study aimed to observe the fractionation distribution of metal aluminum (Al), iron (Fe), and manganese (Mn) and soil microbial population in acidic soil horizon. Al fraction parameters included exchangeable Al (Al-exc), non-crystalline Al (Al-o), inorganic non-crystalline Al (Al-po), Organically Bound Al (Al-p), Low- and Medium-Stability Complexes with Organic Matter (Al-Cu) and High-Stability Complexes with Organic Matter (Al-pCu), exchangeable fractionation of Fe and Mn (Fe/Mn-exc), Fe and Mn from Bound to Carbonates/Acid-extractable, Bound to Fe-Mn Oides/Reducible, Bound to Organic Matter Fe Mn/Oxidizable, Fe- Mn Residual and soil microbial population (total microbes and Acidithiobacillus bacteria). The results, distribution of Al fraction on the upper horizon of Jasinga and Lebak were dominated by stabilized organic amorphous Al fraction with fluctuative decrease of organic matter (Al-pCu), while the lower horizon tended to be inorganic amorphous Al (Al-op). The fractionation distribution of Fe fractionation on Jasinga and Lebak was dominated by Oxidizable Fe fraction. Mn fraction distribution on Jasinga and Lebak were dominated by Mn-residual fraction in each acidic soil horizon. The total population of Microbes and Acidithiobacillus .sp in each soil horizon decreased along with the alteration of soil chemical properties in each soil depth horizon.

Keywords: Acidic soil, Fraction of Al, Fe, and Mn, Soil microbes

1. Introduction

Tropical soil is usually acidic and has a high concentration of Al [22]. This acidic land has 67% area of the total land in Indonesia with the order Entisols, Inceptisols, Ultisols, Oxisols, and Spodosols. Considering the area and distribution, acidic mineral soil has great potential for agricultural development. However, acidic mineral soil nowadays has not been utilized. Acidic mineral soil generally has acidic to highly acidic pH, namely ≤ 5.5, followed with poor exchangeable base content, besides rich in oxide and hydroxide of Al and Fe [15]. Acidic soil can lead to increased toxicity of Al, Fe, and Mn to plants, phosphorous deficiency, reduced alkaline cation (calcium, potassium, and magnesium) and molybdenum [17]. Acidic soil
affects soil chemical and biological characteristics, including the availability of nutrients and metal toxicity (which affects the microbial community in many aspects [18]). Beneficial microbes and crops prefer a nearly neutral pH with the range of 6 to 7, thus resulting in increased soil benefits accompanied by microbe types and activity shifts in the soil. High level of Al on acidic soil as in Oxisol, Ultisol and Inceptisol soil causes low growth of plant roots. The study conducted showed that 90% of acidic soil source was hydrolyzed Al. The solubility of Al in soil solution depends on the pH solution and the existence of components that can release Al. Therefore, Al stability in the soil solid phase is one of the key factors to avoid this element dissolution. [8] reported that Al solubility of 9.25 mmol/L or more could lead to the mortality of cotton plant roots. [28] stated that 1 ppm Al level in soil solution would result decreased soybean production.

Excess concentration of Fe and Mn in the soil will poison the plant, whereas low concentration will suffer the plant from the element deficiency content. Fe element plays a role in the enzyme system in plant metabolism, while Mn serves as an activator of various enzymes, i.e. phosphate transfer and Krebs cycle enzyme. In addition, Mn is an important part of the chloroplasts and participates in oxygen-generating reactions [14]. [11] stated that the deficiency of Fe element will cause chlorotic in the younger parts of the plant, while older tissues remain green. This symptom first arises as a chlorosis among leaf bones, which critically disperses to the entire leaf followed with white coloration of the leaf.

The fractionation of Al, Fe, and Mn aims to observe specifically the reactive mineral fraction affecting the availability of nutrients in the soil. According to [1], the availability of Al in soil can be discovered by extraction method, namely: (1) ammonium chloride (NH₄Cl) extraction, which aims to estimate Al-dd [13], (2) oxalic acid extraction, which aims to estimate amorphous Al (Al-O) [3], (3) sodium pyrophosphate (Al-P) extraction, which aims to estimate organic amorphous Al [2], (4) 0.3M CuCl₂ extraction, which aims to estimate moderate to medium bond of organic Amorphous Al (Al-Cu) [7], (5) strong bond of with organic Al (Al-pCu), the difference of Al-p and Al-Cu [21], and (6) Al-o fraction, which is the difference of Al-o and Al-p fraction to suspect inorganic amorphous Al in the soil [7]. [19] reported that extraction techniques were gradually conducted to separate various forms of Fe, Mn, Cd, Co, Cu, Ni, Pb, and Zn, which were distinguished in five fractions, i.e. exchangeable, bonded to carbonates (acidity extract), bonded to Fe/Mn Oxide (reduced), organic bound fraction (oxidized), and residual fraction (residual). The form of Fe and Mn in the soil based on [19] and [24] are differentiated based on the availability and mobility in the soil, namely: exchangeable fraction (dd), acetic acid extracted (asm) as a less/low available form, oxidized fraction (oks), reduced fraction (red) as unavailable form, and residual fraction (res) as unavailable form for plants. This study aimed to observe the distribution of Al, Fe, and Mn fractionation as well as microbial population in acidic soil horizon.

2. Methods
Soil samples were taken from two locations, namely Neglasari Village, Jasinga, Bogor and Maja Lebak, Banten. Soil samples were taken on each horizon in the land profile. This study was a descriptive study by conducting a sample analysis of the soil without giving any treatments, then presenting and elaborating the result in the form of data and writing. Al fraction parameters included the chloride oxalate acid extracting material (1 g of soil sample shaken for 4 hours with 100 mL 0.2 M ammonium oxalate acidized into pH 3 with oxalate acid), sodium pyrophosphate (1 g of soil sample shaken for 16 hours with 100 mL 0.1 M Na₃P₂O₇), copper chloride (5 g of soil samples shaken for 5 minutes with 100 mL 0.5 M CuCl₂, stopped for 12 hours, and shaken again for 30 minutes), and ammonium chloride (5 g
of soil samples shaken for 5 minutes with 100 mL 1 M KCl, then filtered after 12 hours at extracted Al measured with Atomic Absorption Spectrophotometry (AAS) Extracted Al by oxalate ammonium acid (Al-o) gives non crystalline-Al content [3]. Extraction with sodium pyrophosphate [2] shows organic Al bound (Al-p); Extraction with copper chloride [5]; [7]; [9] provides stabilized Al formed as low or medium complex with organic matter (Al-Cu); Extracted Al by KCl is considered as exchangeable Al [13], the value of Al-Cu from Al-p (Al-pCu) provides highly stabilized Al complex with organic matter [21], Al-o from Al-p (Al-op) provides estimate of the total Al formed as non-crystalline inorganic Al.

Sequential extraction of soil testing stages for the fractionation of Fe and Mn was based on [19]; [24] to estimate exchangeable Fe and Mn fraction (10 mL 1M CH₃COONH₄ pH 7.0 shaken for 1 hour), Fe and Mn fraction of extracted acids (20 mL 1M CH₃COONa pH 5.0 shaken for 5 hours), reduced Fe and Mn fraction (20 mL 0.04 M NH₂OH · HCl 25% CH₃COOH H 96°C shaken for 5 hours), oxidized Fe and Mn fraction (5 mL 0.02 M HNO₃ + 5 ml 30% H₂O₂, 85°C pH 2.0 shaken for 2 hours + 5 ml 30% H₂O₂ 85°C pH 2.0 shaken for 3 hours + 10 mL 3.2 M CH₃COONH₄ in 20% HNO₃ 0.5 hours) and residual Fe and Mn fraction (2 mL HClO₄ + 10 mL HF, then evaporated to almost dry dissolved in 6 M HCl). All final solutions of the extract are further analyzed using Atomic Absorption Spectrophotometry (AAS). Total soil microbial was calculated using dish agar method. Pouring method was done by pouring 20 ml media over 1 ml inoculum that has been inserted into a sterile Petri dish. Furthermore, Petri dish was rotated by hand over the table surface, then cooled down a few minutes to make the solid media hardened. The media used was nutrients for soil microbial analysis (24 g/L of media). Dilution 10³, 10⁴, 10⁵, and 10⁶ were used for the total number of microbes analysis. Acidithiobacillus ferroxidant isolation was performed by inserting 10 g of soil samples into 90 ml of sterilized physiological solution (0.85% NaCl), then shaken for 15 minutes using a shaker. Solution was taken 1 ml and inoculated Leathen liquid media. Incubation was done for 14 days or until the media color turned into rusty yellow at room temperature by shaken using 250 rpm shaker. Color turned on the media was observed every day. Media color turned to yellow or rusty yellow indicated the media contained Acidithiobacillus sp. Data results obtained were analyzed in a descriptive method.

3. Result and Discussion
3.1 Aluminum Fractionation in Acidic Soil
The analysis result of concentration fractionation and fraction percentage of Al in each acidic soil horizon is presented in Table 1 and Figure 1.

Based on Table 1 and Figure 1, the fraction concentration of Al-dd in Jasinga and Lebak had fluctuate increase on soil horizon depth. Concentration of Al-exc in Jasinga was 8.26 – 12.64%, while in Lebak was 8.00 – 11.49%. Al-exc distribution of Jasinga soil accumulated at a soil depth of 37-70 cm while Lebak soil Al-exc distribution accumulated at a soil depth of 0-15 cm.
Table 1. Fraction concentration of Al in each acidic soil horizon

| Depth (cm) | Al-exc | Al-o | Al-p | Al-po | Al-Cu | Al-pCu |
|------------|--------|------|------|-------|-------|--------|
|            | ppm    | %    | ppm  | %     | ppm   | %      | ppm    | %     |
| Jasinga    |        |      |      |       |       |        |        |       |
| 0-35       | 1,800  | 12.24| 12,900| 87.76 | 8,100 | 55.10  | 4,800  | 32.65 |
| 35-70      | 2,200  | 12.64| 15,200| 87.36 | 7,600 | 43.68  | 7,600  | 43.68 |
| 70-100     | 2,000  | 11.56| 15,300| 88.44 | 6,100 | 35.26  | 9,200  | 53.18 |
| 100-120    | 1,900  | 8.26 | 21,100| 91.74 | 8,600 | 37.39  | 12,500 | 54.35 |
| Lebak      |        |      |      |       |       |        |        |       |
| 0-15       | 1,000  | 11.49| 7,700 | 88.51 | 4,000 | 45.98  | 3,700  | 42.53 |
| 15-40      | 1,400  | 9.93 | 12,700| 90.07 | 4,800 | 34.04  | 7,900  | 56.03 |
| 40-70      | 1,200  | 11.32| 9,400 | 88.68 | 4,400 | 41.51  | 5,000  | 47.17 |
| 70-120     | 1,100  | 8.09 | 12,500| 91.91 | 4,400 | 32.35  | 8,100  | 59.56 |

Al-exc = exchangeable; Al-o = Amorphous Al; Al-p = Organic amorphous Al; Al-po = Inorganic amorphous Al; Al-Cu = Organic amorphous Al with low to moderate bound; Al-pCu = Organic amorphous Al with strong bound.

Figure 1. Fraction distribution percentage of Al in each acidic soil horizon. (Al-dd= Al-exc= exchangeable; Al-o= Amorphous Al; Al-p= Organic amorphous Al; Al-po= Inorganic amorphous Al; Al-Cu = Organic amorphous Al with low to moderate bound; Al-pCu= Organic amorphous Al with strong bound.

Al-o fraction is the total Aluminium that binds to organic amorphous and inorganic compounds in the soil. Al-o concentration in Jasinga and Lebak was 87.36-91.74% and 88.51-91.91%, respectively, with fluctuating increase distribution on soil horizon depth. The distribution of the Al-o fraction of Jasinga soil accumulated in the soil depth of 100-10 cm and for Lebak soil at a depth of 70-120 cm. High concentration of Al-o reflected high content of amorphous material. According to [23], Al-o fraction was found in amorphous and humous Al. Concentration of Al-p in Jasinga was 35.26 – 55.10% with decreased distribution...
on soil horizon depth, while in Lebak was 32.35 – 45.98% with declined fluctuative distribution. Distribution of the Al-p fraction of Jasinga soil accumulated at a soil depth of 0-35 cm and Lebak soil accumulated at a soil depth of 0-15 cm. The accumulation of Al-p fraction on the horizon over the soil is related to the content of organic matter where the Al-p fraction is related to the content of Al which is organic.

Al-po fraction concentration in Jasinga was 32.65 – 54.35% with fluctuative increase on soil horizon depth, while in Lebak was 42.53 – 59.56% also with fluctuative increase distribution. The distribution of the Al-po fraction of Jasinga soil accumulated at a depth of 100-120 cm and Lebak soil at a depth of 70-120 cm. This was influenced by the amount of organic matter and texture in the soil sample. Al-Cu fraction is weak and moderately bound Aluminium formed as organic compounds. Al-Cu concentration in Jasinga was 3.69 – 7.22% with reduced distribution on soil horizon depth, while in Lebak was 3.75 – 6.51% with fluctuative decrease on soil horizon depth. The distribution of Al-Cu fraction of Jasinga soil accumulates in the soil depth of 0-35 cm and Lebak soil at a soil depth of 0-15 cm. Al-Cu fraction is closely related to the organic matter in the soil, the more horizon discovered, the lower organic soil observed, resulting lower concentration of Al-Cu. According to [5], the high content of organic carbon would increase Al-P and Al-Cu fraction in the soil. Al-pCu fraction is aluminum that strongly binds with the organic compounds in the soil [1]. The concentration of Al-pCu fraction in Jasinga was 30.25 – 47.88% with fluctuative decrease distribution on soil horizon depth, while in Lebak was 28.60 – 39.47% also with fluctuative decrease distribution. Distribution of Al-pCu fraction of Jasinga soil accumulated in the soil depth of 0-35 cm and Lebak soil at a soil depth of 0-15 cm. This shows that the deeper soil horizon, the lower Al-pCu formed as lower organic matter discovered.

3.2 Iron Fractionation in Acidic Soil
The analysis result of Fe fraction in each acidic soil horizon is presented on Table 2 and Figure 2. The result showed that Fe concentration generally increased on each fractionation stage in acidic land soil.

Based on Table 2 and Figure 2, Fe-exc concentration in the upper horizon of soil was lower than the down horizon with fluctuative increase in the distribution pattern on soil horizon depth. The concentration of Fe-exc fraction concentration in Jasinga was 0.26-1.04%, while in Lebak was 0.09-0.50%. Distribution of Fe-dd fraction on dried soil accumulated at a depth of 37-70 cm and soil swamp at a depth of 40-70 cm. Fe-exc concentration is influenced by soil texture with high clay minerals. [4] reported acidic condition of soil texture dominated by vermiculate clay minerals can be transformed to release Fe ion in the soil.

Fe-chlorolic acid (Fe asm) concentration was higher than Fe-exc fraction. Fe-asm concentration in Jasinga was 0.51-3.31% with fluctuative increase on soil horizon depth, while in Lebak was 0.23 – 1.59% also with fluctuative increase distribution. The distribution of Fe-asm fraction of Jasinga soil accumulates in the soil depth of 100-120 cm and Lebak soil at a soil depth of 15-40 cm. Fe-asm fraction concentration is related to soil texture with high clay minerals. Fe-reduced fraction (Fe-red) aims to see metal compound bound to organic compounds. Fe-red concentration in Jasinga was 5.69 – 11.85 with fluctuative increase on soil horizon depth, while in Lebak was 3.92 – 7.93% with fluctuative decrease distribution on soil horizon depth. The distribution of Fe-red fraction in Jasinga soil accumulates at a soil depth of 100-120 cm and Lebak soil accumulates at a soil depth of 40-70 cm.
Table 2. Fraction concentration of Fe in each acidic soil horizon

| Depth (cm) | Jasinga | Lebak | Total |
|------------|---------|-------|-------|
|            | Fe-exc  | Fe-asm| Fe-red| Fe-Oks | Fe-res | ppm % ppm % ppm % ppm % ppm % ppm % |
| 0-35       | 16.19   | 0.26  | 32.32 | 0.51   | 359.46 | 72.60 | 658.16 | 0.42   | 6317.73 |
| 35-70      | 35.05   | 1.04  | 29.78 | 0.88   | 335.00 | 7.94  | 1247.18| 37.00  | 3370.50 |
| 70-100     | 20.16   | 0.46  | 33.50 | 0.77   | 335.00 | 7.68  | 2520.9 | 57.78  | 4363.06 |
| 100-120    | 11.12   | 0.75  | 49.22 | 3.31   | 176.6  | 11.85 | 564.3  | 37.98  | 1485.65 |

Fe-exc = exchangeable; asm = acid extracted; red = reduced; oks = oxidized; res = residual

Figure 2. Fraction distribution percentage of Fe in each acidic soil horizon. (exc = exchangeable; asm = acid extracted; red = reduced; oks = oxidized; res = residual)

Fe-oxidized fraction (Fe-oks) in each soil horizon was observed with fluctuating decrease in soil horizon depth. Fe-oks concentration in Jasinga was 33.31 – 83.12% with fluctuating decrease distribution, while in Lebak was 43.51 – 78.83% also with fluctuating decrease distribution. The distribution of the Fe-ox fraction of Jasinga soil accumulates at a depth of 0-35 cm and lebak soil in a soil depth of 40-70 cm. Fe-oks fraction is associated with organic compound level in soil, as decreased Fe-oks concentration happened because of deeper soil horizon resulted in lower organic matter content. Residual fraction is the last stage of metal
fractionation. Fe-residual (Fe-res) concentration in Jasinga was 10.42-37.00% with fluctuative decrease distribution on soil horizon depth, while in Lebak was 11.16%-51.94% with fluctuative increase on soil horizon depth. Distribution of Fe-res fraction of Jasinga soil accumulated at a depth of 70-100 cm and Lebak soil at a depth of 70-120 cm. Based on Table 3, Figure 3, and Figure 4, Fe fraction in Jasinga was dominated by oxidized Fe (53.42%), residual Fe (35.80%), reduced Fe (8.79%), acid extracted Fe (1.37%), and interchangeable Fe (0.63%) fraction. Fe fraction in Lebak was dominated by oxidized Fe (60.82%), residual Fe (32.21%), reduced Fe (5.70%), acid extracted Fe (0.96%), and exchangeable (0.31%) fraction. Oxidized Fe fraction indicates the presence of metal that is easily oxidized by peroxide, showing the metal fraction obtained can bind to organic compounds and sulfide [6]. Oxidized Fe fraction is a fraction conditions where Fe are less available, while Fe residual indicates unavailable Fe fraction formed as stabilized crystalline Fe.

3.3 Manganese Fractionation in Acidic Soil
Manganese fraction analysis results in each soil horizon are presented in Table 3 and Figure 3. Mn-exc fraction concentration in Jasinga was 0.05 – 0.26% with fluctuative decrease distribution on soil horizon depth. Mn-exc fraction concentration in Lebak was 0.10 – 0.34% also with fluctuative decrease distribution on soil horizon depth. The distribution of Mn-dd fraction in Jasinga soil accumulated in the soil depth of 0-35 cm and Lebak soil at a soil depth of 0-15 cm. According to [24] Mn concentration is related to the amount of organic matter and type of vegetation on the soil as Mn has weak capability to bind to organic compounds [29].

| Table 3. Fraction concentration of Mn in each acidic soil horizon |
|---------------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Depth (cm) | Fraksi Mn | Jasinga | | | |
| | | ppm | % | ppm | % | ppm | % | ppm | % | ppm | % | Total |
| 0-35 | Mn-exc | 212.09 | 0.26 | 64.83 | 0.08 | 88.18 | 0.11 | 1016.70 | 1.26 | 79539.88 | 98.29 | 80921.67 |
| 35-70 | Mn-asm | 59.22 | 0.08 | 13.23 | 0.02 | 31.02 | 0.04 | 80.64 | 0.11 | 74343.75 | 99.75 | 74527.86 |
| 70-100 | Mn-red | 41.72 | 0.05 | 9.67 | 0.01 | 27.74 | 0.03 | 64.08 | 0.08 | 79595.63 | 99.82 | 79738.83 |
| 100-120 | Mn-Oks | 55.26 | 0.08 | 22.16 | 0.03 | 19.41 | 0.03 | 111.02 | 0.16 | 70625.63 | 99.71 | 70833.47 |
| | Mn-res | | | | | | | | | | |
| | Total | | | | | | | | | | |
| | ppm | | | | | | | | | | |
| | 267.47 | 0.34 | 109.38 | 0.14 | 19.55 | 0.02 | 4961.20 | 6.25 | 74003.38 | 93.25 | 79360.97 |
| | 179.73 | 0.22 | 44.46 | 0.05 | 201.76 | 0.24 | 2779.80 | 3.35 | 79853.13 | 96.14 | 83058.87 |
| | 144.66 | 0.18 | 25.37 | 0.03 | 184.46 | 0.23 | 2171.90 | 2.68 | 78545.63 | 96.88 | 81072.02 |
| | 103.42 | 0.10 | 53.26 | 0.05 | 322.86 | 0.33 | 5538.60 | 5.61 | 92711.25 | 96.88 | 98729.39 |
| | exc = exchangeable; asm = acid extracted; red = reduced; oks = oxidized; res = residual |

Acid extracted Mn (Mn-as) fraction concentration was lower than Mn-dd fraction. Mn-as concentration of Jasinga was 0.01%-0.08% with fluctuating distribution on soil horizon depth, while in Lebak was 0.03%-0.14% with fluctuating decrease distribution on soil horizon depth. The distribution of the Mn-as fraction in Jasinga soil accumulated in the soil depth of 0-35 cm and Lebak soil at a soil depth of 0-15 cm. Fe-as concentration is related to the amount of organic matter in the soil as lower organic matter discovered due to higher soil layer observed. Reduced Mn fractionation (Mn-Red) aims to observe the metal compound that binds to organic compounds. Mn-red concentration in Jasinga was 0.03%-0.11% with
decreased distribution on soil horizon depth, while in Lebak was 0.02%-0.33% with fluctuative increase distribution on soil horizon depth. The distribution of Mn-red fraction in Jasinga soil accumulates in the soil depth of 0-35 cm and Lebak soil at a soil depth of 70-120 cm.

Oxidized Mn (Mn-oks) fraction was observed in each acidic soil horizon with fluctuative decrease distribution. Mn-oks concentration in Jasinga was 0.08%-1.26%, while in Lebak was 2.68%-6.25%. The distribution of Mn-ox fraction in Jasinga soil accumulates in the soil depth of 0-35 cm and Lebak soil at a soil depth of 0-15 cm. Mn-oks is associated with the level of soil organic matter as organic matter concentration decreases due to deeper soil horizon observed.

![Figure 3](image)

**Figure 3.** Fraction distribution percentage of Mn in each acidic soil horizon (exc = exchangeable;asm = acid extracted;red = reduced;oks = oxidized;res = residual)

Residual fraction is the last stage of metal fractionation. Residual Mn (Mn-res) concentration in Jasinga was 98.29%-99.82% with fluctuative increase on soil horizon depth, while in Lebak was 93.25%-96.88% with increased distribution on soil horizon depth. [24] reported that only about 12-41% of Mn-res fraction in soil that could be extracted. Soil originated from Jasinga and Lebak was dominated by residual Mn fraction. According to [24] Mn concentration is related to the amount of organic matter and type of vegetation on the soil as Mn has weak capability to bind to organic compounds [29]. Residual (res) fraction aims to suspect highly stabilized crystalline mineral that is unavailable to plants, binding to aluminosilicate part as the last stage of metal speciation [26].

### 3.4 Soil Microbial Population

Table 4 shows that the total population of microbes and *Acidithiobacillus* sp. in each acidic soil horizon decreased as there was an increased value of soil pH and C-organic content. [25] stated that the growth and development of bacteria, one of which is affected by pH. Most bacteria grow in neutral pH range and fewer bacteria can grow at H ≤ 3, i.e. Acidophilic bacterial group bacteria, such as *Acidithiobacillus ferrooxidant* and *Acidithiobacillus thiooxidant* that can grow at pH 1.
Table 4. Total microbial and Acidithiobacillus in each acidic soil horizon

| Depth (cm) | Total microbial (cfu/g) | Acidithiobacillus,sp x 10^2 Apm.g^-1 |
|------------|-------------------------|--------------------------------------|
|            | Log cfu/g               |                                      |
| Jasinga    |                         |                                      |
| 0-35       | 800794.10               | 5.90                                 |
| 35-70      | 306240.43               | 5.49                                 |
| 70-100     | 515808.09               | 5.71                                 |
| 100-150    | 408891.53               | 5.61                                 |
| Lebak      |                         |                                      |
| 0-15       | 189415.04               | 5.28                                 |
| 15-40      | 32258.06                | 4.51                                 |
| 40-70      | 70652.17                | 4.85                                 |
| 70-120     | 22160.67                | 4.35                                 |

The existence of microbes in soil assists the biochemical process of organic matter as microbes produce enzymes to decompose the organic matter for nutrient source of plants. Microbes also has symbiotic relationship with plant roots that can aid the development and stability of the soil through the exudate production, secondary metabolic, and organic inputs as adhesives between organic and inorganic soil. Increased organic matter can be attributed to the increased microbial biomass and activity, producing extracellular polysaccharides that serve as a good soil sealing agent. Acidithiobacillus bacteria could conduct reduction reaction due to increased pH above the required pH, which was 3–4. According to [27] microbial population dynamics are caused by nutrient factors, humidity, soil aeration, temperature, pH, agricultural practices, fertilization, pesticide usage, and the addition of organic materials. [10] studied Acidithiobacillus ferrooxidant is an acidophilic microbe that grows in low pH environment.

4. Conclusion

Distribution of Al fraction of upper layer soil horizon taken from Jasinga and Lebak was dominated by highly stabilized amorphous Al fraction complex with fluctuative decrease of organic compound (Al-pCu) and amorphous inorganic Al fraction (Al-op) in the down layer. Furthermore, the distribution of Fe and Mn fractionation in acidic soil sample taken from Jasinga and Lebak sequentially in each soil horizon composed of: Fe-exc < Fe-as < Fe-Red < Fe-res < Fe-Oks, while Mn fraction concentration sequentially composed of: Mn-exc < Mn-as < Mn-Red < Mn-ok < Mn-res. In addition, the total population of microbes and Acidithiobacillus sp. in each acidic soil horizon were decreased along with changes in soil chemical properties in each acidic soil horizon.

5. References

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