Soil Characterization In Ex-Manganese Mining Land In North-Central Timor District, East Nusa Tenggara

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Abstract.
Manganese (Mn) mining in North Central Timor results in open land conditions that can change soil qualities. The aim of this study was to determine physical characteristics and chemical properties of the soil in the ex-manganese mining areas. The study was performed from June – September 2021. Soil characterization was carried out at selected locations where manganese mining was carried out both traditionally and using technology. The soil characteristics measured were texture, water content, bulk density, mass density, porosity, organic matter content, pH, cation exchange capacity (CEC), organic C, total nitrogen (N), total phosphorus (P), total potassium (K), and total Mn. The results showed that the physical characteristics of the soil on ex-Mn mining land from 5 villages in TTU, NTT are dominated by sand texture which results in low water content (3.39 - 9.46 %), soil porosity (14.96 - 59.31 %), and high bulk density (1.18 - 1.49 g cm-3). Characteristics of soil chemical properties showed low pH (< 7), organic matter (0.06 – 0.81%), organic C (0.03 – 0.22 %), total N contents (0.05 – 0.22%), and high total P (14.77 – 61.44 me 100 g^{-}), K (66.66 – 71.18 me 100 g^{-}), and Mn (18.802 – 24.055 ppm) contents. Land must be reclaimed Reclamation can be done by land management, top soil conservation, planting pioneer crops or cover crops.

Keywords: *soil physics, soil chemical,and mining.*

I. INTRODUCTION

Mining is an important sector contributing to Indonesia’s foreign exchange earnings. Manganese mining is generally used as material to produce dry batteries. Moreover, Mn from Indonesia is known worldwide for its premium quality, especially Mn originating from East Nusa Tenggara (NTT). Data of Ministry of Energy and Mineral Resources of the Republic of Indonesia; around 60% of Indonesia's resources and 90% of Mn reserves are in East Nusa Tenggara, with details of total ore resources of 36,207,271 tons and 17,206,234 tons of metal and total ore reserves of 79,712,386 tons and 38,998,324 tons of metal (1). Mining is also carried out in the district of Timor Tengah Utara (TTU). Manganese mining in TTU has been booming since the opening of a Mn mining company in 2010. Since then, many people have been mining Mn traditionally. Generally, people mine by digging and then directly selling it in the form of raw material. The community mines Mn selectively because of the random and uneven distribution of Mn deposits in TTU (2).The existence of manganese mining activities may change the nature and characteristics of the soil (3). Manganese excavation leaves land in an open condition and may cause land degradation such as landscape damages, physical properties damages, mixing of tillage layers and subsoil, low organic matter, and exposure of toxic layers (4).

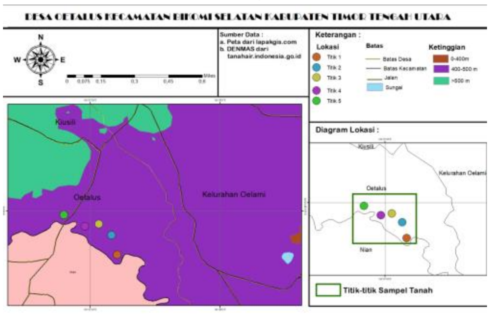
Mining activities in the TTU district leave ex-mining holes that are inundated with water as well as piles of excavated products and leaching of materials containing Mn. As a result, there are no plants that live on the ex-mining land, which indicates that there is a decline in land quality. In addition, the impact of mining causes changes in the landscape, damage to the physical and chemical properties of the soil caused by excavating topsoil, changing the microclimate, affecting the performance of hydraulic functions in the soil, and low land productivity and changes in the distribution of microorganisms (5–9).Extensive mining areas either with technology or traditional have an impact on the wider critical land that should be used for other activities such as converting it into agricultural land or reforesting the area. This decision must be based on the efforts made in restoring the land which can be started by carrying out reclamation activities.

Reclamation is must be done by mining companies according to Article 4 Paragraph 1 that (10) requiring mining companies to carry out reclamation. Reclamation involves many efforts that must be made starting from knowing the character of the land after mining, determining reclamation efforts, rearranging topographic construction and regrading or resloping of ex-mining holes (landscaping) (11).

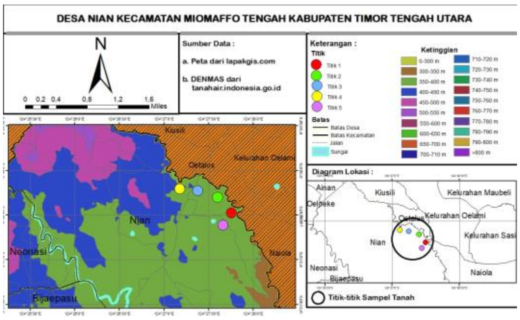
In addition, the material added to the topsoil, soil amendment, revegetation, water flow regulation, maintenance and monitoring should be determined. Before determining reclamation and revegetation, the first step is to know the character of the land through testing the physical and chemical properties of the post-mining soil. Based on these tests, a decision will be made on the next steps to be taken. Until now, there is no detailed information on the character of the ex-Mn mining land, even though this is very important as a reclamation consideration. The important key to determining the reclamation of ex-mining land to become productive land must be done by knowing the dynamics of physical, chemical and biological changes in the land (12). In addition, this study can inform the surrounding community about the condition of the ex-mining land which may contain pollutant substances that are harmful to human health, both from water used for drinking needs, agricultural products containing metals, and livestock drinking water from ex-mining holes. The purpose of this study was to determine the characteristics of soil physical and chemical properties on ex-manganese mining land in TTU district, NTT province as the basis for determining reclamation for Mn mines.

II. METHODS

The study was conducted in June – September 2021 on a former manganese mining area in TTU. Characterization was carried out at selected locations that have experienced manganese mining both traditionally and using technology. The location sites were Oetalus (Pic. 1), Nian (Pic. 2), Oelami (Pic. 3), Tublopo (Pic. 4), and (Pic. 5) villages.



Picture 1



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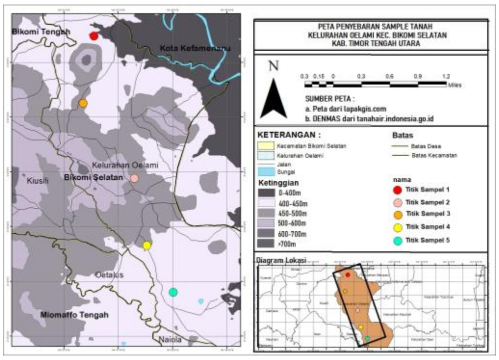

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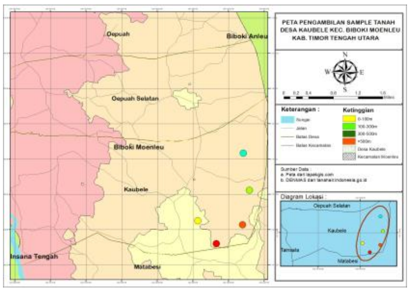

Picture 5

Then the soil samples were tested at the Integrated Laboratory of the Faculty of Agriculture, University of Timor, and the Soil Laboratory of the Faculty of Agriculture, University of Nusa Cendana. The condition of the observation site is characterized by dry land with high lime content. The study stages were started from the site survey, determining the location of the observation points, taking and testing samples. The location of sampling on ex-mining land technologically has a total area of 1 hectare. From these locations, 5 sampling locations by purposive sampling and were determined based on the number of mining locations selected by the community in the village. The principle of determining the sampling location was representative of the area under study using the proportional method. Soil sampling was based on disturbed and undisturbed soil samples. A sampling of disturbed soil was carried out by taking the tillage layer (30 cm from the surface) using a soil drill then composited into individual soil samples. The weight of each sample was 500 g. A sampling of undisturbed soil was carried out using a sample ring with an average diameter of 7.4 cm and an average width of 4 cm. The sample ring was pressed into the ground and the bottom was cut, the sample was leveled according to the height of the ring then closed to the top and bottom of the sample ring. Soil testing was observed based on the physical and chemical properties of the soil namely:

Texture of 3 Fractions

Determination of soil texture was carried out using the Hydrometer method by weighing 25 g of air-dried soil and then put into a 250 mL Erlenmeyer tube, added 50 ml of sodium pyrophosphate solution and then shaken so that the solution blended and then allowed to stand for 24 hours. Then the solution is poured into a measuring cup measuring 500 mL and added with distilled water. The sample was shaken 30 times (amyl alcohol was added to remove the foam). Shaking for 40 seconds and then put into the hydrometer for the first reading, In the next 3 hours put the sample into the hydrometer for the second reading, then determine the percentage of clay, silt and sand with the following formula:

$$\%\ (\text{Clay} + \text{Silt}) = \frac{\text{Hydrometer Reading After 40 Seconds}}{\text{Weight of Soil Sample}}\ \text{X}\ 100\%$$

$$\%\ \text{Clay} = \frac{\text{Hydrometer Reading After 3 Hours}}{\text{Weight of Soil Sample}}\ \text{X}\ 100\%$$

$$\%\ \text{Sand} = 100 - \%\ (\text{Silt} + \text{Clay})$$

$$\%\ \text{Silt} = \%\ (\text{Clay} + \text{Silt}) - \%\ \text{Clay}$$

The percentages of clay, silt and sand are then connected with the United States Departement of Agriculture (USDA) soil triangle to obtain the soil texture for which the soil sample is tested.

Soil Water Content

Weighing 10 g of air-dried soil and then placing it in an oven at 103°C for 24 hours. The soil was put in a desiccator containing silica gel for 10 minutes until the weight was constant. Soil water content is obtained through calculations using the following formula:

$$\text{Soil water content} = \frac{\text{Weight of Air Dry Soil} - \text{Weight of Dry Soil After Oven}}{\text{Weight of Dry Soil After Oven}}\ \text{X}\ 100\%$$

Bulk Density

Testing using the sample ring method. Weigh the sample ring weight before use (Y grams). Weigh the whole soil sample with the soil sample ring (X grams). The soil water content is determined by following the procedure for measuring soil water content. Before looking for bulk density, first find the volume of the soil with the formula: V =¼πd^2 t. The bulk density is then obtained using the following formula:

$$\text{Bulk Density} = \frac{\text{Soil Weight}}{\text{Soil Volume}}\ \mathbf{g\ cm^{-3}}$$

Particel Density

The empty volumetric flask was weighed and then filled with air dry soil of about 50 g. Weighed the measuring flask containing the soil and corrected for the moisture content of the soil. Added about half of the water while rinsing the soil attached to the neck of the pumpkin. Heat the volumetric flask for a few minutes to expel the air inside. Cool the pumpkin and its contents until it reaches room temperature, then add cold water that has been boiled to the volume limit, then weigh the flask (g). Remove the contents of the measuring flask and wash, then fill with cold water that has been boiled to the volume limit. Calculate the particle density value with the following equation:

$$\text{Particel Density} = \frac{\text{Soil Weight}}{\text{Soil Volume} - \text{Pore Space Volume}}\ \text{g cm}^{-3}$$

Soil Porosity

Soil porosity is determined based on the following equation:

$$\text{Total Soil Pore Space} = 1 - \frac{\text{BD}}{\text{PD}}\ \text{X } 100\%$$

Information: BD (*Bulk Density*); PD (*Particel Density*)

Organic Matter and Organic C Content

Testing using the Walkey and Black method. Weigh 0.5 g of soil that has passed a 0.5mm sieve (0.25g for high organic matter and 0.1 for organic matter) into a 500 mL Erlenmeyer flask. Pipette 10 ml of K2Cr2O7 1N was added to the Erlenmeyer flask. Add 20 mL of concentrated H_2SO_4 to the Erlenmeyer flask and then shake it so that the soil reacts completely. Leave the mixture for 30 minutes. The addition of H_2SO_4 was carried out in an acid chamber. A blank (without soil) is worked in the same way. Then the mixture was diluted with 200 mL H_2O and add 10 mL of 85% H_3PO_4, add 30 drops of Diphenylamine indicator. Titrate with 1N $FeSO_4.7H_2O$ through the burette. The titration was stopped when the color changed from dark to bright green. Likewise with blanks.

$$\text{Organic Matter} = \frac{1{,}724\ \text{x}\left((0{,}45\ \text{x}\ \text{b}) - 0{,}4\right)}{\text{Oven Dry Weight}}\ \text{x}\ 100$$

$$\text{Organic C} = \frac{\text{Oven Dry Weight}}{1{,}724}\ \text{x}\ 100$$

pH

Weigh 10 g of air-dried soil that has passed a 2 mm sieve and then put it in a plastic bottle. Add 10ml Aquadest (for pH determination H_2O). Weigh 10 g of air-dried soil that has passed a 2 mm sieve and then put it in a plastic bottle. Add 10 ml of 1N KCl (for pH determination of 1N KCl). Shake with a shaker for 60 minutes then measure using a pH meter that has been calibrated with buffer solution pH = 4 and pH = 7. (note the pH displayed on the pH meter).

Cation Exchange Capacity (CEC)

Tests using a buffer solution of NH4OAc pH 7.0. Weigh 2.5 g of soil and place it into a percolation tube. Add 50 mL of CH3COONH4 1 N pH 7. Wash the soil in the percolation tube with 80% alcohol until the soil solution is free of NH4+ (To determine NH_4^+ is free, use Nesler's reagent; if percholate+ Nesler's reagent is red/yellow, it means that NH_4^+ is still present, but if it is colorless then NH4+ is free). When the NH_4^+ is free from the soil solution, add it by collating a solution of 50 mL of 10% acid NaCl; The percholate was collected in a 50 cc volumetric flask and filled with H_2O to a volume of 50 mL. Pipette 20 mL of percholate from a volumetric flask and place it into a distillation tube and add 50 mL of H_2O. Then place it in the distillation apparatus. In the distillation apparatus, add 15 mL of 40% NaOH to parkolate. The results of the distillation were accommodated in a 250 cc erlenmeyer containing 25 mL of 4% H_3BO_3 and 2 drops of methyl red indicator or mixed indicator. Distillation is considered complete if there is a change in the color of the distillate solution and the volume has been ± 75 mL. Titrate the distillate with 0.1 N HCL; until the color of the solution returns to its original color (before distillation). Calculated by the equation:

$$\text{KTK (me 100 g}^{-}) = \frac{\text{mL Blanko} - \text{mL Sx N NaOh}}{\text{Oven Dry Weight}} \text{ X } 100\%$$

Total N Content

Testing using the Kjeldahl method. Procedure : weigh 2 g of soil sample, place it into the digester tube. Add 2 g of the mixed catalyst (as much as the soil sample) and add 10 ml of H20, then add another 10 ml of the salicylic acid H_2SO_4 mixture. Leave 1 night. Digestion in a digestor (Kjeldhaltherm) at low temperature and gradually increased until the solution is clear/white. (Temperature < 200^oC). After the solution was clear the temperature was raised and continued for 30 minutes. Cool and dilute by adding 15 mL H_2O. Place the destruction tube on the distillation apparatus. Pipette 25 mL of 4% H_3BO_3, place in a 250 cc erlenmeyer and add 3 drops of mixed indicator, and place it as a container for the distillation results. Add 40% ± 25 mL NaOH to the distillation tube and immediately distillate. Distilled ammonia will be accommodated in an erlenmeyer containing H_3BO_3. Distillation was stopped when the solution in the Erlenmeyer turned green and the volume was ± 75 mL. Transfer the distillation erlenmeyer and titrate with 0.02 N HCl. The end point of the titration is indicated by a color change from green to red.

$$\text{N (\%)} = \frac{mL\ HCl\ x\ NHCl\ x\ 14\ x\ 100}{Soil\ Weight\ x\ 1000}$$

Total P and K Content

Testing using 25% HCl extract. Dilute 675.68 ml of concentrated HCl (37%) with ionized water to 1 L. Concentrated P reagent. Dissolve 12 g $(NH_4)6\ Mo7O24.4H_2O$ with 100 ml of deionized water in a 1 L volumetric flask. Add 0.277 g K (SbO)C4H4O6 0.5 H_2O and slowly 140 ml concentrated H_2SO_4. Make 1 L with ionized water. Coloring reagent P. Mix 1.06 g of ascorbic acid and 100 ml of concentrated P reagent, this P reagent must always be made fresh. Parent standard 1000 ppm PO4 (Titrisol). Transfer quantitatively the PO_4 Titrisol mother liquor in the ampoule to a 1 L volumetric flask. Squeeze with ionized water up to the line mark, shake. Parent standard 200 ppm PO_4. Pipette 50 ml of PO_4 parent standard 1000 ppm titrisol into a 250 mL flask. Squeeze with ionized water up to the line mark then shake. Parent standard 1000 ppm K (Titrisol). Transfer quantitatively the standard solution of K Titrisol mother in the ampoule to a 1000 mL volumetric flask. Squeeze with ion-free water up to the line mark then shake.

Standard 200 ppm K. Pipette 50 ml from the parent standard 1000 ppm K into a 250 mL volumetric flask. Squeeze with ionized water up to the line mark then shake. PO4 standard series (0; 4; 8; 16; 24; 32 and 40 ppm). Pipettes in a row 0; 2; 4; 8; 12; 16 and 20 mL of standard 200 ppm PO_4 into a 100 ml volumetric flask. Each was added 5 mL of 25% HCl and ionized water up to the line mark and then shaken. K standard series (0; 2; 4; 8; 12; 16; and 20 ppm) Pipettes 0; 1; 2; 4; 6; 8; 10 mL of standard 200 ppm K into a 100 ml volumetric flask. Each was added 5 mL of 25% HCl and ion-free water up to the line mark and then shaken. Weigh 2,000 g of soil sample size < 2 mm, put into a shaker bottle and add 10 mL of 25% HCl then shake with a shaker for 5 hours. Put in a test tube left overnight or centrifuged. Pipette 0.5 mL of the clear extract sample into a test tube. Add 9.5 ml of deionized water (20 x dilution) and shake well. Pipette 2 mL of aqueous sample extract and standard series were each put into a test tube, then 10 mL of P dye reagent solution was added and shaken. Leave for 30 minutes, then measure the absorbance with a spectrophotometer at a wavelength of 693 nm. For potassium, aqueous sample extracts and K standard series were measured directly with a flamephotometer. Calculation:

Potential P level mg P_2O_5 $(100\ g)^{-1}$
= ppm curve x (ml extract /1.000 mL) x (100 g/g sample) x fp x (142/90) x fk
= ppm curve x 10/1.000 x 100/2 x 20 x 142/90 x fk
= ppm curve x 10 x 142/190 x fk
Potential K level mg K_2O $(100g)^{-1}$
= ppm curve x 10 x 94/78 x fk

Information: ppm curve = sample rate obtained from the curve of the relationship between the standard series grade and its reading after corrected for blanks; fk = correction factor of water content = 100/(100 – % water content); fp = dilution factor (20); 142/190 = PO_4 to P_2O_5. form conversion factor ; 94/78 = conversion factor of the form of K to K_2O.

Total Mn content

Procedure. Weigh 10.00 g of fine soil sample < 2 mm. Add 20 ml of DTPA extracting solution, shaken with a shaker for 2 hours. The suspension was filtered or centrifuged to obtain a clear extract. Measure each element with the AAS tool. Calculation :

Elemental content (ppm)
= ppm curve x ml extract 1.000 ml^{-1} x 1.000 g $sample^{-1}$ x fp x fk
= ppm curve x 20 1.000^{-1} x 1.000 10^{-1} x fp x fk
= ppm curve 2 x fp x fk

III. RESULT AND DISCUSSION

The results of the physical characteristics test of the ex-manganese mining soil in 5 (five) villages in North-Central Timor can be seen in Table 1. Table 1 shows that the soil texture at all observation locations is loamy sand with Bulk density in the high to very high category. Compared to unmined soil, the sand particles in the mined soil will increase and produce a large percentage of sand fraction (13). The composition of the tailings texture is dominated by the sand fraction with a composition of 98%, 0.6% silt, and 1.3% clay (14). Nian and Kaubele villages have very high bulk density, while Oelami and Tublopo villages have high bulk density, and Oetalus has medium bulk density. Soil bulk density is a description of the density of the soil that compares the dry weight of the soil with the pore volume of the soil. High bulk density may occur because of heavy tillage by creating soil piles from top to bottom (13). High bulk density on ex-mining land may also be caused by heavy equipment activity during topsoil placement (15). The higher the bulk density of the soil, the denser the soil, and the denser the soil, the harder it is for water or plant roots to penetrate.

Soil porosity at all locations observed was in the low category except in Oetalus village. This causes the bulk density of soil in Oetalus village to be medium category. However, not in other villages that are included in the high and even very high category. High bulk density on ex-tin mining land is caused using heavy equipment for a long-time during mining activities which have an impact on decreasing soil porosity (7). Related to soil density, Oetalus village has a good density but not for other villages. Soil density is generally assumed to be around 2.66 $g.cm^{-3}$ (16), humus around 1.3 – 1.5 g cm^{-3}, and gypsum 2.3 – 2.4 $g.cm^{-3}$ (17). Oetalus village has a soil mass density of 2.90 g cm^{-3}. Soil in the villages of Nian, Oelami, Tublopo, and Kaubele have low particel density, although compared to the mass density of gypsum and humus. Particel density is closely related to the mass density which determines the total pores in the soil. Low porosity will affect the increase in bulk density of the soil. Porosity is the part of the soil volume (in percent) that is not occupied by soil solids. Mining that changes the topography of the land greatly affects the density of the soil so that it dominates the soil mass density at the location being observed tends to be lower. Soil excavation also reduces pore space, whereas soil porosity is an indicator of drainage and aeration quality. Porosity can be affected by soil bulk density and soil organic matter content. Soils with high porosity tend to have low soil bulk density (18). However, in fact, in this study, the opposite happened. It is suspected that the soil texture in this study was dominated by the sand fraction, causing the soil to be low in density and make the soil not being able to store water.

Table 1. Physical characteristics of the ex-manganese mining soil in TTU

No	Sample	Texture (%)			Texture class	Soil Water Content (%)	Bulk Density (BD) (g cm^{-3})	Particel density (g cm^{-3})	Soil Porosity (%)
		Sand	Silt	Slay					
1.	Oetalus	80,00	14,67	5,33	Loamy sand	9,46l	1,18m	2,90h	59,31m
2.	Nian	84,22	14,88	6,12	Loamy sand	7,29l	1,45vh	1,94l	25,25l
3.	Oelami	81,33	10,67	8,00	Loamy sand	8,61l	1,25h	1,47l	14,96l
4.	Tublopo	74,00	20,67	5,33	Loamy sand	3,39vl	1,32h	1,85l	28,64l
5.	Kaubele	79,00	14,88	6,12	Loamy sand	8,90l	1,49vh	1,76l	15,34l

Note: m: medium; l: low; vl: very low; h: high; vh: very high

The low content of organic matter in the soil may also be caused by tillage (Table 2). Organic matter that is abundant in the topsoil will be greatly reduced in extreme tillage. Mining activities result in excavation of the soil to the deep which causes piles of excavated soil to reveal the sub soil to the top layer and change the top layer to the bottom. The condition of low organic matter and decreasing after mining is the result of the lifting of the top layer which causes the humus to also move downwards (19).Manganese mining in TTU also causes loss of vegetation which causes no contribution of soil biomass from plants above the ground. In fact, plant biomass can increase the C-organic content and can reduce soil bulk density accompanied by an increase in soil porosity and have a positive effect on the constant infiltration rate of the soil (20,21). The presence of vegetation contributes to litter production and soil microbial activity (7,22).

Table 2 shows that the total Mn in the soil is in a very high category which causes no vegetation grow in the area. Soil usually contains 20 – 3000 ppm of Mn, with an average of 600 ppm (23). Soil is deficient Mn if its content is below 20 ppm, and the soil will be poisoned by Mn if the Mn content is more than 3000 ppm. High Mn may reduce soil pH while increasing pH due to liming will reduce Mn in the soil (24). Observations of locations with dry land dominated by sand showed a soil pH range of 4.5 – 6.7 (25). Mining activities will result in sulfide oxidation which can also lead to low soil pH (26). Moreover, a high sand fraction can also cause low soil pH (14,27).

Table 2. Soil chemical characteristics of manganese mining in TTU

No	Sample	pH	CEC (me/100 g)	Organic matter (%)	Organic C (%)	Total N (%)	Total P (me 100 g$^-$)	Total K (me 100 g$^-$)	Total Mn (ppm)
1.	Oetalus	6,63n	31,27h	0,09vl	0,05vl	0,07vl	14,77l	66,664vh	18.802vh
2.	Nian	6,75n	32,08h	0,13vl	0,07vl	0,10l	23,10m	68,702vh	24.055vh
3.	Oelami	6,23l	33,46h	0,81vl	0,22vl	0,22m	61,44vh	71,189vh	19.089vh
4.	Tublopo	5,59vl	32,93h	0,16vl	0,10vl	0,13l	31,87h	70,236vh	19.177vh
5.	Kaubele	5,49vl	30,95h	0,06vl	0,03vl	0,05vl	9,44vl	67,234vh	19.623vh

Note: m: medium; n: neutral; l: low; vl: very low; h: high; vh:very high

Organic C and total N contents in the soil were low. This is related to the low content of soil organic matter (Table 1). Changing the top layer to the bottom layer and vice versa may lead to low availability of N. Meanwhile, mineralization of N may occur if there is a decomposition of organic matter in the soil. In addition, N is very easily leached off when the rainy season. The low level of mineralized organic N and the low level of mineralization may lead to low N in the mined soil (13). Observation of total N soil showed the N content of 0.02 – 0.18% (very low) on mining land in Talawan village compared to unmined land (28). The role of soil microbes in fixation can also provide N. However, mining conditions will reduce soil microbial populations. The existence of mining will inhibit the growth of microorganisms in the soil (29). The loss of vegetation due to mining will also reduce biomass and lead to a reduction in the organic C content in the soil. One of the sources of organic C in the revegetation area comes from the vegetation litter, which is highly dependent on the type of vegetation component (30). Another impact of mining activity is the decrease in organic C and N contents in the soil (31). Soil accumulation due to mining reduced organic C compared to unmined soil, which is in the range of 0.26 -0.38 and reduces N in the soil in the range of 0.01 – 0.03% (13). The chemical fertility of sand tailings in ex-tin mining areas was low with very low total N, as well as in quartz tailings the total N content was in the range of 0.67 (32,33).

The total P of the soil in the observation locations showed varying results. The low total P content in Oetalus and Kaubele villages is thought to be the result of low organic matter. Provision of total P may be obtained from the P mineralization process involving organic matter. In addition, the result of mining causes leaching and removal of topsoil which causes the low P content of the soil. The high available P is caused by a combination of organic P mineralization from compost, soil fertilizer, and high organic matter (34). The chemical fertility of sand tailings on ex-mining land is low, indicated by very low P_2O_5 and in quartz tailings, the available P content is 0.9 mg. kg- which is also low (32,33). Observations from other villages such as Tublopo and Oelami showed P in the high and very high categories, this is also because the location is often used for livestock and agricultural activities. In Tublopo village, many livestock is free ranged around the excavation areas, the presence of livestock manure is one source of supplying P. Observations in Oelami village showed that the land was previously used for agricultural activities to meet the community's food. The existence of agricultural activities provided additional inputs such as manure and other types of P fertilizers. In these two villages, the plants that grow leave litter such as roots, stems, leaves of plants. This may increase P mineralization in the soil. The loss of P is due to mining activities which cause the soil solum to be shallow and without topsoil resulting from the process of dredging, stockpiling, mixing, and compacting with heavy equipment (19). Manure produces organic acid which forms chelate compounds with free Al^{3+} in the soil so that the exchangeable Al^{3+} decreases and there is a relationship between exchangeable Al and available P, namely by decreasing exchangeable Al it will increase the available P of the soil. The more Al^{3+} ions hydrolyzed, the more H^{+} ions donated, and the soil is more acidic. The decrease of exchangeable Al amount due to the addition of organic matter in the soil may increase the amount of available P (35).

In this study, K in ex-mining land at all observation locations is in the very high category. The high value of K is related to by high CEC values (36). The higher the K cation in the soil, the higher the CEC value. In general, a high soil CEC is influenced by high organic matter and high clay contents. In this study, all the observed soils had a very high CEC. Another factor that affects the CEC is the cation charges obtained from the minerals in the soil. Potassium and Mn are high cations in this study, thus it may affect the high CEC. The number of base cations that can be exchanged affects the CEC value, where if the base cation is high then the CEC value becomes high and vice versa (37). In addition, NTT is known to have dry land and climate. The area of East Nusa Tenggara (NTT) is mostly dry land that has a hilly nature with a dry climate. The dry climate is influenced by monsoons and has short rainy periods. The dry season is longer, which is ± 8 months (April to November), while the rainy season is only 4 months (December to March) (38). The soil characteristics of the Mn ex-mining land indicate that the land must be reclaimed to recover after mining activities. Reclamation can be carried out through top soil conservation activities, adding soil amandemends, land management, erosion control, and planting pioneer crops or cover crops. Furthermore, the use of ex-mining land can be determined as productive land, both as forests, agricultural activities, and others.

IV. CONCLUSION

The physical characteristics of the soil on ex-Mn mining land from 5 villages in TTU, NTT are dominated by sand texture which results in low water content (3.39 - 9.46 %), soil porosity (14.96 - 59.31 %), and high bulk density (1.18 - 1.49 g cm-3). Characteristics of soil chemical properties showed low pH (< 7), organic matter (0.06 – 0.81%), organic C (0.03 – 0.22 %), total N contents (0.05 – 0.22%), and high total P (14.77 – 61.44 me 100 g^{-}), K (66.66 – 71.18 me 100 g^{-}), and Mn (18.802 – 24.055 ppm) contents. land must be reclaimed reclamation can be done by land management, top soil conservation, planting pioneer crops or cover crops.

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