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Vegetation and Seed Banks on Ex-manganese Mining in Kaubele Village Biboki Moenleu District

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ABSTRACT

Mining activities are required to carry out reclamation. Reclamation efforts are aimed at restoring the condition of the mined land. The manganese mine in Kaubele Village has been carried out since 2011 but there has been no clear reclamation effort, causing the land to be abandoned. The study aimed to determine the vegetation and seed banks found on former manganese mining land in Kaubele Village, Biboki Moenleu District. This activity was carried out in July - December 2022 on former manganese mining land in 2010 and 2018. Vegetation was collected using a purposive sampling method. At each observation location, 5 main points were taken. Each point at each location is spread by 250 points with a 2 m x 2 m plot. The soil was taken at a depth of 0-20 cm and an area of 30 cm x 30 cm. Furthermore, it is placed in the nursery media for 3 months to find out the vegetation that grows. Vegetation and seed banks were analyzed based on species density, relative density, species frequency, relative frequency, and important value index. Vegetation analysis is a step in determining plants to restore ex-mining land. The vegetation in 2018 had more species compared to 2010. At both locations, there were the same 3 plants, namely *Cynodon dactylon* L. with an IVI of 21.421% (2010) and an IVI of 17.605% (2018), *Chromolaena odorata* L. with an IVI of 10.409% (2010) and IVI of 9.125% (2018), and *Malvella leprosa* (Ortega) krapov. with an IVI of 8.097% (2010) and an IVI of 7.031% (2018). Analysis of seed banks shows that there are 7 similar seeds found in different mining locations with respective IVI of *Dactyloctenium aegyptium* L. 78.550 % (2010) and 14.169 % (2018), *Chloris virgata* Trin 13.113 % (2010) and 8.986 % (2018), *Panicum virgatum* L. IVI 20.384 % (2010) and 46.834 (2017). (2018), *Synedrella nodiflora* L. IVI 22.068 % (2010) and 14.169 (2018), and *Phyllanthus urinaria* L. IVI 13.177 % (2010) and 12.957 % (2018).

Keywords: accumulator; important value index; reclamation efforts.

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INTRODUCTION

Mining is an important sector for the country's foreign exchange earner. The mining of manganese is generally used as material for the production of dry batteries. Manganese from Indonesia is known to have premium quality in the world, especially manganese from East Nusa Tenggara (NTT). Approximately 60% of Indonesia's manganese resources and 90% are located in East Nusa Tenggara, with details of total ore resources of 36,207,271 tons and metals of 17,206,234 tons, and total ore reserves of 79,712,386 tons and metals of 38,998,324 tons (Kementerian ESDM, 2017). Mining is also carried out in the district of Timor Tengah Utara (TTU). Mining of manganese in TTU has started to flourish since the opening of a manganese mining company in 2010. Since then, the community has been carrying out traditional mining of manganese. Generally, people do this by digging and then selling it in raw form. The community mines manganese selectively because of the random and uneven distribution of manganese deposits in TTU (Seran & Edi, 2021).

Kaubele Village is one of the manganese mining locations in TTU that uses technology. Mining began in 2011 with a total area of ± 700 ha. Land that has been mined as much as 15 hectares. Mining is carried out openly, causing changes in land conditions to become critical. Land conditions have changed the existence of existing flora and fauna. Reclamation efforts are important to improve the condition of ex-mining land. Mining reclamation is mandatory (Patiung et al., 2011). Pasal 4 Ayat 1, Peraturan Pemerintah (PP) about Reklamasi dan Pascatambang (2010) requires mining companies to carry out reclamation. Reclamation involves many efforts that must be made starting from knowing the character of the land after mining and determining reclamation efforts (Iskandar et al., 2012). Reclamation efforts start from the revegetation or replanting stage. Revegetation can be started from the analysis of vegetation that is able to grow and can restore the condition of the land from the former mining land itself. This is the natural ability of the land to recover but requires a longer time compared to producing seeds with the selection of the ability to grow faster in restoring former manganese mining land. The existence of seed banks makes it possible for plants to exist which are in a state of dormancy but which have the potential as plant candidates to be used as land remediators.

Revegetation efforts need to pay attention to the types of plants selected and the conditions for growing plants with land conditions, so that reclamation success criteria can be achieved (Setyowati et al., 2017). The selection of plants that are adaptive, suitable, and in accordance with the characteristics of ex-mining land is also the main key in determining the success of the process of reclamation of ex-mining land. Such conditions will also make the program run economically, effectively, and efficiently (Taqiyuddin & Hidayat, 2020). Identification of plants that are able to grow for the first time after mining is very important to determine plants that can support the success of reclamation. These plants are called pioneer plants that have experienced succession. Pioneer plants have a high ability to adapt to disturbed environments (Pramuseto et al., 2020). This is the basis for knowing the vegetation and seed banks on former manganese mining land in Kaubele Village. This activity can be a recommendation for miners and the government to use what type of plants on former manganese mining land so that the land returns to its function.

MATERIAL AND METHODS

Research has been conducted on former manganese mining land in Kaubele Village (Picture 1). The research was conducted from July to December 2022. The tools used were GPS, tape measure, raffia rope, camera, and stationery. Materials used are flora books, soil as samples for analysis of seed banks, and plastic bags. Vegetation observations were carried out in 2 locations in 2010 and 2018 (Picture 2). Each location is taken 10% of the total area. Vegetation sampling using a purposive sampling method. At each observation location, 5 main points were taken. Each point at each location is spread by 250 points with a 2 m x 2 m plot.

Vegetation collection is done by uprooting intact and complete plants. Soil sampling at each observation location at the same time as the vegetation observation location. The soil was taken at a depth of 0-20 cm and an area of 30 cm x 30 cm. Furthermore, it is placed in the nursery media for 3 months to find out the vegetation that grows. Vegetation analysis was carried out based on the Flora book and then calculated density (D), relative density (RD), frequency (F), and relative frequency (RF) and Important Value Index (IVI) using the formula.

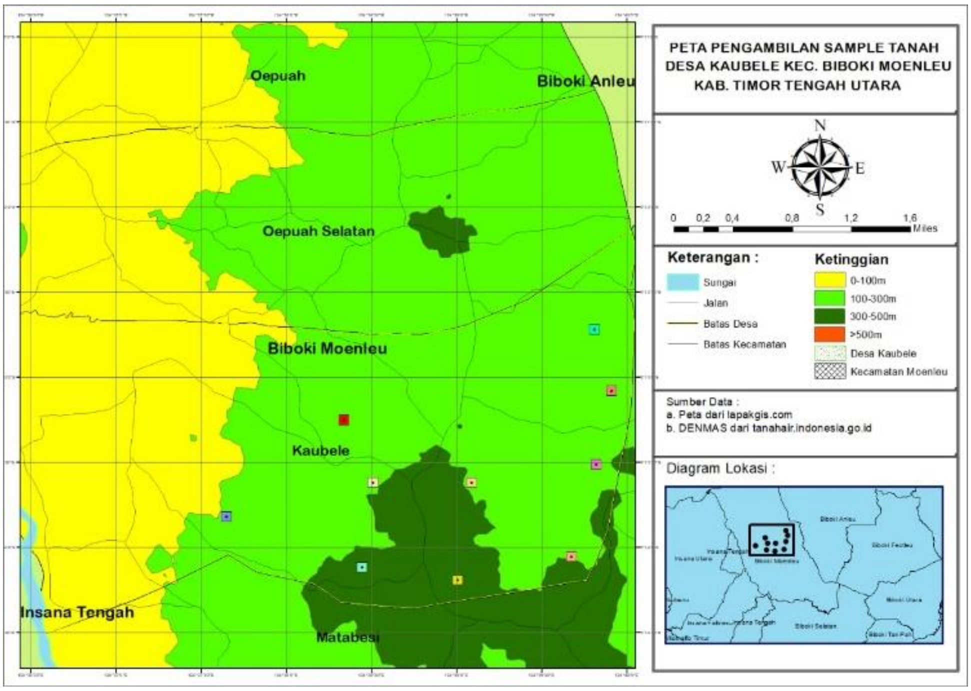
$$\text{Density (D)} = \frac{\text{Number of individu}}{\text{Sampling area}}$$

$$\text{Relative Density (RD)} = \frac{\text{Density of certain species}}{\text{Sum density of all spesies}} \times 100\ \%$$

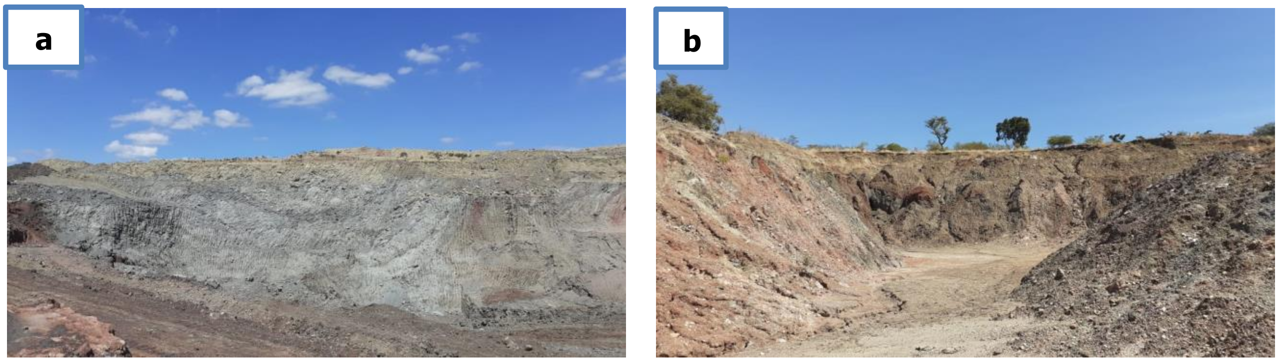
$$\text{Frequency (F)} = \frac{\text{Number of observation plot for a typ}}{\text{Total Observation Plot}} \times 100\ \%$$

$$\text{Relative Frequency (RF)} = \frac{\text{Relative frequency of certain spesies}}{\text{Sum relative frequency of all spesies}} \times 100\ \%$$

Important Value Index (IVI) = Relative Density (RD) + Relative Frequency (RF)



Picture 1. Observation Location Map



Picture 2. Mining Locations in 2010 (a); Mining Locations in 2018 (b)

RESULTS AND DISCUSSION

Vegetation on Former Manganese Mine Land in Kaubele Village

Based on the results of the analysis of vegetation on ex-mining manganese land in Kaubele Village (Table 1), there are 2 different locations of ex-manganese mines, namely mining in 2010 and 2018. Table 2 shows the results of the analysis of vegetation on ex-mining land in 2010. Based on observations, it is known that 12 species are growing on former manganese mining land in 2010. There were 6 plants of 12 species with IVI values above 15%. *Cyperus rotundus* L. had the highest IVI value with a value of 34.291%, *Paspalum distichum* L. 28.749%, *Panicum virgatum* L. 26.781%, *Digitaria sanguinalis* L. Scop 25.175%, and *Cynodon dactylon* L. 21.421%; and *Jatropha gossypifolia* L. 18.414 %.

Based on the results of vegetation analysis on ex-manganese mining land in Kaubele village in 2018, 23 species were found (Table 2). From Table 3 it is known that 6 plants from 23 species were found with IVI values above 15%. *Calotropis gigantea* L. Dryand as a plant that has the highest IVI value of 21.046%, *Ziziphus mauritiana* Lam 20.219%, *Corchorus olitorius* L. 17.873%, *Cynodon dactylon* (L.) Per 17.605%, *Xanthium strumarium* L. 17.023%, and *Typha angustifalia* L. 15.919%.

In ex-mining land, it is important to carry out a vegetation analysis as a step in determining plants to restore the land. At this research location, it was known that the total Mn in Kaubele village was 19.623 ppm (Tobing et al., 2022). Usually, in the soil there is Mn with an average of 600 ppm and poisoning will occur if it is more than 3000 ppm (Lindsay, 1980). In general, the vegetation on the mine land in 2018 had more species than in 2010. At both locations, there were the same 3 plants, namely *Cynodon dactylon* L. 21.421% in 2010 and 17.605% in 2018, *Chromolaena odorata* L. 10.409% in in 2010 and 9.125% in 2018, and *Malvella leprosa* (Ortega) krapov. 8.097% in 2010 and 7.031% in 2018. *C. dactylon* is a plant that is classified as grass. The results of the inventory show that the ability of this plant to live is quite good on former manganese mining land. This is presumably the ability of *C. dactylon* to accumulate Mn found in former manganese mining areas. *C. dactylon* is the dominant species that grows in ex-mining sites even though its accumulation has not exceeded the concentration of Mn in the plant (>10,000 mg kg−1 Mn or Zn) (Kumar et al., 2017). However, other studies have shown that *C. dactylon* has the potential as a phytoremediation because it can tolerate and accumulate metals in relatively high amounts (Sabo & Iadan, 2018). *C. dactylon* colonized naturally found in heavy metal-contaminated land in Tandil City, Argentina (Albornoz et al., 2016), manganese mining area and antimony mining area in Hunan Province; China (Xue et al., 2014; Yang et al., 2014). The use of *C. dactylon* inoculated with arbuscular mycorrhizal fungi has the potential to restore vegetation on ex-metal mining land (Zhan et al., 2019).

Table 1. Vegetation on Former Manganese Mine Land in 2010

Species	Total	D	RD (%)	F	RF (%)	IVI (%)
Cynodon dactylon L.	74	0.019	12.231	0.136	9.189	21.421
Malvella leprosa (Ortega) krapov	31	0.008	5.124	0.044	2.973	8.097
Ballota nigra L.	20	0.005	3.306	0.048	3.243	6.549
Silene nocturna L.	35	0.009	5.785	0.040	2.703	8.488
Bituminaria bituminosa L.	18	0.005	2.975	0.028	1.892	4.867
Panicum virgatum L.	77	0.019	12.727	0.208	14.054	26.781
Paspalum distichum L.	84	0.021	13.884	0.220	14.865	28.749
Jatropha gossypifolia L.	46	0.012	7.603	0.160	10.811	18.414
Solanum viarum Dunal	4	0.001	0.661	0.016	1.081	1.742
Cyperus rotundus L.	93	0.023	15.372	0.280	18.919	34.291
Digitaria sanguinalis L.	82	0.021	13.554	0.172	11.622	25.175
Chromolaena odorata L.	27	0.007	4.463	0.088	5.946	10.409
Amaranthus deflexus L.	14	0.004	2.314	0.040	2.703	5.017
Total	605	0.151	100	1.480	100	200

Information: D=Density; RD=Relative Density; F= Frequency; RF= Relative Frequency; IVI= Important Value Index.

Table 2. Vegetation on Former Manganese Mine Land in 2018

Species	Total	D	RD (%)	F	RF (%)	IVI (%)
Malvella leprosa (Ortega) krapov	17	0.004	3.881	0.032	3.150	7.031
Chromolaena odorata L.	21	0.005	4.795	0.044	4.331	9.125
Amaranthus albus L.	13	0.003	2.968	0.028	2.756	5.724
Cynodon dactylon (L) Pers	34	0.009	7.763	0.100	9.843	17.605
Lantana viburnoides	8	0.002	1.826	0.020	1.969	3.795
Ziziphus mauritiana Lam	42	0.011	9.589	0.108	10.630	20.219
Chenopodium vulvaria L.	16	0.004	3.653	0.036	3.543	7.196
Citrullus lanatus (Thunb.)	2	0.001	0.457	0.008	0.787	1.244
Calotropis gigantea (L.) Dryand	37	0.009	8.447	0.128	12.598	21.046
Xanthium strumarium L.	28	0.007	6.393	0.108	10.630	17.023
Corchorus olitorius L.	30	0.008	6.849	0.112	11.024	17.873
Ipomoea lacunosa L.	21	0.005	4.795	0.048	4.724	9.519
Chamaesyce hirta L.	26	0.007	5.936	0.040	3.937	9.873
Amaranthus viridis L.	11	0.003	2.511	0.036	3.543	6.055
Phyllanthus urinaria L.	8	0.002	1.826	0.024	2.362	4.189
Medicago arabica L.	9	0.002	2.055	0.032	3.150	5.204
Lepidium draba L.	3	0.001	0.685	0.012	1.181	1.866
Typha angustifolia L.	68	0.017	15.525	0.004	0.394	15.919
Euphorbia amygdaloides L.	4	0.001	0.913	0.008	0.787	1.701
Chrozophora tinctoria L.	3	0.001	0.685	0.012	1.181	1.866
Erigon annuus L Desv	5	0.001	1.142	0.012	1.181	2.323
Paspalum vaginatum Swartz	23	0.006	5.251	0.040	3.937	9.188
Corchorus capsularis L.	9	0.002	2.055	0.024	2.362	4.417
Total	438	0.110	100	1.016	100	200

Information: D=Density; RD=Relative Density; F= Frequency; RF= Relative Frequency; IVI= Important Value Index.

Chromolaena odorata L. is a plant that can live in 2 locations with high levels of ex-mining manganese. The ability of C. odorata is known to be significant in accumulating high heavy metals in ionic and non-ionic forms (Omoregie et al., 2019). *C. odorata* can survive in polluted soil (Ikhajiagbe, 2016). This plant grows and produces seeds very quickly, so it is widely chosen as remediation for land polluted by heavy metals (Uyi et al., 2014). This ability causes *C. odorata* to be adaptive to the former manganese mining land in Kaubele Village. The *Malvella leprosa* plant is a plant that also grows at the two former manganese mining sites in Kaubele village. However, compared to the two previous plants, the IVI of this plant was smaller, namely 8.097% (2010) and 7.031 (2018). This plant has creamy white flower petals to pale light yellow so it is often also called "white seed". This plant can live in open land. There have not been many studies on this plant on ex-mining land. However, because of its ability to live in full sun, it is thought to be able to live also in ex-mining land which has resulted in open land. This plant is also known as “alkaline mallow” in California and is highly adaptive to the saline or alkaline soils of the Central Valley (Fiedler, 1996). Its ability to grow in alkaline areas supports the growth of M. leprosa in ex-mining areas located ± 200 m asl.

Vegetation analysis results on ex-mining land in 2010 obtained *Cyperus rotundus* L. wth an IVI of 34.291%, *Paspalum distichum* L. at 28.749%, *Panicum virgatum* L. 26.781%, *Digitaria sanguinalis* L. 25.175%, and *Jatropha gossypifolia* L. 18.414%. This plant was not found in ex-mining land in 2018. *C. rotundus* has been widely studied as an accumulator of heavy metals in ex-mining land. *C. rotundus* is able to accumulate metals such as Zn, Pb, Cd, and Ni from the soil and translocate them to the shoots (Garba et al., 2018). This also makes *C. rotundus* a hyperaccumulator. *P. distichum* is known to have the potential as an accumulator as a phytoremediation in mercury (Hg) contaminated soil (Liang et al., 2016). The increase in Hg accumulation is very good in roots (Ding et al., 2019). P. virgatum in the US is cultivated for soil conservation because it has extensive roots and the potential to accumulate heavy metals (Sarkar, 2013; Minick et al., 2014). This plant is tolerant to nutrient stress and drought stress (Wright & Turhollow, 2010; Minick et al., 2014; Adkins et al., 2016). Acidic soil conditions increase the accumulation of Cd in the roots of the *P. virgatum* (Guo et al., 2019). *D. sanguinalis* is one of the heavy metal accumulator plants that grows dominantly in the lead-zinc mining area in Nanjing (Li et al., 2018). Cd accumulation was very high in the areas mined by *D. sanguinalis* in the roots and crowns compared to others (Wang et al., 2020). This accumulation is due to the large abundance of strains of Cyanobacteria Limnothrix sp. KO05 which has the ability to absorb high levels of Cd and can be used for detoxification and Cd remediation tests (Haghighi et al., 2017; Belhaj et al., 2018; Divya et al., 2018; Du et al., 2019). Studies on J. gossypifolia have not been widely tested for its function as a remediator in degraded land such as former mines. These plants are found outside the mining area. Allegedly the ability to grow this plant is tolerant to hot temperatures. Mining activities make land open without vegetation. The results of the study explained that J. gossypifolia is able to grow up to a temperature of 30OC and is an indicator of climate change in South Africa (Moshobane et al., 2022).

The results of the analysis of vegetation on former manganese mining land in 2018 obtained another plant that was not present on the land in 2010, namely *C. gigantea* as vegetation that has the highest IVI value of

21.046%, *Z. mauritiana* 20.219%, *C. aestuans* 17.873%, *X. strumarium* 17.023%, and *T. angustifolia* 15.919%. *C. gigantea* is a plant that also grows wild outside mining areas. This plant is very easy to find along the island of Timor. The ability to grow in dryland areas is very good. This plant also occurs naturally at paper mill waste disposal sites and has great potential for revegetation (Das et al., 2021). This plant is also found growing as the dominant species in various coal mining sites in India (Arshi, 2017; Kar & Palit, 2016). The *Z. mauritiana* plant has not been widely studied for its function as a remediation plant. A study of heavy metal accumulation on the side of the road by Z. mauritiana due to vehicle pollution shows a high ability to accumulate Ni (Altaf et al., 2021). This plant also includes plants that are often found in dry land types. As a result of mining, there is a change in the soil. The results of a study of changes in land use on species diversity in India show that *Z. mauritiana* dominates the dry tropical region (Srivastava et al., 2020). *C. olitorius* plant is also one of the plants that is quite common in former manganese mining areas. This plant is known to be very capable of accumulating heavy metals. Studies of this plant on soils drained by untreated wastewater showed that *C. olitorius* L. is phytostabilizing (Cd, Ni, and Mn) in the roots and is able to translocate Pb, Cu, Cr, Fe, and Zn to the leaves. This shows that plant roots are hyperaccumulators of Pb, Cr, Cu, Fe, and Zn metals (Ahmed & Slima, 2018). The potential of *X. strumarium* as a remediation plant has been widely studied. This plant is spread throughout China and is intended for manganese phytoremediation (Pan et al., 2018). In the study of manganese accumulation by *X. strumarium* in 2 different ecotypes (mining ecotypes and non-mining ecotypes) the results showed that the accumulation in all sections observed was very high. The results showed that the chloroplasts of *X. strumarium* with the highest concentration of 20,000 mM were spherical in shape and increased in number and accumulation of tilakiod granum occurred. This means that this plant is very good at detoxification and Mn tolerance and has high potential as Mn phytoremediation (Pan et al., 2019). *T. angustifolia* is a plant that has been tested in several studies for phytoremediation. This species has a high ability to tolerate the metal contamination tested (f Al, As, Cd, Cr, Cu, Hg, Mn, Ni, Pb, Zn) (Bonanno & Cirelli, 2017). In other studies, *T. angustifolia* has a high ability to accumulate and translocate heavy metals to Cd metal. Plants are most appropriate for use for phytostabilization (Duman et al., 2015).

Seed Banks of Former Manganese Mine Land in Kaubele Village

Based on the results of vegetation analysis from the seed bank on former manganese mining land in 2010, there were 8 species of pioneer plants growing (Table 3). *Dactyloctenium aegyptium* L. is a plant that grows dominantly with an IVI of 78.550%. *Synedrella nodiflora* L., *Trianthema portulacastrum* L., *Panicum stoloniferum* Poir, and *Euphorbia heterophylla* L. had an IVI of above 15%.

Seed bank analysis on ex-mining land in 2018 in Kaubele Village obtained 13 plants with the highest IVI found in *Panicum stoloniferum* Poir with a value of 46.834%. *Chromoleana odorata* L., *Salvia tiliifolia* Vahl, and *Euphorbia heterophylla* L. are some other plants that have an IVI of more than 15% (Table 4).

The results of seed bank testing on former manganese mining land obtained 7 seeds that were the same with different IVI, namely *Dactyloctenium aegyptium* L., *Chloris virgata* Trin, *Panicum virgatum* L., *Euphorbia heterophylla* L, *Salvia tiliifolia* Vahl, *Synedrella nodiflora* L., and *Phyllanthus urinaria* L. *Dactyloctenium aegyptium* L. showed a sizable IVI in 2010, namely 78.550%, but in 2018 it showed an IVI of 14.169%. *D. aegyptium* is an annual species with a C4 photosynthetic mechanism. Of the several species tested for heavy metal accumulators as an effort to restore polluted soil, the only one was *D. aegyptium* by accumulating several heavy metals of more than 100 mg.kg-1 (Irshad et al., 2015). *C. virgata* 13.113% in 2010 and 8.986% in 2018. *C. virgata* has the ability to grow well in full sunlight. This species exhibits a C4 photosynthetic mechanism and is commonly found in mainland Australia (Ngo et al., 2018). These characteristics make this plant important as a restoration on degraded grasslands in China (Wang et al., 2016). This type of plant indicates that this plant also grows well in semi-arid lands such as the Timor plains in NTT and is able to grow in open land after dry mining. It is also stated that this plant is tolerant of drought and alkaline conditions and can even become a dominating community because it is relatively stable and productive.

P. virgatum is one of the seeds that is also found on former manganese mining land with an IVI of 20.384% (2010) and 46.834 (2018). This plant was also at the manganese mining site in 2010 and 2018. Research on *P. virgatum* at Cd concentrations of 0–500 μM showed good germination. This plant accumulates Cd at an acidic pH (4.1-5.9) and is very suitable for use in phytoremediation (Wang et al., 2015). *E. heterophylla* is a plant with an IVI of 19.083% (2010) and 15.549% (2018). In testing as a weed on cotton and tomatoes, *E. heterophylla* seeds had the ability to germinate over a wide temperature range and without light conditions (Chachalis, 2015). This ability to grow makes this plant also able to grow in mine wasteland with open condition *S. tiliifolia* IVI 11.684% (2010) and 16.844% (2018) have a high ability to germinate on former manganese mining land. The results of *S. tiliifolia* research showed a high tolerance to Cd so that it was able to germinate with soil Cd concentrations of up to 50 mg.kg-1 (Li et al., 2021). In other reviews, this plant has a high ability to adapt to strong environments so it is identified as a hyperaccumulator to Cd (Lin et al., 2014). *S. nodiflora* IVI 22,068 % (2010) dan 14,169 % (2018).

The adaptation of *S. nodiflora* to post-mining land and its accumulation of heavy metals has not been studied much, but there are studies on morphological and physiological adaptations in this plant that suggest that it has good adaptability to germinate at higher elevations than the altitude test 0-813 m asl in several different locations (Dwiati & Susanto, 2020).

Table 3. Seed Banks on Former Manganese Mine Land in 2010

Species	Total	D	RD (%)	F	RF (%)	IVI (%)
Dactyloctenium aegyptium L.	64	1.778	45.714	0.611	32.836	78.550
Euphorbia heterophylla L.	10	0.278	7.143	0.222	11.940	19.083
Panicum virgatum L.	16	0.444	11.429	0.167	8.955	20.384
Synedrella nodiflora L.	10	0.278	7.143	0.278	14.925	22.068
Trianthema portulacastrum L.	14	0.389	10.000	0.222	11.940	21.940
Chloris virgata	10	0.278	7.143	0.111	5.970	13.113
Phyllanthus urinaria L.	8	0.222	5.714	0.139	7.463	13.177
Salvia tiliifolia Vahl	8	0.222	5.714	0.111	5.970	11.684
Total	140	3.889	100	1.861	100	200

Information: D=Density; RD=Relative Density; F= Frequency; RF= Relative Frequency; IVI= Important Value Index.

From the tests, there were bacterial strains that were able to increase the growth of *P. urinaria*. The presence of this bacterium also causes the adaptability of *P. urinaria* in heavy metal-polluted land (Ratan et al., 2015).

The results of seed bank analysis on former manganese mining land in 2010 obtained another plant that did not exist on ex-mining land in 2018, namely *T. portulacastrum* with an IVI of 21.940. This plant has a very good adaptation in dry lands. *T. portulacastrum* has low dormancy, heat tolerance, high reproduction, and high distribution because it can survive even in extreme climates (Ugalechumi et al., 2018; Kaur & Aggarwal, 2017; Mandal et al., 2017). Seed banks analysis on former manganese mining land in 2018 obtained other plants that did not exist on ex-mining land in 2010, namely *C. odorata* with an IVI of 21.254%, *P. ruderale*, *R. minima*, *D. triflorum*, *S. anthelmia* had the same IVI of 10.366% and *C. rotundus* 7.774%. *C. odorata* is also found in the analysis of plants found on ex-mining land. Its existence as a pioneer plant explains that there are indeed many seed banks in that land. This plant has also been shown to be drought tolerant, thus contributing to its spread (Li et al., 2022). *P. ruderale* is known to be a major competitor in crop cultivation. The results of a study of the effects of temperature and light on the germination of P. ruderale showed that the percentage of successful germination was at 25ºC - 30ºC (Yamashita et al., 2008). This also indicates that this seed has a very good ability to adapt to hot conditions such as open pit mining conditions.

R. minima, *D. triflorum*, *S. anthelmia* had the same IVI of 10.366%. These three plants have not been widely studied for remediation and the existence of seed banks in soils contaminated with heavy metals. *R. minima* is often known as a medicinal plant and there have not been many studies on the use of *R. minima* for heavy metal remediation. Its use has been studied in degraded grazing lands. The deep root morphology of *R. minima* makes this plant suitable for planting in dry and semi-arid areas that have limited water (Osman et al., 2022). Just like *R. minima*, *D. triflorum* has not been studied much in postmining fields. However, its presence is often found in disturbed locations around beach areas, dry slopes, waste areas, grasslands, and roadside (Ilandara et al., 2015). This information supports the existence of a *D. triflorum* seed bank in former manganese mining areas. *S. anthelmia* plants are also commonly found on roadsides and deserts in Nigeria. The results of tests on water deficit, this plant is more sensitive to water during the vegetative period than the generative (Umebese et al., 2012). These three plants show the ability to grow on dry lands. This ability facilitates seed dispersal even in post mining fields. *C. rotundus* is a plant that grows on ex-mining land. This plant seed bank was found on ex-mining land in 2017 with an IVI of 7,774. Several results of *C. rotundus* germination studies at observed temperatures showed that there was almost no constant temperature. Temperature fluctuations for *C. rotundus* germination support the plant's ability to dominate cultivated land and the dormancy level of *C. rotundus* is high when the seeds are at a depth of 5 cm (Loddo et al., 2019). However, due to changes in topography due to mining, dormant seeds can germinate when they emerge from the soil surface.

Table 4. Seed Banks on Former Manganese Mine Land in 2018

Species	Total	D	RD (%)	F	RF (%)	IVI (%)
Chloris virgata.	8	0.222	4.848	0.167	4.138	8.986
Chromolaena odorata L.	18	0.500	10.909	0.417	10.345	21.254
Dactyloctenium aegyptium L.	12	0.333	7.273	0.278	6.897	14.169
Euphorbia heterophylla L.	12	0.333	7.273	0.333	8.276	15.549
Panicum virgatum L.	42	1.167	25.455	0.861	21.379	46.834
Phyllanthus urinaria L.	10	0.278	6.061	0.278	6.897	12.957
Porophyllum ruderale (Jacq) Cass.	8	0.222	4.848	0.222	5.517	10.366
Rhynchosia minima L.	8	0.222	4.848	0.222	5.517	10.366
Synedrella nodiflora L.	12	0.333	7.273	0.278	6.897	14.169
Desmodium triflorum L.	8	0.222	4.848	0.222	5.517	10.366
Cyperus rotundus L.	6	0.167	3.636	0.167	4.138	7.774
Salvia tiliifolia Vahl.	13	0.361	7.879	0.361	8.966	16.844
Spigelia anthelmia L.	8	0.222	4.848	0.222	5.517	10.366
Total	165	4.583	100.000	4.028	100.000	200.000

Information: D=Density; RD=Relative Density; F= Frequency; RF= Relative Frequency; IVI= Important Value Index.

CONCLUSION

Vegetation found on former manganese mining lands has a lot of potential as accumulators in reclaiming former manganese mining lands including *Cynodon dactylon* L., *Cyperus rotundus* L., *Chromolaena odorata* L., *Corchorus olitorius* L., *Xanthium strumarium* L., *Typha angustifolia* L. Seed banks *Chloris virgata*, *Panicum virgatum* L., *Euphorbia heterophylla* L., *Trianthema portulacastrum* L., *Chromolaena odorata* L., *Cyperus rotundus* L. These are plants with seeds that are able to adapt to dry lands with high heat and have the potential to be used as an accumulator. A deeper study is needed on each vegetation and seed banks found to help the reclamation of former manganese mining land in Kaubele Village.

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