Vegetation composition in gold post-mining land of PT. Sultra Utama Nickel, Bombana District

F D Tuheteru1,*, Husna1, Basrudin1, A Arif1, Albasri1, I Mustafa1

1 Department of Forestry, Faculty of Forestry and Environmental Sciences, Halu Oleo University, Jalan Mayjen S. Parman, Kampus Lama, Kemasaya, Kendari, Southeast Sulawesi Province, Indonesia

* E-mail: fdtuheteru1978@gmail.com

Abstract. This study aimed to determine vegetation composition in the gold post-mining land of PT Sultra Utama Nickel in Bombana District. The method used in this research was the plotted path method by placing transects in accordance with purposive sampling technique. Transects were arranged systematically with a between-transects distance of 50 m. The number of transects arranged were 18 transects with 3 plots each with size of each plot was 2 x 2 m, resulted in a total plot of 54 plots. Plant identification results showed that plant species found in the study area were 19 families, 30 genera, 34 species and 4 habitat. Results of vegetation analysis showed that of the 34 plant species found in the research location, plant species with the highest IVI value of 34.54% was Imperata cylindrica. The lowest IVI of 0.54% were found for Lygodium sp., Glochidion sp., Seleria levis Retz., Scoparia dulcis L., Sida rhombifolia L and Solanum torvum. The diversity index was 2.59, indicating moderate abundance category.

1. Introduction
Southeast Sulawesi Province is one of provinces having gold mining. One of gold mining activities in Southeast Sulawesi Province is in Bombana Regency. Gold mining activity can severely damage the ecosystem. Post-mining land is marginal land with physical characteristics of compacted soil which can damage the water system and soil aeration, leading to productivity decrease and slow plant growth; hence the need for land revegetation [2].

Revegetation is the activity of replanting post-mining land with plants having the capabilities to grow in a damaged environment. The aim of revegetation is sustainable replanting of native plants to improve biodiversity and restore post-mining land. The restoration directly benefits the environment through improving wildlife habitat, biodiversity, soil productivity and water quality. Revegetation can occur naturally (natural succession), which is indicated by the emergence of new adaptive plant species in the post-mining land [17].

Natural succession in post-mining land has been carried out using several methods. Several studies including [14] reported that there were 23 plant species growing in gold post-mining land in Mandailing Natal. [16] reported that 13 species were found around the tailings of PT Antam, in Pongkor, Bogor Regency. [8] reported that there were 17 plant species with phytoremediation potential in the gold post-mining area of PT Newmont Minahasa Raya. [12] also reported that there were 10 plant species in the Timika gold mine tailings area.
Research on vegetation composition in gold post-mining land of PT Sultra Utama Nickel (SUN) in Bombana Regency has never been reported. Therefore, this research needs to be done to determine vegetation composition in the gold post-mining land of PT Sultra Utama Nickel in Bombana Regency.

2. Methods
This study was conducted in the gold post-mining area of PT SUN in Bombana Regency. This research was conducted using the plotted path method with transect placement carried out deliberately (purposive sampling). Distance between transects was 50 m. Total number of transects arranged were 18 transects. Each transect had 3 plots with plot size of 2 x 2 m, with an interval of 2 m between plots. The total number of plots arranged were 54 plots. Each plant in the plot was recorded for species name and the number of individuals.

Data collected in the field were analyzed using the following indices:

*Important Value Index (IVI)* [7]

\[ Density \ (K) \ (\text{Indv./ha}) = \frac{\text{Number of Individuals}}{\text{The area of the entire plot}} \]

\[ Relative \ Density \ (%) = \frac{\text{Species density}}{\text{The density of all species}} \]

\[ Frequency; \]

\[ Frequency \ (%) = \frac{\text{Number of species found}}{\text{total number of plots}} \]

\[ Relative \ Frequency \ (%) = \frac{\text{Frequency of a type}}{\text{Frequency across species}} \times 100\% \]

\[ Important \ Value \ Index: \ RD + RF \]

Species Diversity Index \( H' \). Species diversity is determined using the Shannon Index of General Diversity formula (Shannon-Wiener, 1963 in [11]):

\[ H' = - \sum \left\{ \frac{n_i}{N} \right\} \ln \left\{ \frac{n_i}{N} \right\} \]

Note:
H’ = Shannon-Wiener diversity index
n.i = Number of individuals of type I
N = Total number of individuals
\( \ln \) = Natural logarithm
n.i / N = Proportion of samples in species

The criteria for assessing species diversity:
H’ > 3: The diversity of a species is high
H’1 ≤ H’ ≤ 3: Medium species diversity
H’ < 1: The diversity of a species is low

3. Results and discussion
3.1. Species Composition Based on Family
Results of plant species identification at the study location showed that there were 34 species from 19 families. Family having the highest number of species was the Poaceae family with a percentage of 17.65%.
Table 1. Vegetation types in PT Sultra Utama Nickel (SUN) based on plant family

| No. | Family                | Number of types | Percentage (%) |
|-----|-----------------------|-----------------|----------------|
| 1   | Poaceae               | 6               | 17.65          |
| 2   | Fabaceae              | 4               | 11.76          |
| 3   | Cyperaceae            | 3               | 8.82           |
| 4   | Compositae/Asteraceae | 2               | 5.88           |
| 5   | Malvaceae             | 2               | 5.88           |
| 6   | Phyllanthaceae        | 2               | 5.88           |
| 7   | Pteridaceae           | 2               | 5.88           |
| 8   | Schizaeaceae          | 2               | 5.88           |
| 9   | Ericaceae             | 1               | 2.94           |
| 10  | Muntingiaceae         | 1               | 2.94           |
| 11  | Passifloraceae        | 1               | 2.94           |
| 12  | Drosperaceae          | 1               | 2.94           |
| 13  | Plantaginaceae        | 1               | 2.94           |
| 14  | Asteraceae            | 1               | 2.94           |
| 15  | Lamiaceae             | 1               | 2.94           |
| 16  | Rubiaceae             | 1               | 2.94           |
| 17  | Linderniaceae         | 1               | 2.94           |
| 18  | Solanaceae            | 1               | 2.94           |
| 19  | Verbenaceae           | 1               | 2.94           |
|     | **Total**             | **34**          | **100**        |

3.2. Species composition based on genera

Plant species identification based on genera observed 34 plant species from 30 genera. The highest number of species belongs to *Imperata, Lygodium, Sida* and *Ceratopteris* genera. Each genus was consisted of approximately 2 species or 5.88%.

Table 2. Vegetation types in PT Sultra Utama Nickel (SUN) based on genera

| No. | Genera       | Number of types | Percentage (%) |
|-----|--------------|-----------------|----------------|
| 1   | Imperata     | 2               | 5.88           |
| 2   | Lygodium     | 2               | 5.88           |
| 3   | Sida         | 2               | 5.88           |
| 4   | Ceratopteris | 2               | 5.88           |
| 5   | Cheilanthus  | 1               | 2.94           |
| 6   | Chromolaena  | 1               | 2.94           |
| 7   | Cymbopogon   | 1               | 2.94           |
| 8   | Cynodon      | 1               | 2.94           |
| 9   | Golocchidion | 1               | 2.94           |
| 10  | Grosera      | 1               | 2.94           |
| 11  | Hyptis       | 1               | 2.94           |
| 12  | Acasia       | 1               | 2.94           |
| 13  | Lespedeza    | 1               | 2.94           |
| 14  | Lindernia    | 1               | 2.94           |
| 15  | Actinoscirpus| 1               | 2.94           |
| 16  | Megathyrsus  | 1               | 2.94           |
| 17  | Oldenlandia  | 1               | 2.94           |
| 18  | Paspalum     | 1               | 2.94           |
| 19  | Passiflora   | 1               | 2.94           |
| 20  | Phyllanthus  | 1               | 2.94           |
| 21  | Polytrias    | 1               | 2.94           |
3.3. Species composition based on habitat
Plant species identification based on habitat in post-mining land were grouped into 4 habitat, namely shrubs, grasses, bushes and trees. The highest number of habitat found was grass habitat with 16 species or 47.06%. The lowest habitat was tree habitat, i.e., 2.94%.

Table 3. Vegetation types in PT Sultra Utama Nickel (SUN) based on habitat

| No. | Habitus  | Number of types | Percentage (%) |
|-----|----------|-----------------|----------------|
| 1   | Grass    | 16              | 47.06          |
| 2   | Shrubs   | 13              | 38.24          |
| 3   | Bush     | 4               | 11.76          |
| 4   | Tree     | 1               | 2.94           |
|     | Total    | 34              | 100            |

3.4. Vegetation analysis
Vegetation analysis in gold post-mining land of PT Sultra Utama Nickel (SUN) showed that Imperata cylindrica had the highest relative density and relative frequency. The lowest IVI were found in Lygodium sp., Glochidion sp., Seleria levis Retz, Scoparia dulcis L., Sida rhombifolia L., and Solanum torvum.

Table 4. Values of Density (D), Relative Density (RD), Frequency (F), Relative Frequency (RF), Important Value Index (IVI), and Plant Diversity Index (H’) in Gold Post-Mining of PT Sultra Utama Nickel (SUN)

| No. | Species                        | D    | RD   | F    | RF   | IVI  | H’   |
|-----|--------------------------------|------|------|------|------|------|------|
| 1   | Imperata cylindrica            | 2472.22 | 24.20  | 0.39 | 10.34 | 34.54 | 0.34 |
| 2   | Imperata sp.                   | 10046.30 | 9.83  | 0.44 | 11.82 | 21.66 | 0.23 |
| 3   | Chromolaena odorata            | 5740.74 | 5.62  | 0.43 | 11.33 | 16.95 | 0.16 |
| 4   | Megathyrsus maximus            | 10509.26 | 10.29 | 0.24 | 6.40  | 16.69 | 0.23 |
| 5   | Phyllanthus sp.                | 6250.00 | 6.12  | 0.35 | 9.36  | 15.48 | 0.17 |
| 6   | Vernonia sp.                   | 9398.15 | 9.20  | 0.19 | 4.93  | 14.12 | 0.22 |
| 7   | Polytrias sp.                  | 8796.30 | 8.61  | 0.15 | 3.94  | 12.55 | 0.21 |
| 8   | Cynodon dactylon (L.) Pers     | 6157.41 | 6.03  | 0.13 | 3.45  | 9.47  | 0.17 |
| 9   | Colopogonium                   | 3611.11 | 3.53  | 0.22 | 5.91  | 9.45  | 0.12 |
| 10  | Sida sp.                       | 1712.96 | 1.68  | 0.17 | 4.43  | 6.11  | 0.07 |
| 11  | Uraira lagopodoides (L.)       | 1805.56 | 1.77  | 0.15 | 3.94  | 5.71  | 0.07 |
| 12  | Lespedeza sp.                  | 1944.44 | 1.90  | 0.11 | 2.96  | 4.86  | 0.08 |
| 13  | Andropogon sp.                 | 1203.70 | 1.18  | 0.11 | 2.96  | 4.13  | 0.05 |
| 14  | Hyptis brevipes poit           | 2129.63 | 2.08  | 0.07 | 1.97  | 4.05  | 0.08 |
| 15  | Drosera burmanni Vahl          | 1990.74 | 1.95  | 0.04 | 0.99  | 2.93  | 0.08 |
Results of plants exploratory analysis in the post-mining land of PT Sultra Utama Nickel (SUN) in Bombana Regency showed that there were 34 plant species from 19 families (Table 3). There were six species of the Poaceae family found in post-mining land (17.65%). Results obtained showed that species from the Poaceae family were found in almost all observation plots. The Poaceae family presumably has high adaptation and quick reproduction capabilities. [13] stated that the Poaceae family can grow in areas having tropical to cold climates with sufficient rainfall; and these plants are also able to live without shade, and can grow at an altitude of 1-2,700 m asl [15]. One species of the Poaceae family found in the study area was *Imperata cylindrica*.

The results showed that grass habitat dominated the post-mining land with 16 species (47.06%), while tree habitat is the least found, having only 1 species of *Acacia mangium*. This situation is presumably due to the open and no shade condition of the post-mining land, leading to the growth difficulties of tree habitat. In post-mining land, such as gold mine, the first vegetation to grow is cover crops [9]. It is assumed that the vegetation community is hyper-tolerant and hyper-accumulator, which can tolerate high metal concentration in the plant tissue [18]. Lower plants can also tolerate various types of environment, including dry, barren and nutrient-poor environment [13]. Therefore, cover crop is widely used as a pioneer crop to rehabilitate marginalized and disturbed land, such as gold post-mining land.

Cover crop found in post-mining land of PT Sultra Utama Nickel consisted of several genera with a variety of species. Several genera, such as *Imperata*, *Lygodium*, *Sida*, and *Ceratopteris* were the dominant genera represented by 2 species (5.88) for the respective genera, of the total 30 genera found. *Imperata* is the one genus tolerant to open areas, as well as invasive, and is represented by *Imperata cylindrica* in the study location. This is in line with the study conducted by [1] which showed that *Imperata* is one of the genera that can grow in open areas. The high spread of *Imperata cylindrica* is supported by its propagation method through seeds and rhizobium [4]. *Imperata* seeds are very light and can spread to other places by means of wind, water, animals and human activities [10].

In our study, *Imperata* is found in every plot because of its ability to grow and adapt well to any environment, even adverse environment. This results agrees with the study conducted by [1] which
indicated that *Imperata cylindrica* of the *Imperata* genus can wildly grow and are widely distributed in forests, rice fields, gardens or yards, and other open environment types. *Imperata cylindrica* can grow in an environment with direct sun, in wet/moist soil and in dry soil. This ability is supported by the generative (seeds) and vegetative (rhizomes) means of reproduction [4]. The flowering process often occurs during dry season due to stress as a result of burning activity, deforestation, or drought [10].

The number of genera and species found in the study location also had different values of density, frequency and index. From our study, the highest density, frequency, diversity, index of importance and the highest diversity was found in *Imperata cylindrica* of the Poaceae family, with a value of 34.54% (Table 6). The lowest value was found in *Lygodium* sp., *Glochidion* sp., *Seleria levis* Retz, *Scoparia dulcis*, *Sida rhombifolia*, and *Solanum torvum* with respective values of 0.53% (Table 6). The results of vegetation analysis showed that plant diversity found in the post-mining area of PT Sultra Utama Nickel was 2.59 (Table 6), indicating that the species diversity index ($H'$) of the understory plant in the studied post-mining land was classified as moderate. The index value is influenced by environmental conditions that are not homogeneous, because in the post-mining land there are many mining pits and irregular mounds of soil, as well as high heavy metals content, leading to plant growth difficulties and abnormal plant growth [9].

Plant species with a high frequency have a wide distribution, while plant species with a low frequency have limited distribution [6]. [3] stated that frequency is a parameter that indicates vegetation distribution in an ecosystem.

4. Conclusion
There are 34 species of understory vegetation from 19 families, 30 genera and 4 habitat. The most common species found in the post-mining land was *Imperata cylindrica* from the genus *Imperata*. The most common family found in the study location was the Poaceae family. The Important Value Index of *Imperata cylindrica* was 34.54%, with Diversity Value Index of 2.59 or moderate.

5. Acknowledgment
This research was funded through Fundamental Research National from the Ministry of Research and Technology/BRIN. The authors also thank the Chairman of PT.Sultra Utama Nickel for providing research site.

References
[1]. Balkema A A 1997 Tailings and mine waste Rotterdam. Netherlands. Noordhoff-Groningen
[2]. Sukmana S dan Abujamin S 1986 Pengaruh Pengolahan Pada Eutropepts Bekas Sawah Terhadap Sifak Fisik Tanah dan Hasil Tanaman Semusim Pemberitaan Penelitian Tanah dan Pupuk 5 42-48.
[3]. Sipayung J, Delvian, dan Hartini K S 2014 Analisis Vegetasi Tumbuhan Bawah Pada Areal Lahan Bekas Tambang Emas Rakyat (Vegetation Analysis of Ground Cover on Field Area of ex Civilian Gold Mining in KecamatanNaga Juang Kabupaten Mandailing Natal). Program Studi Kehutanan, Fakultas Pertanian, Universitas Sumatera Utara.
[4]. Suharno, Sancayaningsih R P, Soetarto E S, Kasiamdari R S 2014 The presence of arbuscular mycorrhizal fungi in the tailing of minig gold timika as an attempt of environmentally friendly Jurnal manusia dan lingkungan 21 (3) 295-303.
[5]. Juhaeti T F, Syarif and Hidayati N 2005 Inventarisasi Tumbuhan Potensial untuk Fitoremediasi Lahan dan Air Terdegradasi Penambangan Emas Jurnal Biodiversitas 6 (1) 31 -33.
[6]. Purnomo D H, Magandhi M, Helmanto M dan Witono J R 2015 Jenis-Jenis Tumbuhan Reklamasi Potensial Untuk Fitoremediasi Di Kawasan Bekas Tambang Emas.Lembaga Ilmu Pengetahuan Indonesia. Bogor 1(3) 496-500.
[7]. Indriyanto 2006 *Ekologi hutan* Jakarta: penerbit PT Bumi Aksara.
[8]. Odum E 1993 *Dasar-Dasar Ekologi*.Terjemahan oleh Tjahjono Samingad dari Buku Fundamentals of Ecology. UGM. Yogyakarta.
[9]. Setiawan K A, Sutedjo, Matius P 2017 Composition of understorey species in post-coal mine revegetation 1(2) 182–195.
[10]. Hilu K W 2006 Skewed distribution of species number in grass genera: is it a taxonomic artefact. In: Hodkinson, T. R and Parnell, J. A. N. (eds). Reconstructing the Tree of Life; Taxonomy and Systematics Of Species Rich Taxa. The Systematics Association. New York. p. 165-176.
[11]. Steenis C G G J van. 2013 Flora Untuk Sekolah di Indonesia. Jakarta: Terjemahan Moeso Surjowinoto, Soenarto, dan Soerjo. PT Pradnya Paramita.
[12]. Mansur I 2013 Teknik Silvikultur Untuk Reklamasi Lahan Bekas Tambang. Southeast Asian Regional Centre for Tropical Biology (SEAMEO BIOTROP). Bogor. Indonesia.
[13]. Widyati E 2011 Potency of Understory as a Heavy Metal Accumulator in Supporting of Ex- Mining Site Rehabilitation Journal Mitra Hutan Tanaman 6 (2) 37-46
[14]. Atien S 2008 Life Pharmacy for Spices and Wild Plants. Bandung. Yrama Widya.
[15]. Fujiyanto Z, Prihastanti E, Haryanti S 2015 Characteristics of Environmental Conditions, Number of Stomata, Morphometry, Imperata that Grows in the Open Field Areas in Blora and Ungaran Districts Bulletin of Anatomy and Physiology 23 (2) 48-53.
[16]. Murniati 2002 From Imperata cylindrical Grasslands To Productive Agroforestry.Ph.D. thesis.Wageningen: Wageningen University.
[17]. Ismaini L, Lailati M, Rustandi dan Sunandar D 2015 Analisis komposisi dan keanekaragaman tumbuhan di Gunung Dempo, Sumatera Selatan Pros Sem Nas Masy Biodiv Indon. 1(6) 1397-1402.
[18]. Fachrul M 2007 Metode Sampling Bioekologi Bumi Aksara. Indonesia.