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Five years of biodiversity index values in the reclamation area of former tin mining

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Abstract

Mining activities continuously change the landscape. For tin mining activities, the end is a stretch of sandy land that is poor in nutrients. Thus, reclamation activities which consist of revegetation are needed to overcome the problem of land degradation. This study aims to calculate the index of diversity or diversity including the Shannon Wiener index, Margalef index, evenness index and the dominance index of vegetation types on the reclamation area of formerly mined land with the time period of five years. Data was collected using a purposive sampling random method. The result of the survey is the reclamation area mainly consists of 18 main plant species and 13 understory species. There are ±5 types of early environmental setting plants before the mining started including sengon (Albizia falcataria), cashew (Annacardium occidantale), oil palm (Ellais guenensis), rubber (Havea brasiliensis), and ketapang (Teminalia catappa). Nevertheless, at the time the research was conducted, there were 18 types of plants that grew naturally, indicating the occurrence of land restoration by natural succession.

Keywords: *mine reclamation, revegetation, biodiversity, Bangka Belitung Indonesia*

1 Introduction

Indonesia is one of the countries with the greatest biodiversity in the world (along with Brazil, Zaire and the Democratic Republic of the Congo). This biodiversity includes plants and animals that are spread throughout Indonesia. Indonesia ranks fourth in the world for the diversity of plant species (flora), with approximately 38,000 species. The diversity of plant species is reflected in the forests that are spread throughout Indonesia (Nugroho & Yassir 2017). One of the anthropogenic influences that affects plants is tin mining. The Bangka Belitung Islands Province has enormous tin resources, spread over land, rivers and beaches. This mineral has been mined for hundreds of years, and currently only a small part of the onshore reserves remains and most of it is tailings from past mining (Yunianto 2009).

PT TIMAH Tbk as a state-owned enterprise (BUMN) has various business activities such as mining, industry, trade, transportation and services. Nevertheless, the company's main activity is as a holding company that carries out tin mining operations and sells tin mining products. PT TIMAH Tbk has several subsidiaries which are engaged in workshops and ship building, engineering services, tin mining, consulting services and mining research as well as non-tin mining. The company is located in Pangkal Pinang, Bangka Belitung Province and has operational areas in the Bangka Belitung Islands Province, Riau Province, South Kalimantan, Southeast Sulawesi and Banten.

PT TIMAH Tbk, as one of the international-class mining companies, is also required to handle environmental management issues such as environmental monitoring and reclamation. Reclamation is an activity carried out throughout the stages of the mining business to restore and improve the quality of the environment and

ecosystems so that it can return to its intended purpose (Syari et al. 2019). In the last five years, the former tin mining area of the company has been reclaimed and appears to be recovering in one ecological aspect, biodiversity. This is what underlies our research to see the extent of changes in biodiversity recovery in ex-tin mining areas through these reclamation activities.

2 Methodology

2.1 Study areas and time

This research is focusing on the development of biodiversity in post-tin mining revegetation land during 2015–2019 in several locations, as seen Figure 1. The data taken for this research is taken from January 2022 to March 2022.

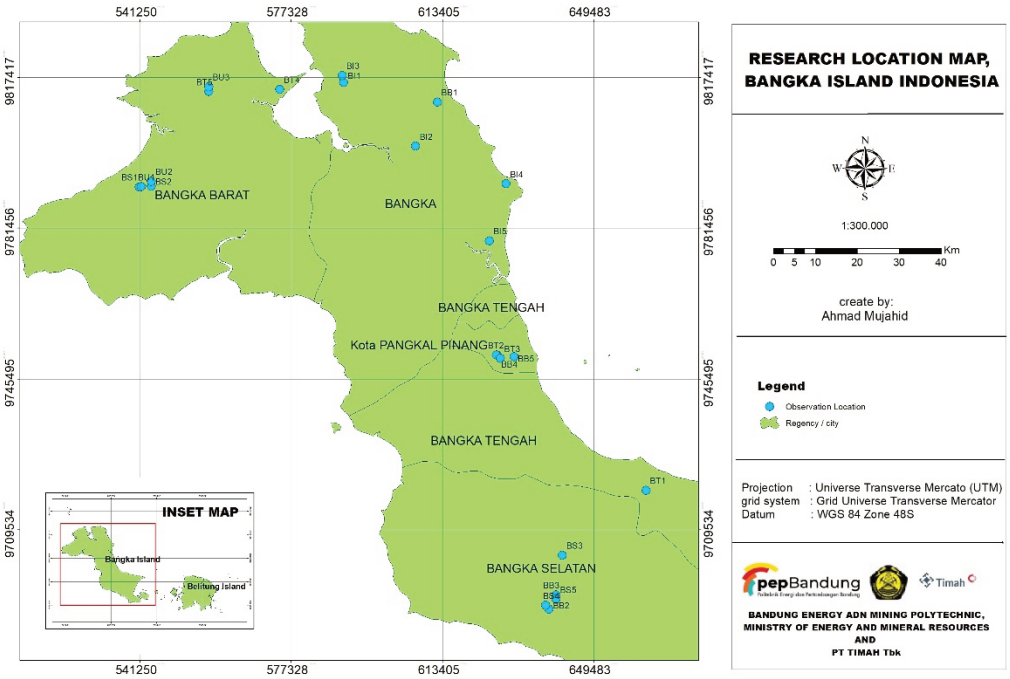

Figure 1 Survey location

2.2 Equipment

Some of the equipment and materials used in this research include survey tapes, metre measuring tool, cameras, GPS, tally sheets, guidebooks for plant species identification and maps of the reclamation plan.

2.3 Research procedure

2.3.1 Field orientation

Field orientation activities are part of the research carried out prior to data collection in the field. This stage is carried out by studying the situation and field conditions thoroughly. The purpose at this stage is to determine the location that will be used as a place of research, namely in the form of a research sample plot, therefore making the next stage easier.

2.3.1.1 Sample plot establishment techniques

The primary data collection was carried out at the research site by sampling post-mining land and the type of vegetation as follows: the pioneer plants that are intentionally planted, pioneer plants that grow from the natural regeneration process and cover crop which is small plants such as grass and legumes that provides soil protection, and soil improvement to the post-mining land. The primary data collection was carried out

by making research sample plots and descriptive exploration, which will be recorded in sampling forms. The research sample plot was created as the location for the biodiversity sampling. And the number of research sample plots amounted to 5% of the total area of the research location (Figure 2).

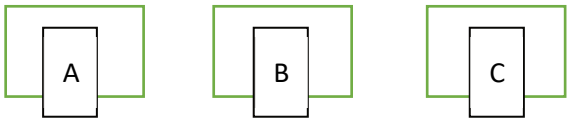

Figure 2 Sample plot illustration where sample plots are 8 × 8 m, and cover 5% of the total area of interest

This research is a type of exploratory survey, which is intended to obtain information or data by making direct observations at the research site. Sampling is done by a purposive sampling method, where the object of research is plants that grow from natural regeneration processes.

2.3.2 Data analysis

To determine the diversity of species in the reclaimed land, there are four data analysis used as follows.

2.3.2.1 Species diversity index

Species diversity index is a quantitative degree that reflects how many different types of species there are in a dataset (a community). Species diversity index can also be used to measure community stability, namely the ability of a community to keep itself stable despite disturbances to its components (Soegianto 1994). High diversity indicates that a community has high complexity due to high species interactions that occur in that plant community. The number of species diversity (low or high) can be seen by using the diversity index. Diversity has the greatest value if all individuals come from different genera or species. While the smallest value is obtained by one genus or only one species (Odum 1953). Analysis of species diversity was determined using the Shannon (H') Diversity Index formula according to Magurran (1988).

$$H' = -\Sigma\{(ni/N)\cdot \ln(ni/N)\} \quad (1)$$

where:

H' = Species diversity index.

ni = Number of individuals of each species –i.

N = Total number of individuals.

2.3.2.2 Species richness index

The species richness index is the simplest biodiversity measurement method since it only counts the difference of species number in a certain area.

$$R = \frac{S-1}{Ln\ n} \quad (2)$$

where:

R = Species richness index.

S = Species number.

Ln = Natural logarithm.

n = Number of area observations.

2.3.2.3 Species evenness index

In the species evenness index (E) according to Odum (1953), larger values of E indicate an abundance that is almost uniform and even between species. The value of the species evenness index (E) ranges from 0–1, where 0 indicates an uneven abundance, while the maximum number is 1 indicates an even abundance.

$$E = \frac{H`}{Ln\ S} \tag{3}$$

where:

H` = Species diversity index.

S = Number of species.

E = Species evenness index.

2.3.2.4 Species dominance index (C)

The species dominance index (Index of Dominance) is a parameter that states the level of concentration of species dominance (mastery) in a community. Mastery or dominance of species in a community can be concentrated in one species, several species, or in many species (Indriyanto 2012). The dominance index is calculated by using the formula for the species dominance Index (C) according to Margalef (1958):

$$C = \sum^{(pi)^2} \tag{4}$$

where:

C = Species dominance index.

pi = Proportion of individuals in the i species.

The highest species dominance index value is 1, which indicates that the community is dominated by one species or concentrated in one species. If several species dominate together, the dominance index will be close to zero.

3 Results and discussion

3.1 Understory plant presence in revegetated land

Based on the results of the data collection in the observation plots, there were 13 species from nine understory families that were frequently encountered (an example can be seen in Figure 3). In addition to understory, there are several types of cover crops that have survived until the time the research was conducted. The types of understories are mentioned in the Table 1.

Figure 3 ***Melastoma malabachtricum*** **as one of the understory plants**

Table 1 **Understory species (covercrop)**

No	Name	Family	Habitus
1	*Chromolaena odorata*	Asteraceae	shrub
2	*M.malabachtricum*	Melastomaceae	Shrub
3	*Merremia peltata*	Convulaceae	Liana
4	*Micania micrantha*	Asteraceae	Liana
5	*Paspalum conjugatum*	Poaceae	Herb
6	*Imperta sp*	Poaceae	Herb
7	*Dicranopteris linearis*	Gleicheniaceae	Herb
8	*Clidemia hirta*	Melastomaceae	shrub
9	*Mimosa pigra L.*	Leguminosae	shrub
10	*Schefflera elliptica*	Araliaceae	shrub
11	*Urena lobate L*	Malvaceae	shrub
12	*Centrosema pubescens*	Leguminosae	shrub
13	*Eupathorium odoratum*	Asteraceae	shrub

3.2 The presence of pioneer plants in revegetation land

Pioneer tree species (Figure 4) are those that are the first to dominate areas that are not vegetated. Of the various types of pioneer trees that grow on the reclaimed land, there are five tree species which are tree species that were found before the mining started. In addition, there are plants that grow due to natural

regeneration in the tin mine revegetation land without any human involvement which are aged 3–4± years old, indicating that there is land recovery (Table 2).

Figure 4 ***Acacia mangium*** **as one of the pioneer plants**

Table 2 **Main pioneer plant species**

No	Latin plant names	Local names	Family
1	*Acacia mangium*	Akasia	Fabaceae
2	*Albizia falcataria*	Sengon	Fabaceae
3	*Anthochepalus cadamba*	Jabon	Rubiaceae
4	*Bambusa vulgaris*	Bambu	Poaceae
5	*Casuarine equisetifolia L.*	Cemara laut	Casuarinaceae
6	*Dillenial Indica*	Simpur	Dilleniaceae
7	*Elaeis guineensis*	Sawit	Arecaceae
8	*Muntingia calabura*	Kersen	Elaeocarpaceae
9	*Syzigium oleana*	Pucuk merah	Myrtaceae
10	*Melaleuca leucadendra*	Gelam	Myrtaceae
11	*Terminalia catappa*	Ketapang	Combretaceae
12	*Schima wallichi*	Seru	Theaceae
13	*Guazua ulmifolia*	Jati Belanda	Sterculiaceae
14	*Syzigium cumini*	Jamblang	Syzigiaceae
15	*Psidium guajava*	Jambu biji	Myrtaceae
16	*Annacardium occidantale*	Mete	Myrtaceae
17	*Gnetum gnemon*	Melinjo	Gnetaceae
18	*Havea brasiliansis*	Karet	Haveaceae

3.3 Types of invasive plants in reclaimed land

Disturbance to a community is not only caused by over-exploitation, land use change, or climate change, but also due to the presence of invasive species that have the ability to grow and spread rapidly, out-competing other species. Invasive species are defined as plants, animals, microorganisms, and other organisms that are not part of an ecosystem that can cause damage to ecosystems, the environment, economic losses, and have a negative impact on biodiversity (example Figure 5). The types are presented in Table 3.

Figure 5 *Panicum repens L* one of the soil weeds

Table 3 Invasive species in reclaimed land

No	Latin plant names	Local names	Family	Types of disturbance
1	*Asystasia gangetica (L.)*	Pulutan	Acentaceae	Palm weed
2	*Panicum repens L.*	Lalampuyangan	Poaceae	Soil and agriculture weeds
3	*Mikania micrantha Kunth.*	Sambung rambat	Asteraceae	Parasites/twisting on the host

3.4 Biodiversity index

Biodiversity index analysis determines the value of the species diversity index, species richness index, species evenness index and species dominance index from 2015–2019 in four districts, namely: Bangka Regency, West Bangka Regency, Central Bangka Regency and South Bangka Regency. The tables and graphs are presented in Tables 4–8 and Figures 6–10.

Table 4 Year 2015

Location	Diversity index	Richness index	Evenness index	Dominance index
Bangka regency	1.5	1.3	0.6	0.2
	1.4	1.2	0.6	0.3
West Bangka regency	2.1	1.2	0.9	0.1
Central Bangka Regency	1.4	2.0	0.5	0.3
South Bangka Regency	1.3	2.2	0.4	0.3

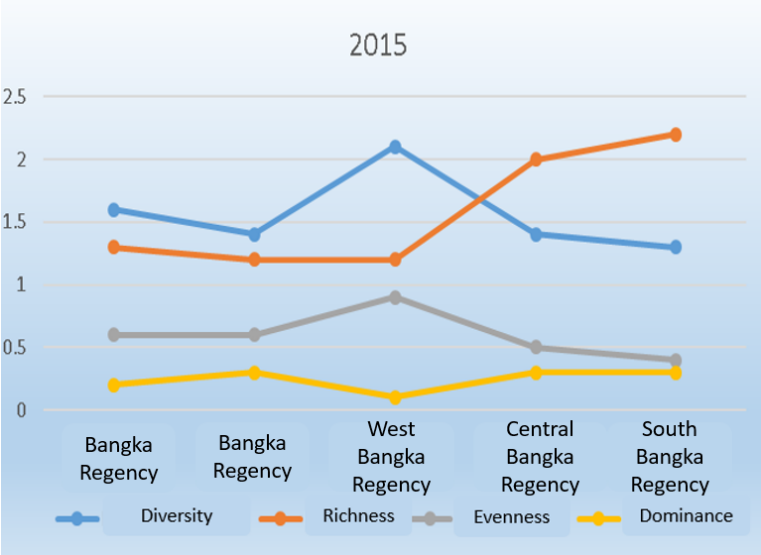

Figure 6 Biodiversity index year 2015

Table 5 Year 2016

Location	Diversity index	Richness index	Evenness index	Dominance index
Bangka regency	1.4	1.3	0.5	0.3
West Bangka regency	1.6	1.9	0.5	0.3
Central Bangka Regency	1.7	2.5	0.6	0.2
South Bangka Regency	1.3	1.9	0.4	0.3

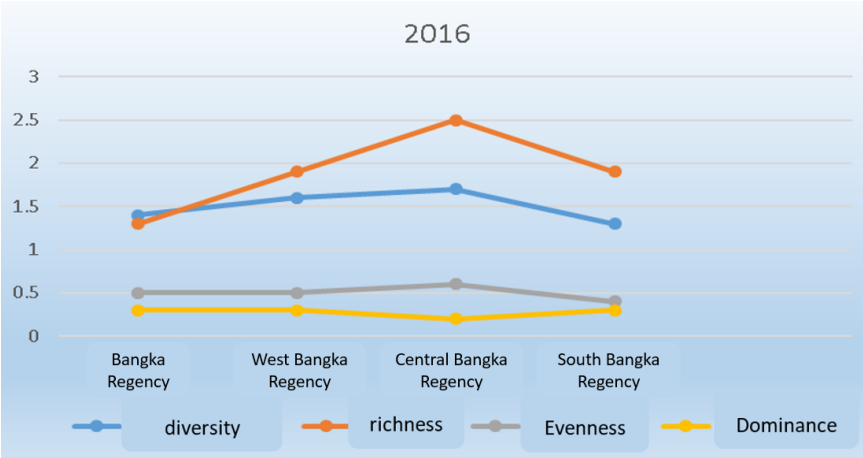

Figure 7 Biodiversity index year 2016

Table 6 Year 2017

Location	Diversity index	Richness index	Evenness index	Dominance index
Bangka regency	1.4	1.3	0.5	0.3
West Bangka regency	1.5	1.5	0.5	0.3
Central Bangka Regency	1.4	1.7	0.5	0.3
South Bangka Regency	1.5	1.8	0.5	0.3

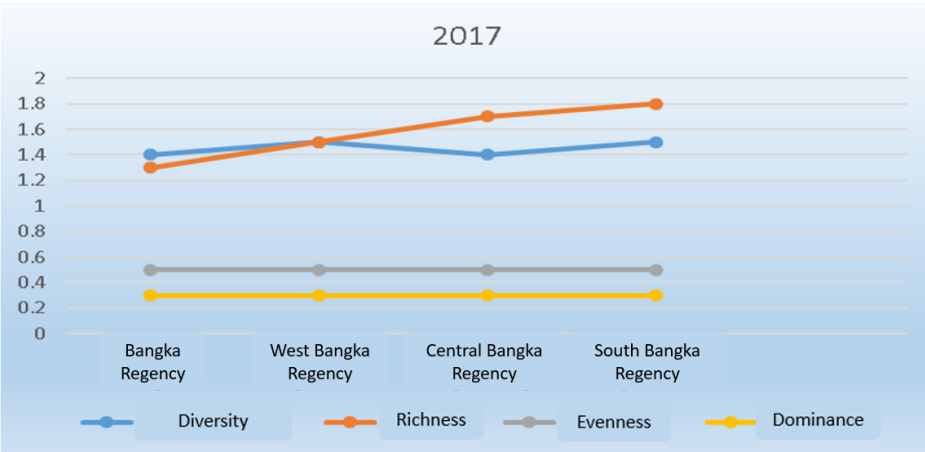

Figure 8 Biodiversity index year 2017

Table 7 Year 2018

Location	Diversity index	Richness index	Evenness index	Dominance index
Bangka regency	1.4	1.4	0.5	0.3
West Bangka regency	1.6	1.6	0.6	0.3
	1.2	1.6	0.4	0.3
Central Bangka Regency	1.3	1.8	0.5	0.3
South Bangka Regency	1.4	2.0	0.5	0.3

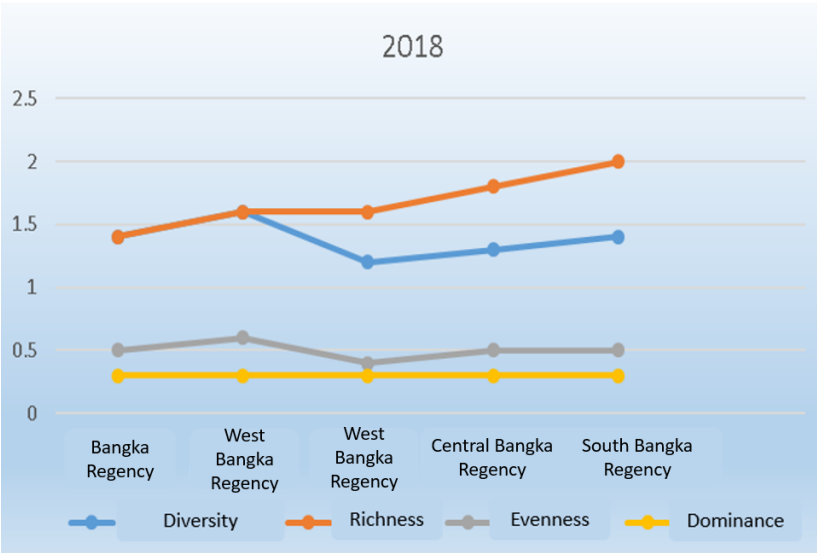

Figure 9 Biodiversity index year 2018

Table 8 Year 2019

Location	Diversity index	Richness index	Evenness index	Dominance index
Bangka regency	1.2	1.5	0.4	0.4
West Bangka regency	1.5	1.7	0.5	0.3
	1.3	2.4	0.4	0.3
Central Bangka Regency	1.4	2.4	0.5	0.3
South Bangka Regency	1.4	1.9	0.5	0.3

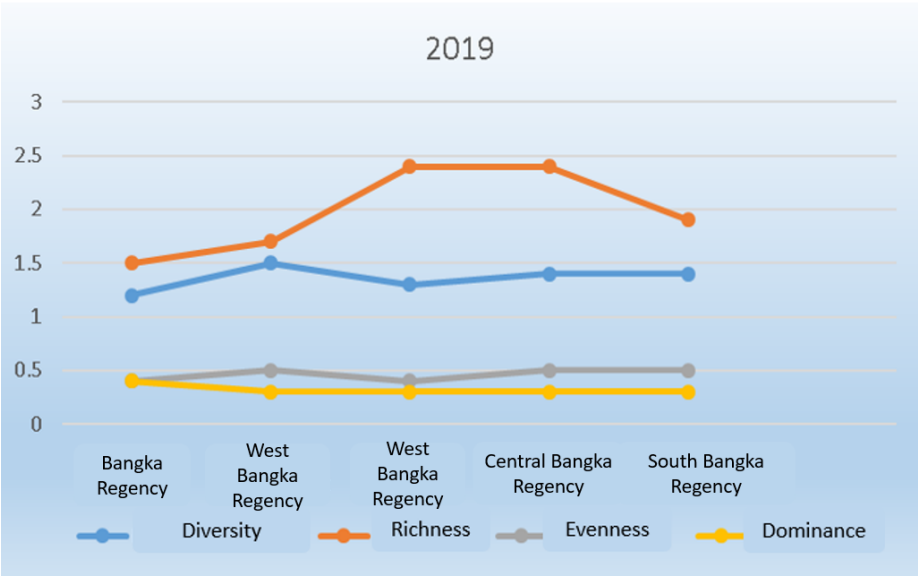

Figure 10 Biodiversity index year 2019

Biodiversity can be affected by the disturbance of a community caused by over-exploitation, land use change, etc. However, plant health is also affected by competition or the presence of invasive species that have the ability to grow and spread quickly, out-competing the main pioneer species.

The average value of Shannon's Species Diversity Index (H') in the revegetation area on post-tin mining land from 2015–2019 is 1.4, where the highest diversity index value (2.1) is in West Bangka Regency reclamation area in the plantation year of 2015. For this index, values of <1 indicate low diversity, 1–3 indicate medium diversity and >3 indicates high diversity. The value of species diversity in a community is often low if it is physically controlled by humans, therefore tree stands due to natural regeneration are possible if the revegetation area has high species diversity.

Species richness index (R) is the simplest measure of biodiversity because it only takes into account the difference in the number of species in a certain area. The value of the species richness index can be influenced by the species diversity factor and also the area of the data collection plot. The average value of the species richness index on revegetation land in 2015–2019 in four districts was 1.7 with the highest value in Central Bangka Regency with a value of 2.5. These values all indicate low richness and diversity, as values of R <3.5 are considered low, values of R of 3.5–5.0 are moderate, and values of R> 5.0 are high.

The species evenness index (E) in revegetation areas of former tin mines at reclamation sites in 2015–2019 in four districts has a fairly uniform value with an overall average value of 0.5, which means the evenness index is still in a low classification, with the highest value being 0.9 in the reclamation area in 2015 in West Bangka Regency. In the analysis of the evenness of species, if the value of the species evenness index is close to 1 (maximum value), then the number of individuals for each species is almost the same. Thus, in the

research plots, there are several dominant species. We suspect that these dominant species are able to make better use of the available abiotic resources and thereby suppress the growth of other species.

Species dominance index (C) of vegetation in the revegetation area of former tin mines in 2015–2019 in four districts has an average value of 0.28 and can be seen in the Figure 11. According to Kusmana (1997), if the species dominance index value is close to 1, then the dominance is concentrated in one or several species, whereas if the dominance index value is close to 0, then the species dominance is concentrated on many species. From the results of the analysis on the ex-tin mining reclamation land, it was found that the dominance that occurs is quite evenly distributed for several types of plants. This dominance occurs when a species can adapt well to its surrounding habitat and effectively compete with other species for sources of nutrients and growing space (Alikodra 1988). From the results of the analysis, it can be interpreted that the plants that have grown are able to adapt to their surrounding habitat well.

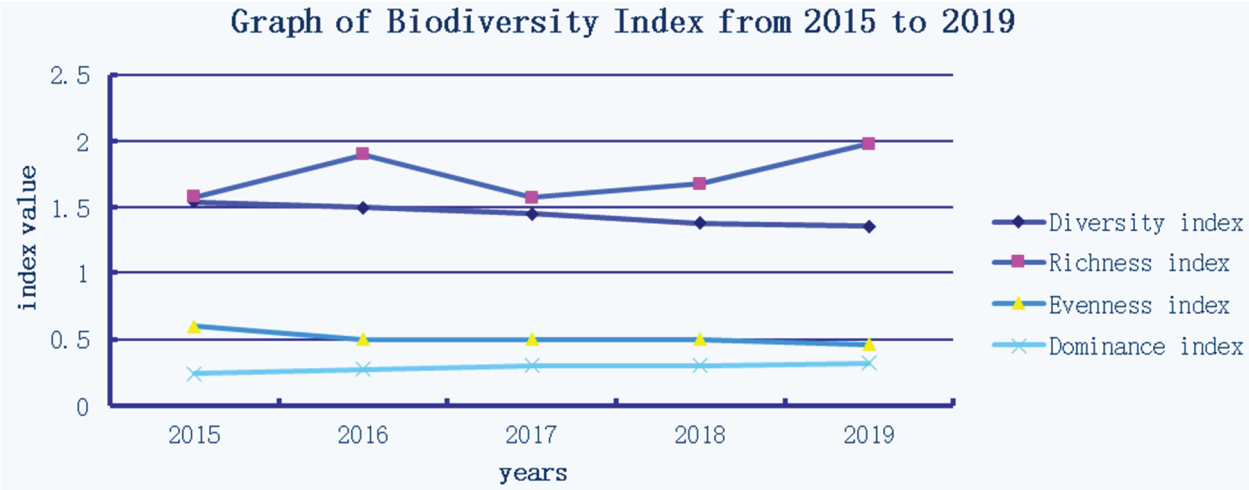

Figure 11 Biodiversity index from 2015 to 2019

4 Conclusions

The post-tin mining area is a landscape that is experiencing severe disturbances. In this post-mining revegetation area, pioneer species that grow naturally include plants that are typically found on nutrient-poor lowlands, such as Karamunting (*Melasthoma malabachtricum*), and some long-lived woody plants.

Based on the results of the inventory, undergrowth can be used as an indicator. As in secondary forest, understory will grow if environmental conditions allow, such as soil conditions that are not eroded. Based on the results of the inventory, there are 13 species from nine understory families that are often encountered.

There are 18 types of pioneer plants that are often found in revegetation land, based on the results of the inventory. Seven types of plants are early colonising plants. The growth of these species in post-mining revegetation land aged 3–4± years indicates that land recovery is starting. In addition, the types of pioneers there are gymnosperms or open-seeded species that are easily carried by the wind, birds, or other animals.

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