BIOVALENTIA: BIOLOGICAL RESEARCH JOURNAL
***e*-ISSN: 2477-1392**
Vol. 6 No. 2, Nov 2020

Diversity and Composition of Soil Arthropode in The Revegetation Area of Coal Mining Used Land of Pt. Bara Alam Utama, Site Lahat, South Sumatera

Puput Pujiati[1], Syafrina Lamin[2]* dan Yuanita Windusari[2]

[1]*Department of Conservation Biology Program, Faculty of Science, Sriwijaya University, Jalan Padang Selasa 524, Palem-bang, South Sumatra 30139, Indonesia.*
[2]*Department of Biology, Faculty of Mathematics & Natural Sciences, Sriwijaya University. Jalan Raya Palembang-Prabumulih km 32, Indralaya, Indonesia.*

*Corresponding author

E-mail address: rinairsyad@yahoo.co.id (Syafrina Lamin).
Peer review under responsibility of Biology Department Sriwijaya University

Abstract *:*

Coal mining can disrupt the balance of the ecosystem, including the soil environment ecosystem as a habitat for soil arthropods. This study aims to see the soil arthropod family, relative density, diversity, dominance and evenness of soil arthropods in the revegetation area of the ex-mining area of PT. Bara Alam Utama. The re-search was conducted in the revegetation area of the former coal mine area of PT. Bara Alam Utama in Lahat district, South Sumatra. The research area consists of 8 location points, namely natural areas, revegetation areas of age 7,6,5,4,3,2 and 1 year. The study was conducted using an exploratory survey method, sampling was car-ried out based on the purposive sampling method by drawing a 100 m long transect with 5 sample plots inside measuring 20 x 10 m at each revegetation age. The results showed that the highest soil arthropod diversity index was found at the 3 year old revegetation location (H = 0.915) and the highest soil arthropod evenness index was at the 3 year old revegetation location (e = 0.17), while the highest soil arthropod dominance index was at 5 year old revegetation location (D = 0.886) which causes the 5 year revegetation location to have the lowest soil ar-thropod diversity index and evenness index (H = 0.351 and e = 0.054), while the lowest soil arthropod domi-nance index value is at the 3 year old revegetation location (D = 0.667), so it can be seen that there is a correla-tion between the diversity index and the evenness index of soil arthropods where both are in-versely proportional to the results of the calculation of the dominance index. The high and low diversity index at each research loca-tion is influenced by abiotic factors (pH, soil temperature and soil moisture), age of revegetation and type of vegetation

Keywords: Soil Arthropods, Dominance, Diversity, Evenness, Population Density, Revegetation.

Received: October 05, 2020, Accepted: January 02, 2021

1. Introduction

Indonesia is one of the largest coal producers and exporters in the world after Australia. The three provinces that have the largest coal reserves in Indonesia include South Sumatra, South Kalimantan and East Kalimantan [8]. PT. Bara Alam Utama (BAU) is a coal mining company located in Lahat, South Sumatra, which started production in January 2011. PT. BAU is a coal supplier for electric utility activities and the industrial sector in Asia [15].

Mining activities can cause the balance of the ecosystem to be disturbed. Damage due to mining includes changes in natural conditions, loss of soil fertility, and changes in water systems, changes in soil structure and texture resulting from excavation and dredging activities [12].

The Indonesian government requires reclamation activities in the form of land restoration and post-mining environmental management, in order to reduce the loss of

biodiversity due to mining operations (Government Regulation No 78/2010; Law 4/2009; Permen ESDM 26/2018; [10].

Revegetation analysis is used as the main factor to see the success of revegetation [16]. The success of revegetation can also be seen by analyzing the diversity of soil macrofauna, one of which is soil arthropods, because soil macrofauna diversity is strongly influenced by vegetation conditions, soil macrofauna itself plays an important role in maintaining soil fertility through overhauling organic matter, nutrient distribution and increasing soil aeration [23].

Analysis of population density, diversity, dominance and evenness of soil arthropods really need to be carried out in the revegetation area which was originally marginal land, this is done to see the success of revegetation activities of ex-coal mining areas which are strongly influenced by abiotic factors, including soil conditions. Soil conditions that may change due to coal mining activities can be improved through revegetation activities. In addition to analyzing vegetation diversity to see the success of revegetation activities, soil arthropod diversity itself is also a parameter of environmental quality that can be used to evaluate the success of ex-mining revegetation activities. Therefore it is necessary to conduct research to see population density, diversity, dominance and evenness of soil arthropods found in the revegetation area of the ex-mining area of PT. BAU, Lahat, South Sumatra.

This research aims to see how the population density, diversity, dominance and evenness of soil arthropods in the revegetation area of the ex-mining area of PT. BAU.

2. Materials and Methods

Time and place

The research was conducted in December 2019. Located in the revegetation area of the ex-mining IUP of PT. BAU, Lahat, South Sumatra. Arthropoda specimen identification was carried out at the Animal Systematics Laboratory, Biology Department, Faculty of Mathematics and Natural Sciences, Sriwijaya University, Indralaya.

Tools and Materials

The tools used in the study were a time manual, stationery, 5 mm wire sieve, 200 ml collection bottles, the book Key to Insect Determination [19], Agricultural Entomology [9], Introduction to Insect Lessons [5], Collembola (ekorpegas) [20], Spider Biodiversity in North Sulawesi [11]. Soil Animal Ecology [12] and Buguidnet.com, plastic funnels, petri dishes, Tullgren funnels or Barlese, Environment meter, GPS, plastic cup with a diameter of 7.5 cm and a height of 10.5 cm, calico cloth, DLSR camera, iron wire, 10-25 Watt lamp, millimeter block, stereo microscope, microcame, plastic cover, tweezers, metal pipe with a diameter of 5 cm, gloves, soil tester, rope. The materials used are 70% alcohol, water and detergent.

Procedure

The research was conducted with an exploratory survey and the determination of the sampling location was carried out by using purposive sampling method, which is determined based on representative locations. The method of taking systematic random sampling is done by determining the sampling points deliberately in areas that can be represented by the line transect technique which is carried out at 8 observation locations. Each observation location is installed with 1 transect with a line length of 100 m with 5 plots within which are determined systematically [6]. The plot area of the plots is 20 x 10 m [1]. Each plot is 10 m apart and there are 3 plot points as replications at the diagonal position of the plot [2]. Meanwhile, the collection of soil arthropods was carried out by direct collection, litter sieve, and the use of pitfall traps in the form of plastic cups with a diameter of 7.5 cm and a height of 10.5 cm. The trap solution is a mixture of 1 liter of 70% alcohol, 25 ml of detergent solution and 4 liters of water and is applied for 2x24 hours in the field [17]. The trapped soil macrofauna was put into the sample bottles according to the plot and preserved with 70% alcohol [18] and extracted the soil using a Tullgren or Barlese funnel.

Data Analysis

Relative Population Density

Relative population density is calculated from the proportion or percentage of the population of each species or family [21].

Pi = × 100%

Information:
Pi = relative population density of the ith species
ni = abundance of type i
N = total number of all individuals

Diversity Index

Diversity is calculated using the Shannon-Wiener index (H') [21].

$$H' = -\sum Pi \log_2 Pi$$

Information :
H' = Shannon-Wiener diversity index
Pi = proportion of species i to total number

Domination Index

According to [14] the dominance index (Simpson's Index) is;

$$C = \sum\left(\frac{ni}{N}\right)^2$$

Information :
ni = abundance of the ith species
N = total number of all individuals

Evenness Index

According to [14] the evenness index (Pielou's Evenness Index) is;

$$e = \frac{H'}{Log\ S}$$

Information :
H' = Shannon-Wiener diversity index
S = number of species

Simple Linear Regression Analysis

The relationship between abiotic factors and soil arthropod diversity found was carried out by linear regression analysis [4]. Regression analysis is a statistical method that observes the relationship between the dependent variable Y and a series of X variables with the aim of predicting the Y value for a given X value, the equation with the following equation [7].

$$Y = a + bX$$

Information:
Y: The dependent variable that was predicted
X: The independent variable
a and b: regression coefficient

3. Results and Discussion

Relative Population Density of Soil Arthropods in the Revegetation Area of Ex-Coal Mining Land of PT. BAU, Site Lahat, South Sumatra

Based on the calculation of the relative population density of soil arthropods obtained, it can be seen in Figure 3.1 that the highest percentage of arthropods was obtained in the revegetation area of the former coal mine area of PT. BAU is the insect class that is 99% when compared to the Arachnida class with a percentage of only 1%.

The most common families found from the insect class of the 8 location points were the formicidae family, as many as 4101 individuals. This is because the fornicidae family has a wide distribution, besides that the formicidae family also has large colonies with a large number of individuals. According to [13], the formicidae family is a very common group and spreads widely in various habitats because formicidae has a large number of individuals. The results of research by [22] also stated that the hymenoptera order has a habit of colonizing.

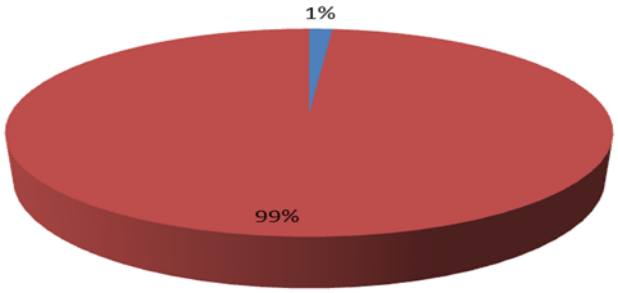

Figure 1. Percentage Diagram of Archnida and Insecta Class Arthropods in the Revegetation Area of PT. BAU, Site Lahat, South Sumatra

Diversity Index, Dominance Index and Evenness Index of Soil Arthropods in the Revegetation Area of Ex-Coal Mining Land of PT. BAU, Site Lahat, South Sumatra

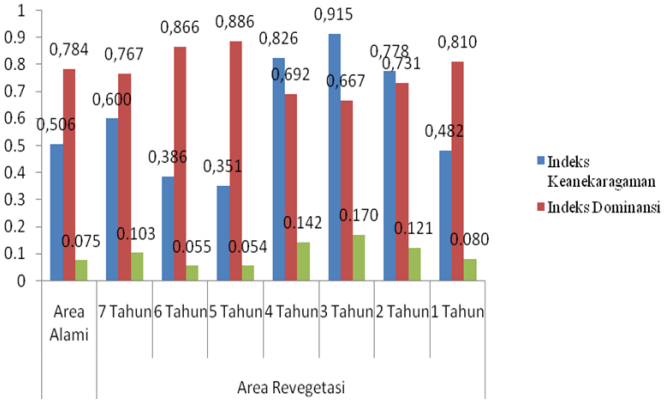

Figure 2. Diversity Index Diagram, Dominance Index and Evenness Index of Soil Arthropods in the Revegetation Area of Ex-Coal Mining Land of PT. BAU, Site Lahat, South Sumatra.

Based on the diagram above, we can see that the highest diversity index is at the 3 year old revegetation location (H '= 0.915) and the highest evenness index is at the 3 year old revegetation location (e = 0.17) this causes the 3 year old revegetation location to have The lowest dominance index value (D = 0.667), while the highest dominance index is at the 5 year old revegetation location (D = 0.886) which causes the 5 year old revegetation location to have the lowest diversity index and evenness index (H '= 0.351 and e = 0.054), so that it can be seen that there is a correlation between the diversity index and the evenness index of soil arthropods where both are inversely

proportional to the results of the calculation of the dominance index. This is in accordance with the research results of [3] stated that the higher the abundance value (D), the lower the diversity value.

Taksa	Area Alami	Area Revegetasi							Jumlah
		7 Tahun (2012)	6 Tahun (2013)	5 Tahun (2014)	4 Tahun (2015)	3 Tahun (2016)	2 Tahun (2017)	1 Tahun (2018)	
Kingdom : Animalia (Larva)	0	0	0	1	1	1	0	0	3
Filum : Arthropoda									
1. Kelas : Arachnida									
Ordo : Aranae									
Famili : 1. Linyphiidae	1	0	0	0	1	0	0	0	2
2. Salticidae	0	1	2	0	0	0	0	0	3
3. Scytodidae	0	0	1	0	0	0	1	0	2
4. Ctenidae	1	0	0	2	0	0	0	0	3
5. Thomisidae	1	1	0	3	0	0	0	0	5
6. Pholcidae	1	0	0	0	0	0	0	0	1
7. Oxyopidae	1	0	1	1	0	0	3	0	6
8. Agelenidae	0	1	1	0	0	1	1	0	4
9. Lycosidae	1	0	9	2	1	4	5	2	24
10. Pisauridae	0	8	0	1	4	2	2	0	17
11. Tetragnathidae	0	0	0	0	0	0	0	1	1
2. Kelas : Insecta									
1. Ordo : Hymenoptera									
Famili : 1. Formicidae	744	296	1060	637	282	179	524	379	4101
2. Ordo : Dermaptera									
Famili : 1. Carcinophoridae	2	0	0	1	0	0	0	0	3
3. Ordo : Orthoptera									
Famili 1. Grillydae	2	20	20	3	14	10	17	24	110
2. Acrididae	0	0	0	1	0	0	0	0	1
3. Blatidae	6	0	28	17	4	2	11	6	74
4. Ordo Coleoptera									
Famili : 1. Staphylinidae	0	0	0	0	0	0	2	0	2
2. Scarabaeidae	0	0	0	0	0	0	1	1	2
3. Nitidulidae	0	1	0	0	0	0	0	0	1
4. Curculionidae	13	0	10	2	6	2	12	4	49
5. Elateridae	0	6	2	0	0	1	0	0	9
6. Cerambycidae	0	0	1	0	0	0	0	0	1
7. Cicindelidae	0	1	0	0	0	1	0	0	2
8. Brenthidae	0	1	0	0	0	0	0	0	1
9. Scolytidae	0	0	0	1	0	0	0	0	1
10. Erotylidae	0	0	0	0	0	2	0	1	3
11. Mycetophagidae	0	1	0	0	0	1	1	0	3
12. Chrysomelidae	0	0	0	0	0	0	1	0	1
13. Pselaphidae	0	0	0	0	0	2	3	0	5
5. Ordo : Collembola									
Famili : 1. Entomobryidae	0	1	0	0	12	9	17	0	39
6. Ordo : Diptera									
Famili : 1. Drosophilidae	0	0	0	0	8	0	2	0	10
2. Cecidomyiidae	0	0	0	0	1	2	2	1	6
7. Ordo : Hemiptera									
Famili : 1. Anthocoridae	69	1	1	2	2	0	0	0	75
2. Alydidae	0	0	1	0	3	0	6	3	13
3. Reduviidae	0	0	2	0	0	0	0	0	2
4. Lygaeidae	0	0	0	2	0	0	0	0	2
5. Nabidae	0	0	0	0	1	0	0	0	1
8. Ordo : Lepidoptera									
Famili : 1. Noctuidae	2	0	1	1	0	1	1	0	6
9. Ordo : Homoptera									
Famili : 1. Pseudococcidae	0	0	0	0	0	0	1	0	1
2. Cicadellidae	0	0	0	0	0	0	1	0	1
Jumlah Individu	**844**	**339**	**1140**	**677**	**340**	**220**	**614**	**422**	**4596**

Taksa	Area Alami	Area Revegetasi							Jumlah
		7 Tahun (2012)	6 Tahun (2013)	5 Tahun (2014)	4 Tahun (2015)	3 Tahun (2016)	2 Tahun (2017)	1 Tahun (2018)	
Kingdom : Animalia (Larva)	0	0	0	1	1	1	0	0	3
Filum : Arthropoda									
1. Kelas : Arachnida									
Ordo : Aranae									
Famili : 1. Linyphiidae	1	0	0	0	1	0	0	0	2
2. Salticidae	0	1	2	0	0	0	0	0	3
3. Scytodidae	0	0	1	0	0	0	1	0	2
4. Ctenidae	1	0	0	2	0	0	0	0	3
5. Thomisidae	1	1	0	3	0	0	0	0	5
6. Pholcidae	1	0	0	0	0	0	0	0	1
7. Oxyopidae	1	0	1	1	0	0	3	0	6
8. Agelenidae	0	1	1	0	0	1	1	0	4
9. Lycosidae	1	0	9	2	1	4	5	2	24
10. Pisauridae	0	8	0	1	4	2	2	0	17
11. Tetragnathidae	0	0	0	0	0	0	0	1	1
2. Kelas : Insecta									
1. Ordo : Hymenoptera									
Famili : 1. Formicidae	744	296	1060	637	282	179	524	379	4101
2. Ordo : Dermaptera									
Famili : 1. Carcinophoridae	2	0	0	1	0	0	0	0	3
3. Ordo : Orthoptera									
Famili 1. Grillydae	2	20	20	3	14	10	17	24	110
2. Acrididae	0	0	0	1	0	0	0	0	1
3. Blatidae	6	0	28	17	4	2	11	6	74
4. Ordo Coleoptera									
Famili : 1. Staphylinidae	0	0	0	0	0	0	2	0	2
2. Scarabaeidae	0	0	0	0	0	0	1	1	2
3. Nitidulidae	0	1	0	0	0	0	0	0	1
4. Curculionidae	13	0	10	2	6	2	12	4	49
5. Elateridae	0	6	2	0	0	1	0	0	9
6. Cerambycidae	0	0	1	0	0	0	0	0	1
7. Cicindelidae	0	1	0	0	0	1	0	0	2
8. Brenthidae	0	1	0	0	0	0	0	0	1
9. Scolytidae	0	0	0	1	0	0	0	0	1
10. Erotylidae	0	0	0	0	0	2	0	1	3
11. Mycetophagidae	0	1	0	0	0	1	1	0	3
12. Chrysomelidae	0	0	0	0	0	0	1	0	1
13. Pselaphidae	0	0	0	0	0	2	3	0	5
5. Ordo : Collembola									
Famili : 1. Entomobryidae	0	1	0	0	12	9	17	0	39
6. Ordo : Diptera									
Famili : 1. Drosophilidae	0	0	0	0	8	0	2	0	10
2. Cecidomyiidae	0	0	0	0	1	2	2	1	6
7. Ordo : Hemiptera									
Famili : 1. Anthocoridae	69	1	1	2	2	0	0	0	75
2. Alydidae	0	0	1	0	3	0	6	3	13
3. Reduviidae	0	0	2	0	0	0	0	0	2
4. Lygaeidae	0	0	0	2	0	0	0	0	2
5. Nabidae	0	0	0	0	1	0	0	0	1
8. Ordo : Lepidoptera									
Famili : 1. Noctuidae	2	0	1	1	0	1	1	0	6
9. Ordo : Homoptera									
Famili : 1. Pseudococcidae	0	0	0	0	0	0	1	0	1
2. Cicadellidae	0	0	0	0	0	0	1	0	1
Jumlah Individu	**844**	**339**	**1140**	**677**	**340**	**220**	**614**	**422**	**4596**

Results of Simple Linear Regression Analysis The Relationship Between Abiotic Factors and Diversity of Soil Ar-thropods in the Revegetation Area of Ex-Coal Mining Areas of PT. BAU, Site Lahat, South Sumatra

Table 2. Relationship between Arthropod Diversity and Soil Abiotic Factors in the Revegetation Area of Ex-Coal Mining Land of PT. BAU, Site Lahat, South Sumatra

	Natural Area	2012 (7 year)	2013 (6 year)	2014 (5 year)	2015 (4 year)	2016 (3 year)	2017 (2 year)	2018 (1 year)
Diversity Index	0.506	0.600	0.386	0.351	0.826	**0.915**	0.778	0.482
pH	**6.8**	**6.8**	6.6	6.7	4.7	6.3	5.6	5.8
Soil moisture	53.43	42.12	31.06	33.95	47.95	**57.40**	36.20	25.67
Soil Tem-perature	26.38	30.56	**33.85**	30.91	28.75	31.96	31.39	33.15

Based on the table above, it is known that the 4 year old revegetation location (4.7) has the lowest soil pH and the natural area and 7 year old revegetation location (6.8) has the highest soil pH. Whereas the highest soil moisture was in the revegetation area of 3 years (57.40%) and the lowest was in the 1 year old revegetation location (25.67%) and the highest soil temperature was in the revegetation area of 6 years (33.85^{o}C) and the lowest was in the area. natural (26.38 ^{o}C).

Based on the data above, it can be seen that soil arthropods can live in a pH range of 4.7-6.8 with soil moisture between 25.67% - 57.40% and a temperature range between 26.38^{o}C - 33.85^{o}C. The correlation between soil moisture and soil arthropod diversity was at a significant level of R2 total of 39.5%, while the correlation between arthropod diversity and soil pH and temperature was at a significant level of total R2, respectively 34% and 2.3%.

4. Conclusion

Based on the results of research that has been obtained regarding the diversity of soil arthropods in the revegetation area of the ex-coal mining area of PT BAU Site Lahat, South Sumatra, it can be concluded that:

1. Soil arthropods were collected from the 8 research locations as many as 4596 specimens divided into 2 classes, 10 orders and 40 families with the highest population density of soil arthropods from the insect class, namely 99%, which was dominated by the formicidae family as many as 4101 collected specimens.
2. The highest soil arthropod diversity index was found at the 3 year old revegetation location (H '= 0.915), while the lowest soil arthropod diversity index was found at the 5 year old revegetation location (H' = 0.351)
3. The highest soil arthropod dominance index was at the 5 year old revegetation location (D = 0.886) while the lowest soil arthropod dominance index was at the 3 year old revegetation location (D = 0.667).
4. The highest soil arthropod evenness index was at the 3 year old revegetation location (e = 0.17), while the lowest soil arthropod evenness index was found at the 5 year old revegetation location (e = 0.054).

5. Conflict of Interest

Authors stated that there is no conflict of interest with any institution and/or any person related with the re-search and publication.

6. Acknowledgements

The author would like to thank the leadership and staff of Environmental PT. BAU who has facilitated and assisted the author in this research

References

[1]. Abo, O and E, Ice. 2014. Biodiversity of Soil Arthropods in Nigerian Institute for oil Palm Research (NIFOR), Nigeria. J. Appl. Sci. Environ. Manage. 18(3): 377-386.

[2]. Adhi. L.S., Mochamad, H., dan Udi, T. 2017. Keanekaragaman dan Kelimpahan Semut sebagai Predator Hama Tanaman Padi di Lahan Sawah Organik dan Anorganik Kecamatan Karanganom

Kabupaten Klaten. Bioma. 19(2): 125-135.
[3]. Agustinawati., Moh. H.T., Dan Abd. W. 2016. Keanekaragaman Arthropoda Permukaan Tanah Pada Tanaman Cabai (Capsicum annum L.) Dengan Sistem Pertanaman Yang Berbeda Di Kabupaten Sigi. E-J. Agrotekbis. 4(1): 8-15.
[4]. Amin, A., Ibrohim., dan Hawa, T. 2016. Studi Keanekaragaman Arthropoda pada Lahan Pertanian Tumpangsari untuk Inventarisasi Predator Pengendalian Hayati di Kecamatan Bumiaji Kota Batu. Jurnal Pertanian Tropik. 3(2): 139-149.
[5]. Borror, D.J., Triplehorn, C.A., Dan Johnson, N.F, Pengenalan Pelajaran Serangga. Yogyakarta: Universitas Gadjah Mada, 1996.
[6]. Fachrul, M, Metode Sampling Bioekologi. Jakarta: Bumi Aksara, 2007.
[7]. Hijriani, A., Kurnia, M. dan Erlina, A.A. 2016. Implementasi Metode Regresi Linier Sederhana pada Penyajian Hasil Prediksi Pemakaian Air Bersih PDAM Way Rilau Kota Bandar Lampung dengan Sistem Informasi Geografis. Jurnal Informatika Mulawarman. 11(2): 37-42.
[8]. Indonesia Investment. 2018. Batubara. www.indonesia-investment. Diakses pada Tanggal 31 Juli 2019 Pukul 21.20 WIB.
[9]. Jumar, Entomologi Pertanian. Jakarta: PT. Rineka Cipta, 2000.
[10]. Keputusan Menteri Energi dan Sumber Daya Mineral Republik Indonesia Nomor 1827 K/30/MEM/2018 Tentang Pedoman Pelaksanaan Kaidah Teknik Pertambangan yang Baik.
[11]. Koneri, R, Biodiversitas Laba-Laba Di Sulawesi Utara. Bandung: CV. Patra Media Grafindo, 2016.
[12]. Larasati, W., Rully, R., dan Mochamad, H. 2016. Struktur Komunitas Mikroartropoda Tanah di Lahan Penambangan Galian C Rowosari, Kecamatan Tembalang, Semarang. Jurnal Biologi. 5(1): 15-23.
[13]. Normasari, R. 2012. Keragaman Arthropoda pada Lima Habitat dengan Vegetasi Beragam. Jurnal Ilmiah Unklab. 16(1): 41-50.
[14]. Odum, E.P, Dasar-dasar Ekologi Edisi Ketiga. Yogyakarta: Gadjah Mada University Press, 1993.
[15]. PT. Bara Alam Utama. 2019. Profil PT. BAU. Lahat: PT. Bara Alam Utama. (Tidak di Publikasi)
[16]. Rizal, A., Kissinger, dan Syam'ani. Analisis Keberhasilan Revegetasi Pasca Tambang Batubara di PD. Baramarta Kabupaten Banjar Provinsi Kalimantan Selatan. Jurnal Sylva Scienteae. 3(1): 13-25.
[17]. Rubiana, R., Rima, P., dan Araz, M. 2018. Keanekaragaman Species dan Struktur Komunitas Serangga di Area Reklamasi Bekas Tambang Batubara di Kabupaten Muaro Jambi, Provinsi Jambi. Jurnal Lahan Suboptimal: Journal of Suboptimal Lands. 7(1): 37-42.
[18]. Simbolon, A.S., Mariani, S., dan Tengu, S. 2018. Deskripsi Makrofauna pada Tanah Andisol di Kabupaten Karo dengan Berbagai Ketebalan Abu Vulkanik Gunung Sinabung. Jurnal Pertanian Tropik. 5(1): 20-29.
[19]. Subyanto dan Sulthoni, A, Kunci Determinasi Serangga. Yogyakarta: Penerbit Kanisius, 1991.
[20]. Suhardjono, Y.R., Louis, D., Dan Anne, B, Collembola (Ekorpegas). Bogor: Vegamedia, 2012.
[21]. Suin, N.M, Ekologi Hewan Tanah. Jakarta: Bumi Aksara, 1997.
[22]. Suterisni, M., Bhakti., dan Endang, W.W. 2018. Studi Keanekaragaman Arthropoda Tanah di Area Konservasi Kura-Kura Manouria emys Universitas Bengkulu dan Pengembangan Pembelajaran Siswa SMA. PENDIPA Journal of Science Education. 2(6): 106-112.
[23]. Wibowo, C dan Wulandari, A.D. 2014. Keanekaragaman Insekta Tanah Pada Berbagi Tipe Tegakan di Hutan Pendidikan Gunung Walat dan Hubungannya dengan Peubah Lingkungan. Jurnal Silvikultur Tropika.5(1): 33-42.