Plant Dispersal at Bangka Post-Tin Mining Revegetated Land Correlated with Soil Chemical Physical Properties and Heavy Metal Distribution

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ABSTRACT
Land preparation for post-tin mining revegetation at Bangka Island will affect physical-chemical as well as heavy metals' properties of the soil, and those properties affect plants distribution on the post-tin mining lands. The purpose of the research is to study the distribution of plants in the post-tin mining lands in relation to the physical-chemical properties and heavy metals' concentrations in the revegetated soils. Four types of land use were selected to conduct this study, namely: forest, more than 5 year revegetated post-tin mining land, less than 5 year revegetated post-tin mining land and active tin mine. Soil samples were taken from a depth of 0-40 cm using a soil auger. Once taken, the samples were immediately brought to the laboratory for routine soil chemical analysis (pH, C,N, potential P and K, available P and K, exchangable cations, cations exchange capacity, base saturation, exchangeable acidity and metals (Fe, Mn, Cu,Zn, and Al) as well as heavy metals (Pb, Cd, Co, Cr, Ni, Mo, Ag, Sn) analysis. Plant species around the soil sampling site were identified at the Bangka Belitungense Herbarium at Bangka Belitung University. The data obtained were then analyzed were analyzed using multivariate statistical analysis with principal component analysis biplots (PCA biplots), as well as test for significance of Pearson's Correlation Coefficient using PAST v4.03. The number of families and the number of plant species have increased along revegetation activities with the highest was found in forest. The number of plant species has strong correlation with the chemical physical properties of soils and heavy metals. The strong positive correlation was found between the numbers of plant species with pH (KCl), C, N, C/N, available P, exchangeable Mg, Se, and As, while the negative strong correlation was observed with exchangeable Na and the relative proportion of silt.
Keywords* : *Bangka, post-tin mining, revegetation, physical-chemical properties, heavy metal

1. INTRODUCTION

Tin mining activities on Bangka Island leave a large polluted area that includes ex-tin mining ponds and tailing dumps [17]. Previous studies showed that the disposed of tailings caused health and environmental problems as the by products of tin mining which are concentrated in tin tailing contain: Chromium (Cr), Nickel (Ni), Copper (Cu), Zinc (Zn), Cadmium (Cd), Mercury (Hg) and Arsen (As) [1,2]. The concentration of those metals in the post-tin mining land varies greatly from location to location. Pb in the sediment of ex-tin mining ponds at Kacang Pedang, Bangka reached 54.3 ppm [6]. Lead in soil from the tin mine reclamation site of Pemali Village, Bangka reached 50.53 ppm [13], while in Bencah Village, South Bangka it reached 10.80 ppm [17]. One of the efforts made by PT. Timah (Persero) Tbk., a state owned tin mining company, to reduce the impact of this problem is by revegetating the post-tin mining lands [7,8,11].

Minister of Energy and Mineral Resources Regulation No.7 of 2014 on Reclamation and Mine Clossure Implementation in Mineral and Coal Mining Activities states that the success of post-tin mining reclamation must include the diversity of vegetation.

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There are various types of plants that grow in the post-tin mining revegetated land. Those are *Calophyllum inophyllum*, *S. wallichii*, *Syzygium garcinifolium*, *Ficus superba*, *Vitex pinnata*, *Hibiscus tiliaceus*, *Syzygium polyanthum*, *Mallotus paniculatus*, *Aporosa* sp., *Macaranga* sp., *Hevea brasiliensis* (Willd. ex A.Juss.) Müll.Arg., *A. mangium* Wild, *A. auriculiformis* A. Cunn. Ex. Benth, *Albizia falcata* L., *Swietenia mahagoni* L. Jacq, *Pinus merkusii* Jungh, *Pennisetum purpureum* Schum, *Setaria spachelata* Schum, *Jatropha curcas* L, *Brachiaria decumbens*, *Panicum maximum*, *Pennisetum purerium*, *Dolichus lablab*, *Crotalaris* sp., *Canavalia* sp., *Vigna* sp., *Tephrosia* sp., *Dioscroea* sp., *Ipomea batatas*, *Mucuna* sp., *Arachis pintoi*, *Centrosema* sp., *Calopogonium* sp. [3,4,5,9,12,15,18]. Some of the plants that have been used for revegetation, such as *Acacia mangium*, *Acacia auriculiformis*, and *Schima wallichii* have the potential as phytoremediator of metals [13,14]

Revegetation program of post-tin mining land usually started with land preparation to improve the physical, chemical, and biological properties of the soil. In order to find out the necessary physical-chemical improvement of soil which is related to the presence of plant diversity, an evaluation of the distribution of plants related to the physico-chemical and metal properties of soil in the post-tin mining areas is necessary to be carried out. So, this research aims to study the distribution of plants in the post-tin mining lands in relation to the physical-chemical properties and heavy metals' concentrations in the revegetated soils.

2. MATERIALS AND METHODS

Soil samples were taken from 4 sites and 3 sampling points from each site. The sampling sites were forest [FS] at Rebo Village, Bangka, Indonesia; more than 5 years revegetated post-tin mining land [RA] at Jelitik Village, Bangka, Indonesia, less than 5 years revegetated post-tin mining land [RB] at Air Jangkang Village, Bangka, Indonesia and still actively mined land [MA] at Jelitik Village, Bangka. Sampling coordinates of each sites were shown in Tabel 1. Soil samples were taken from Acacia rhizospheric soils as Acacia were found in all sites except for MA, where revegetation has not been carried out.

Table 1. Sampling coordinates of each sites

No	Sampling sites	Coordinate of the Sampling Points		
		Sampling point 1	Sampling point 2	Sampling point 3
1	Forest (Rebo, Bangka)	1° 54' 56,22" S; 79° 50' 7,338" E	1° 54' 54,496" S; 79° 50' 9,928" E	1° 54' 54,366" S; 79° 50' 9,896" E
2	More than 5 years revegetated (Jelitik, Bangka)	1° 53' 28,959" S; 79° 50' 20,277" E	1° 53' 26,191" S; 79° 50' 19,178" E	1° 53' 33,647" S; 79° 50' 18,3" E
3	Less than 5 years revegetated (Air Jangkang, Bangka)	2° 0' 14,924" S; 79° 52' 37,747" E	2° 0' 15,087" S; 79 ° 52' 37,908" E	2° 0' 15,25" S; 79° 52' 38,135" E
4	Still actively mined (Jelitik, Bangka)	1° 52' 13,539" S; 79° 51' 53,5" E	1° 52' 19,662" S; 79° 51' 55,276" E	1° 52' 23,961" S; 79° 51' 55,435" E

Table 2. Characteristics and its methods of analysis

No.	Characteristics	Methods of Analysis
1	Texture	Mechanical analysis using the pipette method
2	pH	H_2O & KCl; pH meter
3	Carbon	Walkey & Black
4	Nitrogen	Kjeldahl
5	C/N	Calculation
6	Potential P	HCl 25%; spectrophotometric
7	Potensial K	HCl 25%; flame photometric
8	Available P	Bray; spectrophotometric
9	Available K	Morgan; flame photometric
10	Exchangeable Cation (Ca_{exc}; K_{exc}, Mg_{exc}, Na_{exc})	NH_4-OAc; flame photometric and AAS
11	Cation Exchange Capacity (CEC)	NH_4-OAc; destilation
12	Base Saturation (BS)	Calculation
13	Exchangeable Acidity (Al_{exc}, H_{exc})	KCl; titration
14	Metals (Cr, Mn, Fe, Co, Ni, Cu, Zn, Mo, Cd, Al, Sn, Pb, As, and Se)	HNO_3; AAS

Soil sampling is carried out by carefully digging the soil around the root using a soil spoon. The roots were then separated from large chunks of soil and left as much soil attached to the roots as possible. The soil were then separated from the roots where it was attached, put in a plastic bag and brought to the laboratory. The soil sample was then dried, finely ground and then analyzed for its chemical physical properties at the Soil, Plant, Fertilizer, Water Laboratory – Soil Research Center, Bogor, West Java, Indonesia. The methods used are shown in Table 2. In addition, plant species in the vicinity of the soil sampling location were also collected and then were identified at the Bangka Belitungense Herbarium at Bangka Belitung University.

The data were analyzed discriptively and presented in the form of tables or graphs. Correlation analysis (Pearson Correlation) between concentrations of metals and soil chemical physical properties was performed using PAST 4.03. The data were also analyzed using multivariate statistical analysis with principal component analysis biplots (PCA biplots)

3. RESULT AND DISCUSSION

From Table 3, it can be seen that some soil characteristics dominate in each land. Forests have the highest mean values for: C, N, C/N ratio, potential and available P, Mg_{exc}, CEC, Al_{exc}, heavy metals Co, Mo, Ag, Sn, Se, and As, while the most dominant revegetation is: pH H_2O, sand, potential and available K, Ca_{exc}, K_{exc}, the total of exchangeable cations, base saturation, heavy metal Pb for those above 5 years, and heavy metal Cr for those under 5 years. The dominant soil characteristics in active tin mines are: pH KCl, silt, clay, Na_{exc}, H_{exc}, heavy metals Cd and Ni. Mn metal and heavy metal Sn are the highest metals/heavy metals compared to the others. The amount of litter produced on the land greatly contributes to the physical and chemical properties of the soil on land where tin mining has been carried out. The negative charge on soil organic matter and clay indicates how much positive ions are attracted to heavy metals/metals in the soil.

Plant data obtained from four different lands in Bangka with a total of 31 plant species. There are 21 plant species in the forest, 19 plant species in tin mining revegetation land > 5 years, 9 plant species in tin mining revegetation land < 5 years, and 0 plant species in active tin mining. (Table 4). The order of the number of plant species is, FS> RA> RB> MA. Many types of plants are similar between tin mining revegetation land > 5 years and tin mining revegetation land < 5 years. This is also supported by the similar physical and chemical soil conditions on the two lands.

The distribution of plant species is also different in each land. Plant species found only in three areas, except for active tin mining, namely: *A. mangium.* There are 18 types of plants that are only found in forests consisting of: *A. auriculiformis, Adinandra sarosanthera*, *Aporosa octandra, Arthrophyllum diversifolium, Calophyllum pulcherrimum, Eurya acuminta, Guioa pubescens, Helicia serrata,* Hibrid *A. mangium & A. auriculiformis, Ilex cymosa, Kibatalia maingayi, Lithocarpus blumeanus, Oncosperma tigillarium*, *Phsycotria* sp., *Plectocomonia geminiflora*, *Rhodamnia cinerea*, *S. wallichii,* and *Syzygium pycnanthum*. There are 9 types of plants that are only found in tin mining vegetation for > 5 years (*Anacardium occidentale, Calophyllum ferrugineum, Cocos nucifera, Dillenia sufruticosa, Melastoma malabathricum, P. maximum, Rolandra fruticosa. Scleria laevis*, and *Shorea balangeran)* and 3 types of plants in tin mining revegetation land < 5 years (*Phyllanthus niruri, Sauropus androgynus,* and *Trema orientalis). V. pinnata* is the only species of the same plant found in forests and tin mining revegetation land >5 years. There are also several types of plants found in both revegetation lands, such as: *Elaeis guineensis, Eragrostis chariis, Imperata cylindrica,* and *M. malabathricum).* Forests in South Bangka are dominated by: *S. wallichii, C. pulcherrimum, A. octandra* and post-tin mining land that is reclaimed is dominated by *I cylindrica* and *M.malabatrichum* [14].

Table 3. Results of soil routine chemical and soil-specific chemistry analysis on four different fields in Bangka

No	Soil Characteristics	Forest		Tin Mine Revegetation Land > 5 Years		Tin Mine Revegetation Land < 5 Years		Active Tin Mine	
		Mean	Std	Mean	Std	Mean	Std	Mean	Std
A	*Analysis of soil routine chemical*								
1	Sand (%)	61.67	2.89	78	10.44	73.67	15.37	46.33	8.96
2	Silt (%)	9.00	1.73	7.67	4.04	13.67	10.02	15.67	0.58
3	Clay (%)	29.33	2.52	14.33	6.43	12.67	5.51	38.00	8.66
4	pH H_2O	4.60	0.00	4.77	0.15	4.50	0.20	4.63	0.06
5	pH KCl	3.80	0.00	3.70	0.10	4.07	0.06	4.13	0.06
6	C-organic (%)	4.14	0.74	2.95	1.21	1.19	0.80	1.25	0.22
7	N (%)	0.23	0.01	0.17	0.04	0.09	0.05	0.10	0.02

8	C/N ratio	18.00	2.65	16.67	2.89	12.33	1.53	13.00	0.00
9	P-potential (mg100 g^{-1})	12.00	3.00	3.00	1.00	5.00	0.00	2.67	0.58
10	K-potential (mg100 g^{-1})	4.00	0.00	8.67	3.51	3.33	0.58	4.00	1.73
11	P-available (ppm)	40.37	11.12	18.43	2.25	21.80	4.10	12.60	2.12
12	K-available (ppm)	33.67	2.08	86.00	48.51	31.00	5.57	36.33	13.80
13	Exchangeable Cation:								
	a). Ca^{2+} (cmolckg^{-1})	0.66	0.08	1.02	0.48	0.31	0.08	0.48	0.24
	b). Mg^{2+} (cmolckg^{-1})	0.57	0.08	0.50	0.26	0.10	0.02	0.20	0.10
	c). K^{+} (cmolckg^{-1})	0.06	0.01	0.16	0.09	0.05	0.01	0.06	0.03
	d). Na^{+} (cmolckg^{-1})	0.19	0.06	0.21	0.02	0.26	0.11	0.27	0.06
14	Total of Exchangeable Cation (cmolckg^{-1})	1.48	0.15	1.89	0.83	0.72	0.15	1.02	0.42
15	Cation Exchage Capacity (cmolckg^{-1})	8.44	0.53	7.31	2.92	4.26	1.36	6.02	2.03
16	Base Saturation (%)	17.33	0.58	26.00	4.36	18.33	7.23	16.67	1.15
17	Acidity:								
	a). Al^{3+} (cmolckg^{-1})	1.55	0.05	0.53	0.47	1.21	0.78	1.45	0.35
	b). H^{+} (cmolckg^{-1})	0.36	0.11	0.35	0.06	0.14	0.15	0.43	0.04
B	*Analysis of soil-specific chemistry: metal and heavy metal*								
1	Fe (ppm)	1.34	0.11	0.11	0.13	0.18	0.11	0.14	0.01
2	Mn (ppm)	19.48	2.24	43.41	11.86	4.39	2.02	14.47	1.85
3	Cu (ppm)	2.07	0.23	2.05	1.15	2.13	1.93	1.92	0.28
4	Zn (ppm)	12.66	2.04	18.92	8.87	6.90	3.72	15.88	1.16
5	Al (ppm)	7.48	0.36	2.85	2.04	0.96	0.75	5.55	1.02
6	Pb (ppm)	6.8	1.19	24.34	10.23	5.77	4.46	20.3	7.52
7	Cd (ppm)	0.04	0.02	0.01	0.02	0.03	0.04	0.06	0.05
8	Co (ppm)	0.74	0.17	0.49	0.12	0.5	0.27	0.59	0.24
9	Cr (ppm)	3.17	1.26	0.79	0.53	4.22	3.2	2.81	0.31
10	Ni (ppm)	3.05	0.47	2.4	1.49	2.69	0.86	5.33	3.41
11	Mo (ppm)	13.25	1.62	6.2	3.35	11.4	4.54	10.05	4.61
12	Ag (ppm)	0.7	0.26	0.28	0.18	0.16	0.18	0.45	0.07
13	Sn (ppm)	45.67	2.74	18.08	14.8	5.76	5.22	35.55	8.27
14	Se (ppm)	0.42	0.1	0.27	0.23	0.16	0.04	0.15	0.01
15	As (ppm)	17.4	2.79	4.62	3.34	1.62	1.39	0.96	0.2

Table 4. Data on plant species on four different lands in Bangka

No	Species Name	Family Name	Plants Presence on Land			
			FS	RA	RB	MA
1	*Acacia mangium* Willd.	*Fabaceae*	1	1	1	0
2	*Acacia auriculiformis* A. Cunn. Ex. Benth	*Fabaceae*	1	0	0	0
3	*Adinandra sarosanthera* Miq	*Theaceae*	1	0	0	0
4	*Anacardium occidentale* L.	*Anacardiaceae*	0	1	0	0
5	*Aporosa octandra* (Buch.-Ham. ex D.Don) Vickery	*Euphorbiaceae*	1	0	0	0
6	*Arthrophyllum diversifolium* Blume	*Araliaceae*	1	0	0	0
7	*Calophyllum ferrugineum Ridl.*	*Calophyllaceae*	0	1	0	0
8	*Calophyllum pulcherrimum* Wall. ex Choisy	*Calophyllaceae*	1	0	0	0
9	*Cocos nucifera* L.	*Arecaceae*	0	1	0	0
10	*Dillenia sufruticosa* Griff	*Dilleniaceae*	0	1	0	0
11	*Elaeis guineensis* Jacq.	*Arecaceae*	0	1	1	0
12	*Eragrostis chariis* (Schult.) Hitchc.	*Poaceae*	0	1	1	0
13	*Eurya acuminta* DC.	*Theaceae*	1	0	0	0
14	*Guioa pubescens* (Zoll. & Mor.) Radlk.	*Sapindaceae*	1	0	0	0
15	*Helicia serrata* Blume	*Proteaceae*	1	0	0	0
16	Hibrid *Acacia mangium & Acacia auriculiformis*	*Fabaceae*	1	0	0	0

17	*Ilex cymosa* Blume	*Aquifoliaceae*	1	0	0	0
18	*Imperata cylindrica* (L.) Raeusch.	*Poaceae*	0	1	1	0
19	*Kibatalia maingayi*	*Apocynaceae*	1	0	0	0
20	*Lithocarpus blumeanus* (Korth.) Rehder	*Fagaceae*	1	0	0	0
21	*Melastoma malabathricum* Linn	*Melastomataceae*	0	1	1	0
22	*Microcos tomentosa* Sm	*Tiliaceae*	1	1	0	0
23	*Oncosperma tigillarium* (Jack) Ridl.	*Arecaceae*	1	0	0	0
24	*Panicum maximum* Jacq.	*Poaceae*	0	1	0	0
25	*Paspalum conjugatum* Berg.	*Poaceae*	0	1	1	0
26	*Phsycotria* sp.	*Rubiaceae*	1	0	0	0
27	*Phyllanthus niruri* L.	*Phyllanthaceae*	0	0	1	0
28	*Plectocomonia geminiflora* H. Wendl.	*Arecaceae*	1	0	0	0
29	*Rhodamnia cinerea* Jack	*Myrtaceae*	1	0	0	0
30	*Rolandra fruticosa* (L) Mur.	*Asteraceae*	0	1	0	0
31	*Sauropus androgynus* (L.) Merr.	*Euphorbiaceae*	0	0	1	0
32	*Schima wallichii* (DC.) Korth	*Theaceae*	1	0	0	0
33	*Scleria laevis* Retz	*Cyperaceae*	0	1	0	0
34	*Shorea balangeran* Burck	*Dipterocarpaceae*	0	1	0	0
35	*Syzygium pycnanthum* Merr. & L.M. Ferry	*Myrtaceae*	1	0	0	0
36	*Trema orientalis* (L.) BI.	*Ulmaceae*	0	0	1	0
37	*Vitex pinnata* L.	*Verbenaceae*	1	1	0	0
	Total		21	16	9	0

Remarks: FS (Forest), RA (tin mining revegation land for more than five years), RB (tin mining revegation land under 5 years), MA (active tin mining, 1 (there is a plant species), 0 (no plant species)

The family that dominates the forest does not exist from grasses, both from *Cyperaceae* and *Poaceae* (Figure 1). The two families are most commonly found in tin mining revegetation land > 5 years. This condition is assumed to be in accordance with the growing place which is dominated by sand which supports the growth of the monocot plant with fibrous roots. The dense canopy cover of plants in the forest may also cause there to be no grass on the forest floor which is a form of competition between plants. *Poaceae* and *Melastomataceae* is a family that can be found in both tin mining revegetation lands. This shows that the two plants from the plant family are adaptive to grow on soil contaminated with heavy metals, such as: Pb, Ni, Cr and Cd. The forest is damaged by nature or humans, the secondary succession that occurs usually begins with grass and shrub vegetation [10, 16].

The distribution of plants in several types of land in Bangka may be influenced by the physical and chemical properties of the soil in the presence of metals and heavy metals in the soil. Most of the plant species are found in the forest and are affected by several dominant soil characteristics, such as: potential and available P, Carbon and Nitrogen content, C/N ratio, clay, CEC, H_{exc}, Mg_{exc}. Some metals/heavy metals, such as: Fe, Al, Sn, Co, As, Se are still commonly found in the forest (Figure 2). Several types of Acacia plants, such as: *A. auriculiformis* and Hybrid *A. mangium & A. auriculiformis* still dominates the forest, while *A. mangium* in addition to the forest also spread from tin mining revegetation land > 5 years. This revegetation land shows improving soil properties and almost resembles the soil conditions in the forest, as reflected in the high potential and available K, base saturation, pH H_2O, Ca_{exc}, Zn and Cu metals.

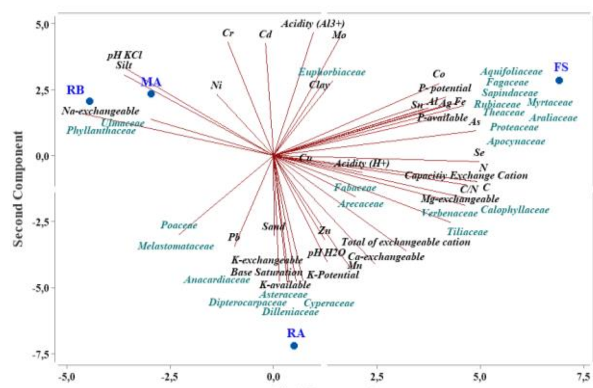

Figure 1 PCA Biplot between plant families and physicochemical and heavy metal soils on different land in Bangka. FS (Forest), RA (Tin Mine

Revegetation Land > 5 Years), RB (Tin Mine Revegetation Land < 5 Years); MA (Active Tin Mine)

However, because this land is a post-tin mining area that produces some waste, including sand tailings so that sand is the most dominant in this area, as well as heavy metal Pb. The age of the land which is still relatively young in the tin mining revegetation land is < 5 years, causing three plants to dominate, such as: *Sauropus androgynus, Phyllanthus niruri, T. orientalis.* The high Na in the tin mining revegetation land < 5 years is estimated to influence the existence of the three plants. The relation between plants and soil characteristics is also strengthened by the results of the Pearson Correlation analysis, that family and plant species have a very strong relation directly proportional to C, N, C/N, available P, Mg_{exc}, heavy metals Se and As, and has a very strong and inverse relation with silt, pH KCl, Na_{exc}, heavy metals Ni (Table 5). The most significant relation at <0,05 level occurred between plant species and Na_{exc}, namely the higher the plant species, the lower the Na_{exc} and vice versa, the lower the plant species, the higher the Na_{exc} (Figure 3).

The number of families and plant species decreased drastically on land where tin mining had been carried out and which were still actively mining tin. The composition of vegetation on post-tin mining land with 0 years of age has 0 number of species and 0 number of families, while 7 years old is 6 number of species and 4 number of family, age of 11 years is 8 number of species and 5 number of family, and age 38 years, namely 16 the number of species and 13 the number of families [9]. Plant species that can survive in areas contaminated with heavy metals are estimated to have potential as heavy metal accumulator plants. *A. auricuculiformis* and *E. chariis* from the land after tin mining in Pemali Village, Bangka has the opportunity as a phytoremediator for heavy metals Pb and Sn [13].

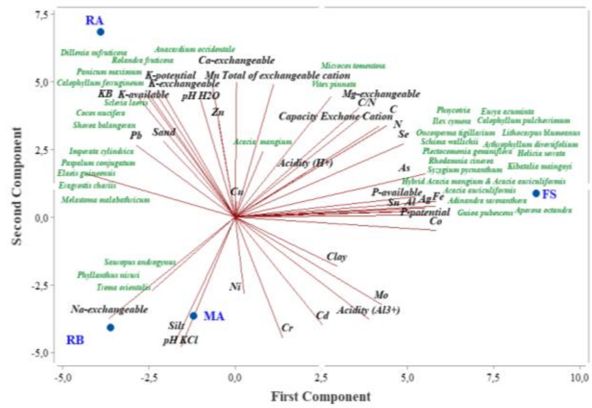

Figure 2 PCA Biplot between plant species and physicochemical and heavy metal soils on different land in Bangka. FS (Forest), RA (Tin Mine Revegetation Land > 5 Years), RB (Tin Mine Revegetation Land < 5 Years); MA (Active Tin Mine)

Table 5. Pearson Correlation between sepecies and family plants with soil characeyeristics

	Family plant	Species plant
Family plant		**0.99875**
Species plant	0.0012461	
Sand	0.6075	0.56711
Silt	**-0.91761**	**-0.91179**
Clay	-0.42212	-0.37694
pH H_2O	0.22338	0.21985
pH KCl	**-0.87168**	**-0.86709**
C	**0.88385**	**0.90345**
N	**0.85742**	**0.87964**
C/N	**0.85245**	**0.86959**
P- potential	0.68206	0.70977
K-potential	0.3575	0.33652
P-available	0.79276	**0.81439**
K-available	0.31856	0.29481
Ca-exchangeable	0.55429	0.5494
Mg- exchangeable	**0.80445**	**0.82155**
K- exchangeable	0.35762	0.33498
Na- exchangeable	**-0.94105**	**-0.95207**
Total of exchangeable cation	0.64107	0.64286
Capacity Exchange Cation	0.64804	0.67658
Base Saturation	0.40427	0.37248
Acidity (Al^{3+})	-0.24455	-0.20628
Acidity (H^{+})	-0.12184	-0.087695
Pb	-0.27982	-0.28665
Cd	-0.6349	-0.5976
Co	0.33374	0.37929
Cr	-0.24238	-0.23435
Ni	**-0.80395**	-0.77406

Mo	0.090202	0.11883
Ag	0.31805	0.36487
Sn	0.14087	0.18914
Se	**0.87351**	**0.89652**
As	0.78683	**0.81601**
Fe	0.64791	0.68196
Mn	0.45755	0.44882
Cu	0.64073	0.61422
Zn	0.031446	0.039432
Al	0.17609	0.22428

Description: low/weak (0,200 - < 0,400); big enough/strong enough (0,400 - < 0,600); big/strong (0,600 - < 0,800); very large/very strong (0,8 - <1)

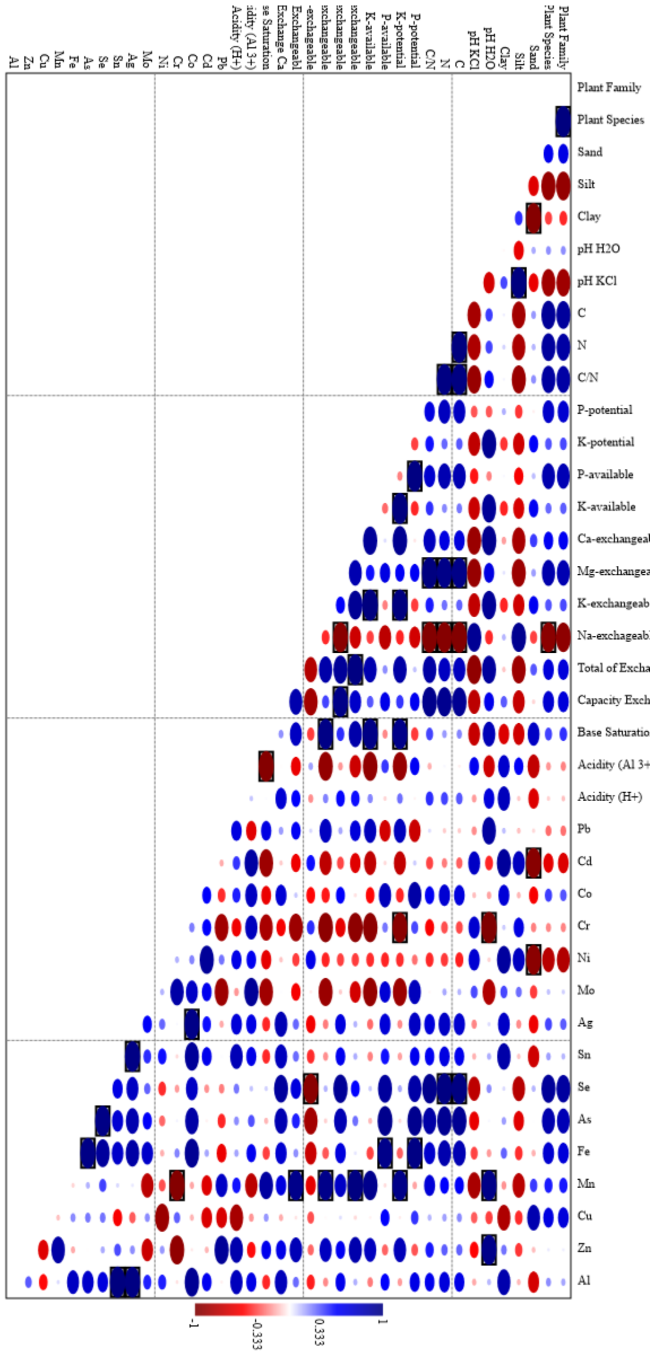

Figure 3 Pearson correlation plot between plant families and species with soil characteristics with a significance of p<0.05. Remark: ▭ p<0.05

4. CONCLUSION

The distribution of plants on four different lands in Bangka Island is affected by physical and chemical factors of the soil and the presence of heavy metals in the soil. Several factors have a very strong relation with the number of families and plant species, namely: C, N, C/N, available P, Mg_{exc}, silt, pH KCl, Na_{exc}, heavy metals Se, As, and Ni. The most significant correlation, namely a very strong and inverse relation between plant species and Na_{exc}. The higher the plant species, the lower the Na_{exc} and vice versa, the lower the plant species, the higher the Na_{exc}. The number of families and plant species in the forest is affected by potential and available P, C, N, C/N, CEC, Mg_{exc}, H_{exc}, total of exchangeable cations, clay, Fe, Al, Ag, Sn, Se, As , and Co, while tin mining revegetation land > 5 years is affected by potential and available K, Sand, pH H_2O, base saturation, K_{exc} , Ca_{exc}, Cu, Zn, Mn, and Pb. The low vegetation in tin mining revegetation land < 5 years is affected by Na_{exc}, while the absence of vegetation in active tin mining is affected by silt, pH KCl, Al_{exc}, and heavy metals Ni, Cr, Cd and Mo.

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