Physico-Chemical Properties of Ultrabasic Soil From Mibang, Ranau, Sabah

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ABSTRACT Assessment on the physico-chemical properties of ultrabasic soil from Mibang, Ranau for agricultural suitability was carried out. Physico-chemical parameters investigated includes soil pH, electrical conductivity (EC), cation exchange capacity (CEC), available macronutrients, heavy metals, organic matter and particle size separates. These parameters were evaluated for their suitability for rice crops by comparing with the MARDI standard. This assessment is necessary to enlighten whether this type of soil is suitable for cultivation. The results showed pH, electrical conductivity and organic matter content were within the suitable range for agriculture, cation exchange capacity was below the suitable value and the heavy metals Ni, Cr and Co were above the maximum allowable concentration (MAC) which is not suitable for agriculture. Whilst some physico-chemical properties of soil can be considered suitable for agriculture, the high amount of heavy metals rendered the soil unsuitable for paddy plant cultivation.

KEYWORDS: Ultrabasic soil; Soil suitability for paddy; Physico-chemical properties; Heavy metals; Maximum allowable concentration.

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INTRODUCTION

Breakdown of rocks material through physical, biological and chemical weathering processes transform the rock into soil and released different types of element which includes heavy metals. Soil developed from ultrabasic rocks released rich amount of Fe and Mg apart from Ni, Cr and Co elements. Ultrabasic soil is less fertile land with near neutral pH 5-6.5 and contains low organic carbon. The most important characteristic of this soil in relation to agricultural use is its infertility, low important macro nutrient and organic matter content, and high magnesium content which creates imbalance in nutrient contents. Heavy metals contents in weathered soil are highly inflated compared to their content in fresh rock Sahibin *et al*. (2008). Ultrabasic soil is unsuitable growing media for most of the plant due to various deficiencies like low N, P, K content, low organic matter content, low cation capacity exchange, low water holding capacity and low Ca:Mg ratio, besides high in heavy metal such as Ni, Cr, and Co. Low N, P, K content is due to slow nutrient cycle (Proctor, 1992; Burt *et al*., 2001). The objective of this paper is to assess the suitability of physico-chemical properties of ultrabasic soil in Mibang for agricultural purposes.

MATERIALS AND METHODS

This research was carried out in Mibang, Ranau, Sabah (Figure 1) located approximately 10 km from Ranau Town (6°0′32.28″N, 116°41′33.48″E). Mibang sit on an ultrabasic hill on the south-eastern flank of Mount Kinabalu and prosper as an agricultural area cultivated with oil palm, dryland rice, vegetables and fruit orchard. About 500 g of topsoil samples (0-30 cm) were taken from five sampling locations with stainless steel Dutch auger. Each sampling locations comprise of three replicates of samples. In the lab the soil were air dried and pounded to pass 2 mm sieve. For heavy metals analysis the soil is further crushed with agate mortar to pass 63 μm sieves.

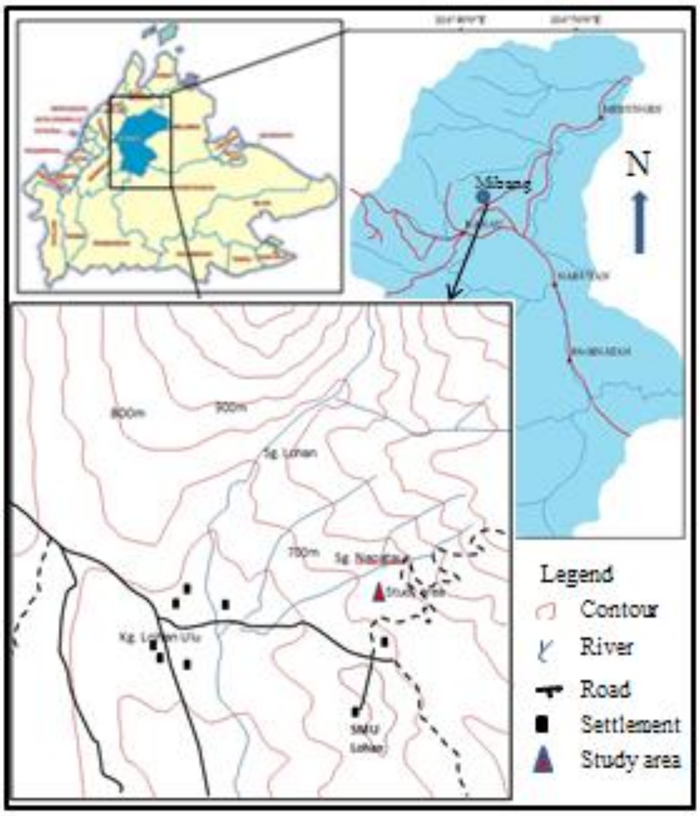

Figure 1. Location of the study area at Kampung Mibang, Ranau

Laboratory works as follow were carried out to determine the soil properties. Soil pH was analysed by using soil and distilled water ratio of 1:2.5 based on Metson (1956) and was measured by pH meter WTW INOLAB Level 1. Electrical conductivity was extracted using saturated gypsum (Massey & Winsor, 1968) and measured by meter conductivity device Model H 18819 Hanna. The cation exchange capacity (CEC) were obtained by the summation method of base cations (Ca^{2+}, K^{+}, Ca^{2+}, Mg^{2+}) and acid cations (Al^{3+} and H^{+}) (Mclean, 1965). Available nutrients in soils were extracted using 0.5 M ammonium acetate-acetic acid ($NH_4CH_3CO_2$-CH_3COOH) solution (Rowell, 1994) and determined using the ICP-OES instrument. Organic matter content was determined using the gravimetric method (Avery & Bascomb, 1982). The soil particle size distribution of the soil samples was determined by using the dry sieving and pipette method (Abdulla, 1966). Heavy metals content in soil were extracted using the USEPA (1996) method 3050b.

RESULTS AND DISCUSSIONS

Table 1 presented the mean and standard deviations value of physico-chemical parameter of soil analysed at different sampling stations which is A1, A2, L1, L2 and L3 at Mibang Ranau, Sabah. The soil pH mean value of all the sampling stations are 5.89 which can be classified as acidic with moderate nutrient availability for P, high availability for Ca and Mg based on Landon (1991).There is no significant difference in pH values and the available nutrients between stations. The percentage of organic matter at the sampling area is moderate based on Acres *et al*. (1975) classification. The effects of the organic matter in the soil on the mobility of metals in the soil are pH-dependent (Yap *et al*., 2009; Kabata-Pendias, 2011; Roslaili *et al*., 2015). The mean of the soil conductivity of the soil at the sampling area was 2.26 mS/cm with value ranged from 2.20 to 2.37 mS/cm. This EC value is equivalent to other ultrabasic soil such as at Felda Rokan Barat (Sahibin *et al*., 2012). Thus, it is classified as salt free (Landon, 1991). According to Singh *et al*.(2009) and Chaoua *et al*. (2019), higher electrical conductivityof soil will contribute to the enhancement of the heavy metals availability by plants.

Table 1. Mean values of the physico-chemical properties of the ultrabasic soils

	Unit	Station				
Parameter		A1	A2	L1	L2	L3
OM	%	5.55 ± 1.24b	6.81± 1.11ab	7.46 ± 1.11ab	7.65 ± 0.82a	8.03 ± 1.02a
Available Nutrient						
K	mg/kg	190.00 ± 72.32b	278.66 ± 79.00ab	301.70 ± 37.07a	369.10 ± 93.56a	392.96 ± 60.99a
P	mg/kg	10.42 ± 1.74a	10.09 ± 4.04a	12.74 ± 4.42a	12.20 ± 2.89a	15.04 ± 17.98a
Mg	mg/kg	473.86 ± 122.79a	419.95 ± 73.74a	299.22 ± 34.11a	374.38 ± 86.79a	477.19 ± 180.21a
Ca	mg/kg	1800.53 ± 456.64a	1410.80 ± 796.63a	1244.29 ± 157.21a	1413.87 ± 404.77a	3865.93± 3561.15a
Total Heavy Metal Content						
Ni	mg/kg	2030.31±104.64a	1174.16± 1013.58a	1794.43± 49.43a	1877.07± 4.63a	1743.10 ± 83.93a
Cr	mg/kg	7261.83±383.45ab	6667.85± 227.64b	7052.32± 303.71ab	7300.96± 290.24a	6488.74± 465.66b
Co	mg/kg	244.22±12.32ab	125.88± 101.25abc	247.07± 6.74a	216.82± 16.14bc	191.02±16.62c
Fe	mg/kg	265202.32±17171.98	244867.16± 14771.94	241602.68± 3498.82	244255.75± 6823.22	228209.11± 11966.95
Mn	mg/kg	1484.39±166.90bc	1299.32± 128.23c	2147.46± 181.07a	1579.06± 72.45b	2221.67± 845.19ab
*CEC	meq/100g	6.80±1.93a	6.23±3.20a	7.36±0.71a	7.79±1.58a	13.64±5.25a
pH		5.90±0.25a	5.84±0.41a	5.74±0.06a	5.85±0.06a	6.13±0.60a
#EC	mS/cm	2.20 ± 0.11a	2.22 ± 0.13a	2.24 ± 0.07a	2.37 ± 0.07a	2.27 ± 0.11a
Sand	%	16	14	8	7	10
Silt	%	45	54	55	52	46
Clay	%	39	32	37	41	44
Texture		Silty clay loam	Silty clay loam	Silty clay loam	Silty clay	Silty clay

*Cation Exchange Capacity, #Electrical Conductivity, +Organic Matter

The mean value of cation exchange capacity (CEC) of the soils for all the stations is 8.36 meq/100g with range 6.23 to 13.24 meq/100 g. This CEC value classified it as low according to Landon (1991) classification. In the previous study by Tashakor (2014) the mean value of ultrabasic soil CEC is 9.33 meq/100g. CEC in the soil is important to indicates the fertility of soil. However, the value of CEC usually vary in the soil as it is affected by clay and organic matter of the soil (Sariam,2008; Kabata-Pendias, 2011).

The soil texture of the ultrabasic soil silty clay loam and silty clay which indicates that the soil has high percentage of silt and low percentage of clay and sand. Particle size of the soil is responsible in providing the exchange bases for plant absorption from soil (Kabata-Pendias, 2011).

Table 2 shows the physico-chemical properties of soil that is suitable for paddy cultivation. This value was suggested by Malaysian Agricultural Research Development (MARDI) regarding the suitability of soil for paddy cultivation (Sariam, 2008). This table show that soil pH, organic matter content and electrical conductivity in the study area comply with the values given by Sariam (2008) thus are suitable for agriculture. However the CEC value and clay content does not comply.

Table 2. Physico-chemical properties of soil suitable for paddy cultivation

Soil Properties	Sariam (2008)	**This Study (2019)**	*MAC (Kabata-Pendias, 2011)	Suitability
pH	5.5 - 6.5	5.74-6.13	-	Yes
Electrical conductivity (mS/cm)	<2.0	2.20-2.37	-	Yes
Organic matter (%)	2.0 – 3.5	5.5-8.0	-	Yes
#CEC (meq/100g)	>20	6.23-13.24	-	Marginal
Clay composition (%)	>50	<44	-	Marginal
Available Zn (mg/kg)	>1.0	-	-	-
Total P (mg/kg)	>200	-	-	-
Exchangeable K (mg/kg)	>78.2	-	-	-
Total Cr (mg/kg)	-	6488.74-7300.96	75-100	No
Total Ni (mg/kg)	-	1174.76-2030.31	100	No
Total Co (mg/kg)	-	125.88-244.22	25-50	No

*Maximum Allowable Concentration, #Cation Exchange Capacity

Chromium and Ni content in soil is very high with range 6488.74±465.66 to 7300.96±290.24 mg/kg and 1174.16±1013.58 to 2030.31±104.64 mg/kg, respectively. These values are in accordance with results obtained by Sahibin *et al*. (2019) for the adjacent area of Ranau Sports Complex. These values already exceeded the maximum allowable concentration (MAC) in soil (Kabata-Pendias, 2011). Cobalt content is also high and exceeds the MAC concentration. Iron (Fe) content was considered as extremely high for all stations with mean values above 20,000 mg/kg. Study by Sahibin et al. (2008) on the weathering of andesite rock show that the concentration of heavy metals in soil inflated many times compared to their content in the rock.

CONCLUSION

It was shown in this study that the size separate of ultrabasic soils are dominated by silt fraction. It contains low cation exchange capacity, moderate availability of P, and high availability of Ca and Mg. Organic matter content is moderate whereas electrical conductivity and pH is optimum for plant growth. The concentration of heavy metal exceeds the maximum allowable concentration (MAC) that rendered this soil unsuitable for paddy plant cultivation.

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