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Research Article

N, P and K storage efficiency on degraded peat soil through ameliorant application

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Abstract: The availability of nutrients, especially N, P, K in the degraded peat are very low. The high organic acids can decrease the soil pH, its causes the negatively charged nutrients such as nitrate and phosphate are also very low. Ameliorant contributes some cations both monovalent and polivalent which acts as a bridge cations, thus increasing the availability of nutrients, especially nitrogen and phosphate. The objective of research was to determine the storage efficiency of N, P, K on application of some ameliorants on degraded peat land. The experiment was conducted at the laboratory of ISARI, Banjarbaru. Peat soil collected from the degraded peat land at Kalampangan, Central Kalimantan. The treatments were 8 ameliorant formula and two control treatments (+NPK and -NPK). The treatments were arranged in CRD, with 3 replications, And using soil coloum (lysimeter). The leaching was conducted every once a week, with 1.25 liter of aquades and the volume of leachate would be recorded. N, P, K concentration in leachate were analyzed periodically at 1, 2, 4, 6, and 8 weeks after incubation. The results showed that the concentrations of N and K on each observation time were relatively same, but P increased significantly at 4 weeks after incubation. The highest concentrations of N, P, and K in leachate were ameliorant from 100% of chicken manure. The storage efficiency of N, P and K varied depending on the type of ameliorant. Ameliorant that improved storage efficiency of N and K was ameliorant which consist of 80% agricultural weed + 20% dolomite, whereas for P efficiency storage was on ameliorant which consist of 80% Chinese water chestnut (*Eleocharis dulcis)* + 20% dolomite.

***Keywords**: ameliorant, efficiency, nitrogen, peat, phosphorus, potassium*

Introduction

Peat land is one potential area for agricultural purpose. Indonesia has 14.91 million ha or 50% of the peat in the tropics. Peat land distributes mainly in three major islands, covering 4.778.004 ha in Kalimantan, and 6.436.649 ha and 3.690.921 ha in Sumatra and Papua respectively (Ritung et al., 2012).

Peat land degradation can occur due to the improper management and the land fires. The indicators of peat land degradation is decreasing in water holding capacity, increasing of soil acidity, decreasing of total organic carbon (TOC) and total-N (Anshari, 2010). The main constrain in increasing the productivity of degraded peat land is soil acidity and the presence of a hydrophobic condition on top layer of peat. Availability of nutrients, especially N, P, and K are very low as well as other micro nutrients such as Cu and Zn. Soil acidity is caused by dissolution of organic acids as a result of further of organic matter decomposition. The last product of peat decomposition is humic substances (Mackowiak et al., 2001). Humic acids consist of organic materials that resist from decomposer with a high molecular weight, and generally dark in color and resistant to biological weathering (Logan et al., 1997). A weathered soil humic material is because of physically protected from microbial decomposers by occurrence of complex organo-mineral so it protects against microbial enzymatic (Qualls, 2003).

The low P availability in the peat soil is because the low ability of peat soils to adsorb P, so that most of P is leached out before it is absorbed by plants. Nitrogen form that often found in degraded peat lands is nitrate.

Ammonium in the oxygen-rich soil conditions become unstable and rapidly oxidized to nitrate with the outcome of NO and N_2O (Regina, 1998). Nitrate in peat land is easily leached because it is negatively charged, so it is quickly lost from the root zone. Efficiency of nutrient storage can be improved by reducing the loss of nutrients from the root zone. Negatively charged nutrients (nitrate and phosphate) in order to survive in the environment of plant roots need delivery cations act as “a cation bridge”.

Availability of K in peat land is also generally low, except in peat land that had been intensively cultivated. Potassium in peat land is one of nutrients that easily leached, because it does not form a coordination bond with a functional group of peat (Adriesse, 1988; Stevenson, 1994). Humic compounds containing active site -COOH and -OH to form coordination bonds with polyvalent cations, but not with monovalent cations (Suranta et al., 1993).

Complexation and dissolution of nutrients on peat land are affected by ameliorant used. Ameliorant is a material added to marginal soil for improving soil fertility and support plant growth (Brown et al., 2007). Research on peat land amelioration had been frequently conducted, among other by Masganti (2003) and Supriyo (2006), using lime at rate of 5 to 5.2 t/ha to raise the pH of saprist peat from 3.34 to 4.5. Amelioration using 20 t/ha chicken manure was reported to increase corn yield (Utami, 2010). Formulation ameliorant consisted of 16 t/ha mineral soil + 1.5 t/ha calcite + 3 t/ha dolomite + 80 kg/ha iron was able to increase soybean yield as 1.77 t/ha (Saragih, 1996). However, specific research about amelioration for the degraded peat land using in situ material is still limited.

Appropriate land management on degraded peat land soil for agricultural sustainability should include soil amelioration. Ameliorant materials have different potential to improve soil fertility, depending on the composition of the material. Fe^{3+}, Al^{3+} and Cu^{2+} on peat soil can increase the P retention when compared with no provision of these cations (Rachim, 1995). P retention capacity of peat soil will increase with increasing content of Fe^{3+} and Al^{3+} (Suryanto, 1993). P can be bound strongly on peat soil through cation bridges, so it is difficult to leach (Mattingly, 1985). Ameliorant formulation of several different materials is intended to improve the quality of the storage efficiency of nitrogen, phosphorus and potassium in degraded peat lands. The purpose of this study was to determine the efficiency of storage N, P, and K through the formulation of some ameliorant in degraded peat land.

Materials and Methods

The experiment was conducted at the Laboratory of Indonesian Swampland Agricultural Research Institute (ISARI) Banjarbaru, South Kalimantan. Peat soil was collected from the burning peat at Kalampangan village, Palangkaraya, Central Kalimantan. The study was conducted in March - June 2011. Peat soil was collected from 0-25cm depth, the 0-5 cm of layer was in hydrophobic conditions, while the hydrophilic layer was in 5-25cm. The treatments consisted of 8 types of ameliorant formula and 2 control treatments i.e. with NPK compound fertilizer (15:15:15) and without NPK compound (Table 1).

Table 1. The composition of the formula used in the study ameliorant

Code	NPK fertilizer	Composition of treatment (%)				
		Chicken manure (PA)	Agricultural weed (GP)	Mineral Soil (TM)	Purun tikus grass (PT)	Dolomite (KD)
A1	+	80				20
A2	+		80			20
A3	+			80		20
A4	+	20	20	20	20	20
A5	+	19.05		71.45		9,5
A6	+	50	50			
A7	+				80	20
A11	+	100				
K1	+	Without ameliorant				
K2	-	Without ameliorant, without NPK fertilizer				

Treatments were arranged in completely randomized design with three replicates. Ameliorant dose was 20 t/ha, equivalent to 8% of the weight of the peat soil to a depth of 25cm. Volume of leaching water was 1250 mL for each leaching. This volume was based on the average amount of rainfall in the area Kalampangan village, Central Kalimantan.

Ameliorant materials consisted of: (1) mineral soil (Spodosol) collected from the Tangkiling village (± 25 km from the study site), (2) agricultural weeds, (3) chicken manure, (4) Chinese water chestnut (*Eleocharis dulcis*) and (5) dolomite, with a nutrient composition similar to that presented in Table 1.

Agricultural weeds used were mixtures of weeds under the crop of sweet corn around the study site that is dominated by "grinting" grass (*Cynodon dactylon*), and *Agerathum conyzoides*, and kentangan (*Borreria latifolia*). Chinese water chestnut (*Eleocharis dulcis*) that is a specific type grass in tidal swamplands was collected from Pulang Pisau District, Central Kalimantan. Before application, agricultural weed in situ and Chinese water chestnut were chopped to size of ± 2cm. Dolomite was used for liming.

Before application, the ameliorant materials were mixed, according to the appropriate treatments, and composted (no added decomposer organisms) for 2 weeks. Compost of ameliorant material were placed into polybags and mixed with peat soil at 120% moisture content based on oven dry weight of the peat.

One kilogram of soil under natural conditions (not air-dried) was mixed with appropriate ameliorant included in lysimeter that made from plastic pots (PVC pipe) with a height of 25cm and a diameter of 16cm. The bottom of PVC pipe was closed with cap cover pipe, riddled at the middle and put connections of water outlet. Put a filter paper at the top and bottom of pipe (Figure 1). Except for the control treatment (K2), all treatments were applied with 300kg/ha NPK fertilizer. The leachate water was collected in a container for chemical analysis of N, P, and K contents of the ameliorant (Table 2).

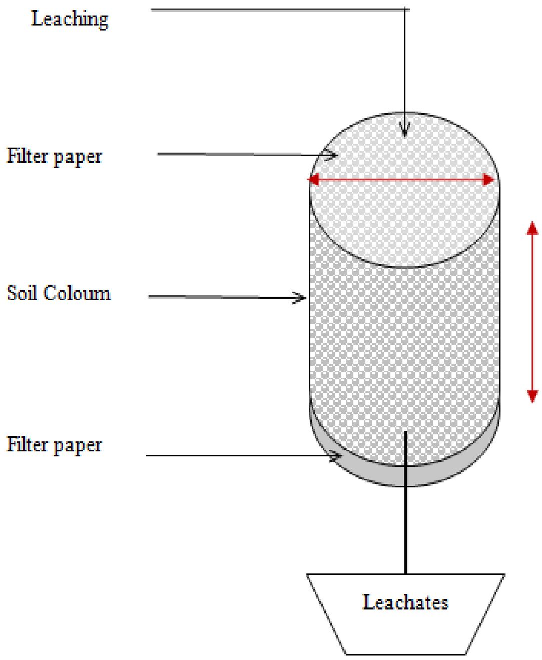

Figure 1. Scheme of lysimeter

Table 2. Nutrient content of some materials used as ameliorant

Ameliorant materials	C	N	P	K	C/N	Ca	Mg	Na	Fe	KA	pH
	%										
Chicken manure	31.93	1.64	0.64	1.26	19.49	5.30	2.32	1.15	1.80	10.56	7.17
Agricultural weed	44.86	0.94	0.25	1.02	47.66	0.91	0.26	1.02	0.04	20.02	4.45
Purun tikus grass	44.48	1.18	0.08	0.99	37.82	0.85	0.19	0.99	0.16	16.11	4.12
Mineral soil	2.45	0.09	nd	nd	25.00	0.02	0.01	nd	0.03	5.39	4.56
Dolomite	nd	nd	nd	nd	-	22.83	8.86	nd	nd	nd	8.32

nd = not detected

Storage efficiency N or P or K peat material was determined by the formula below (Masganti, 2003; Utami, 2010).

$$\text{EP}(\%) = \frac{\text{mg N or P or K (applied - leached)}}{\text{mg N or P or K applied}} \times 100$$

Results and Discussion

Concentrations of N, P, and K in leachate

Concentration of N in leachate showed the differences among treatments (Table 3). The highest concentration of nitrogen was on the treatment without ameliorant (K1). The N concentration among observation time was different depending on the type of ameliorant. However, on each observation time, N concentration was consistently higher that of the control treatment + NPK (K1) which was not different with treatment of ameliorant 100% chicken manure (A11). Ameliorant application absolutely is needed in order to improve peat soil fertility. Besides contributing N, P, K nutrients, it also contribute cations, that act as "cation bridge" between the functional groups of peat with nutrients, especially nitrates and orthophosphate. Chicken manure contained high N, low value of C/N ratio, lignin and cellulose so that the rate of mineralization was faster than other ameliorants.

Chicken manure that was not combined with dolomite or other materials containing high cations increased the loss of N through leaching. N mineralization rate in peat soils with good aeration was fast, and NH_4^+ will be rapidly oxidized to NO_3^- (Kurnain, 2005), negative charged of nitrate cannot bind to the functional groups. As reported by Ruckauf et al. (2004), the NO_3^- in peat soil is very easy to move and leached. Most of the N in the peat soil surface is quickly leached thus affecting the quality of surface water (Droogers et al., 2007).

There was an increase of N concentration in leachate at 2-6 week after incubation (WAI), and decreased at 8 WAI. The decrease of N, P, and K concentrations at 8 WAI indicated that nutritions from fertilizer and ameliorant materials decreased during the observation time. The concentration of P in the leachate was significantly different among treatments (Table 4). The high P concentration was consistent at several observation time and also showed on K1 (control + NPK) which was not significantly different from treatment A11 (100% chicken manure). The chicken manure treatment was rapidly supply P, but the released P did not survive for long time in the exchange complex and was very easily leached, so it needed cation that act as a cation bridge. Cations will replace the H^+, and the amount of H^+ released depends on the valence of the cations used.

Furthermore, there will be an exchange between the OH^- with $H_2PO_4^-$, while the cation will serve as a bridge connecting the two oxygen atoms with the reactive groups of organic material P. The number of H^+ ions released in the adsorption reaction would determine the amount of P adsorbed, so that P sorption amount is determined by valence of cations into a cation bridge (Zhu and Alva, 1993).

The ability of peat soil in storing P is very low, and the cation bridge is necessary between the functional groups of peat with P, so that P remains on the exchange complex and protected from leaching (Masganti, 2003).

Real changes in the concentration of P in the leachate were observed at several observation times (Table 4). But the trend showed that P concentration in leachate increased up to 4 weeks after incubation, then decreased at 6-8 weeks after incubation. The decrease of P concentration decreased at sixth week might be due to the role of base cations as a bridge between P ions with organic groups (P - Ca - COO-), so that P was not leached. As reported by Moilanen et al. (2005) applying Ca and Mg of ash on peat soil can depress loss of P which is applied by fertilizer, because it is bound by Ca and Mg.

The amount of P released from fertilizer and ameliorant decreased at sixth week, so that P leaching was also lower compared to the beginning of the incubation time. In general, concentration of P leached was higher than N and K. Phosphorus availability in the peat soils is generally low so that the plants are often deficient in P. Degraded peat land contains low organic P associated with fulvic and humic acids in the top layer and increases with increasing depth of peat (Ziolek, 2007).

Peat soils have low ability to adsorb P fertilizer (Maas, 1997). This is because the peat soil contains many reactive functional groups with low molecular weight i.e. citric acid, malic and oxalic and functional group of high molecular weight humic and fulvic acids. The functional group has a negative charge, so cation bridge is needed for persisting phosphate in the sorption complex. Reactive functional groups such as carboxylate adsorb P with the weak bond strength (Stevenson, 1994). The type of sorption on peat soil is a specific sorption form that induced by ligand exchange (Tan, 2003).

Addition ameliorant containing cations is expected to reduce the leached since cations can act as a bridge cations between P with functional group peat (Masganti, 2003). Hartatik et al. (2004) reported that Fe cations is capable of improving the provision of storage capacity P by peat, so the loss of P through leaching can be reduced. The influence of the concentration of K type ameliorant leached in water is presented in Table 5. High K concentration in leachate at each observation time was indicated by control treatment with NPK fertilizer (K1).

Table 3. Concentration of N in leachate

Treatment *)	Code	Concentration of N in leachate (mg/L)									
		Weeks after incubation									
		1		2		4		6		8	
80%PA+20% KD	A1	11.67	bc	14.26	be	15.87	bc	13.25	ab	11.67	ab
80% GP+20%KD	A2	7.47	bc	9.78	cde	5.60	d	9.15	ab	4.48	ab
80% TM+20% KD	A3	4.67	bc	4.48	de	5.60	d	18.20	ab	9.80	ab
20%PA+20%GP+20% PT+20%TM+20%KD	A4	13.07	b	21.28	abc	9.61	cd	8.87	ab	8.68	ab
19,05%PA+9,5%KD+71,45%TM	A5	10.27	bc	12.62	be	7.09	d	15.21	ab	16.61	a
50% PA+50%GP	A6	8.40	bc	14.91	cde	19.88	b	18.67	ab	11.20	ab
80%PT+20%KD	A7	10.73	bc	18.25	ad	4.85	d	9.15	ab	9.80	ab
100% PA	A11	23.33	a	24.55	ab	17.73	b	16.33	ab	8.40	ab
CONTROL + NPK	K1	25.17	a	29.27	a	27.93	a	19.70	a	17.57	a
CONTROL - NPK	K2	2.50	c	1.54	d	1.48	d	1.42	b	0.33	c
Mean periodic		11.73		15.68		11.734		12.99		9.85	

*) PA = chicken manure, GP = agricultural weeds, PT = purun tikus grass, TM = mineral soil, KD = dolomite. The numbers followed by the same letter in the same column indicates no significant different between treatments by DMRT test α = 5%.

Table 4. P concentration in leachate water

Treatment *)	**Code**	**P concentration in leachate water (mg/L)**									
		Weeks after incubation									
		1		**2**		**4**		**6**		**8**	
80%PA+20% KD	A1	9.54	cde	34.97	abc	36.61	abc	29.66	ab	28.54	ab
80% GP+20%KD	A2	6.33	de	29.91	abc	14.26	bc	13.12	bc	14.18	ab
80% TM+20% KD	A3	6.33	de	10.46	bc	23.11	bc	22.78	abc	28.75	ab
20%PA+20%GP+20% PT+20%TM+20%KD	A4	15.9	bd	42.18	ab	31.87	abc	22.99	abc	23.15	ab
19,05%PA+9,5%KD+71,45%TM	A5	11.53	be	22.71	abc	50.08	ab	30.08	ab	24.16	ab
50% PA+50%GP	A6	23.86	a	35.53	abc	48.48	ab	23.13	abc	22.5	ab
80%PT+20%KD	A7	3.14	e	51.14	a	13.13	bc	13.14	bc	15.21	ab
100% PA	A11	17.86	abc	42.52	ab	65.9	a	32.6	ab	25.48	ab
CONTROL + NPK	K1	21.75	ab	33.56	abc	68.15	a	50.28	a	35.08	a
CONTROL - NPK	K2	3.28	e	3.55	c	2.28	c	0.77	c	0.82	b
Mean periodic		12.22		30.74		35.39		23.86		21.79	

*) PA = chicken manure, GP = agricultural weeds, PT = purun tikus grass, TM = mineral soil, KD = dolomite. The numbers followed by the same letter in the same column indicates no significant different between treatments by DMRT test α = 5%.

Table 5. K concentration in leachate

Treatment *)	**Code**	**K concentration in leachate (mg/L)**									
		Weeks after incubation									
		1		**2**		**4**		**6**		**8**	
80%PA+20% KD	A1	13.30	ab	14.54	ab	13.62	abc	20.80	a	20.84	ad
80% GP+20%KD	A2	8.29	b	13.32	ab	20.32	abc	6.39	ab	7.19	de
80% TM+20% KD	A3	10.24	b	14.93	ab	10.65	bc	17.22	a	25.30	abc
20%PA+20%GP+20% PT+20%TM+20%KD	A4	15.50	ab	22.31	a	11.03	bc	11.12	a	11.55	be
19,05%PA+9,5%KD+71,45%TM	A5	8.47	b	12.43	ab	8.24	bc	15.07	a	14.45	ae
50% PA+50%GP	A6	15.03	ab	21.90	a	19.29	abc	20.45	a	27.11	ab
80%PT+20%KD	A7	15.55	ab	26.04	a	7.55	bc	6.20	ab	5.18	de
100% PA	A11	15.85	ab	18.83	ab	27.02	ab	18.79	a	9.69	cde
CONTROL + NPK	K1	23.75	a	25.46	a	32.21	a	18.56	a	29.39	a
CONTROL - NPK	K2	6.09	b	3.17	b	2.50	c	1.50	b	0.17	e
Mean Periodic		13.19		17.73		15.24		13.61		15.09	

*) PA = chicken manure, GP = agricultural weeds, PT = purun tikus grass, TM = mineral soil, KD = dolomite. The numbers followed by the same letter in the same column indicates no significant different between treatments by DMRT test $\alpha = 5\%$.

There was a significant change in K concentration among time of observation on all types ameliorant, except in ameliorant A6, A7 and A11.

Treatment consisting of 100% chicken manure (A11) tended show higher concentration of K in leachate than the other treatments at the first and third weeks after incubation. This condition explained that organic material containing high nutrients are easily decomposed and mineralized to quickly release nutrients, but the K released will also be easily leached. In peat land, potassium is a nutrient that is relatively leached rapidly, due to no coordination bond with a functional group of peat (Adriesse, 1998; Stevenson, 1994).

Humic compounds containing active site -COOH and -OH to form coordination bonds with polyvalent cations, but not with monovalent cations (Eedogan et al., 2007). K interaction with humic acid occurs due to the differences between two polar characteristic, thus forming heteropolar salts (Thompson and Troeh, 1978). Potassium is an essential nutrient that is relatively mobile in peat, therefore it is easy to leach (Bohn et al., 2001; Gorham and Janssens, 2005).

Storage efficiency of N, P, and K

Storage efficiency of N, P and K was calculated from the amount of N, P, and K supplied from NPK fertilizer subtracted with leached N, P, and K. The amount of leached N, P, and K from the known concentrations of N, P, and K leached in water multiplied by the volume of water leached. Total of leached N, P, and K is the concentration of leached N, P, and K multiplied with the volume of leachate. Amounts of leached N, P, and K during the experiment are presented in Table 6.

Table 6. Total leached N, P, and K during the observation

Treatment *)	**Code**	**Amount of N, P, and K leached (mg)**					
		N		**P**		**K**	
80%PA+20% KD	A1	81.29	bc	157.13	a	91.27	bc
80% GP+20%KD	A2	45.61	d	103.23	b	73.48	c
80% TM+20% KD	A3	56.98	cd	113.05	b	91.26	bc
20%PA+20%GP+20%PT+20%TM+20%KD	A4	81.97	bc	173.27	a	89.89	bc
19,05%PA+9,5%KD+71,45%TM	A5	84.74	bc	175.68	a	77.89	bc
50% PA+50%GP	A6	96.09	b	173.99	a	97.39	bc
80%PT+20%KD	A7	75.41	bc	82.17	b	99.89	b
100% PA	A11	104.07	ab	186.09	a	111.08	c
CONTROL + NPK	K1	125.77	a	197.93	a	156.49	a
CONTROL - NPK	K2	7.62	e	10.18	c	13.99	d

*) PA = chicken manure, GP = agricultural weeds, PT = purun tikus grass, TM = mineral soil, KD = dolomite. The numbers followed by the same letter in the same column indicates no significant different between treatments by DMRT test α = 5%

Total leached N, P, and K most often occurred in K1 treatment (control + NPK) and A11 (100% chicken manure), followed by A6 (50% chicken manure + 50% agricultural weeds) to N, and A7 (80% Chinese water chestnut + 20% dolomite) for K. Based on the incubation experiment, chicken manure increased the availability of N, P, and K, but they were rapidly leached. Dolomite in chicken manure contributed base cations (Ca and Mg) that reduced leaching, especially for phosphate and nitrate ions. Storage efficiency of N, P, and K was small in K1 (control) and 100% chicken manure (A11) (Table 7)

Chicken manure has higher content of N, P, and K than other materials and release N, P, and K more rapidly, so it made the highest chance for leaching. The nutrient content of the treatment did not directly determine storage efficiency. Storage efficiency of N and K have the highest value on A2 (80% of agricultural weeds + 20% dolomite).

Compared with Chinese water chestnut, the agricultural weeds had more complete nutrient composition, higher cellulose and lower lignin content, therefore it was easier to decompose. Application of dolomite improved ameliorant decomposition to contribute alkaline cations. A2 treatment (80% of agricultural weeds + 20% dolomite) supplied a balance amount of anions and cations in peat solution, so storage efficiency of N, P, K were higher than the others.

The highest P storage efficiency was on A7 (80% Chinese water chestnut + 20% dolomite) followed by A2 (80% agricultural weeds + 20% dolomite). Chinese water chestnut, contained higher Fe than agricultural weeds (Table 2). Fe ions can increase the strength of the bond between phosphate ions with functional groups of peat compared than Al^{3+}, Ca^{2+}, Cu^{2+}. Fe can act as a bridge cation (binder) of P ion at the site by forming a complex reactive organic peat-Fe-P, so P is not lost by leaching (Litoar et al., 2005).

Table 7. Storage efficiency of N, P, and K

Treatment *)	Code	Storage efficiency of N, P, and K (%)					
		N		P		K	
80%PA+20% KD	A1	45.80	bc	22.97	b	54.96	ab
80% GP+20%KD	A2	65.59	a	50.12	a	63.62	a
80% TM+20% KD	A3	52.01	ab	44.58	a	52.34	ab
20%PA+20%GP+20%PT+20%TM+20%KD	A4	45.80	bc	15.06	b	55.35	ab
19,05%PA+9,5%KD+71,45%TM	A5	43.51	bc	15.52	b	61.62	a
50% PA+50%GP	A6	35.51	cd	14.71	b	52.06	ab
80%PT+20%KD	A7	47.95	ab	60,00	a	55.82	ab
100% PA	A11	32.88	cd	10.69	b	42.46	d
CONTROL + NPK	K1	16.15	d	2.98	b	24.97	c

*) PA = chicken manure, GP = agricultural weeds, PT = purun tikus grass, TM = mineral soil, KD = dolomite. Numbers followed by the same letter in the same column indicates no significant different between treatments by DMRT test α = 5%.

Stability of complexes between humic acid-metal is getting weaker in the order of $Al^{3+}>Fe^{3+}>Mn^{2+}>Zn^{2+}>Mg^{2+}>Ca^{2+}$ (Tan, 2003). Ameliorant formulations by combining several ingredients are needed in addition to overcome ameliorant material limitation, as well as to improve the effectiveness of the ingredients in improving the fertility of degraded peat.

The amount of storage efficiency of N, P, and K varied depending on the type of ameliorant. Overall storage efficiency of elements of K > N > P. The lowest N storage efficiency was shown by the control treatment (K1), ameliorant entirely with chicken manure (A11) and ameliorant with the composition of 50% chicken manure + 50% agricultural weeds (A6). Whereas P and K storage efficiency were obtained on K1 and A11 treatment. The addition of dolomite is needed to improve soil fertility in degraded peat land. Dolomite can increase soil pH, and able to increase storability P in these soils.

Conclusion

The results showed that the concentrations of N and K at each observation time were relatively uniform, but P increased significantly at 4 weeks after incubation. The highest concentration of leached N, P, and K was on ameliorant with 100% chicken manure. Storage efficiency of N, P and K varied depending on the type of ameliorant. Ameliorants that improved storage efficiency of N and K were ameliorants consisted of 80% agricultural weed + 20% dolomite, while P was on ameliorant consisted of 80% Chinese water chestnut + 20% dolomite. The addition of dolomite is needed to improve soil fertility in degraded peat land. Dolomite can increase soil pH, and able to increase storability P in these soils.

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