Chapter

Coastal Sediment as an Ameliorant in Post-Mining Land Management

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Abstract

Coastal sediment is a sediment resulting from sedimentation of eroded materials from up land through river flows that are deposited around the coast. It usually contains a lot of alkaline cations, especially Na so that it is good enough to decrease soil acidity. The use of coastal sediment must be considered carefully because it has a high level of salinity, which can inhibit plant growth and even cause death. Coastal sediment as an ameliorant can replace the role of lime in increasing the pH and base saturation of soil. Applying coastal sediment to sandy or post-gold mining soils can reduce soil acidity, increase soil CEC and soil base saturation, as well as the availability of nutrients, especially nutrients, phosphorus, potassium, calcium and magnesium. Improvement of some of these soil properties will encourage increased growth and crop yields in post gold mining land.

Keywords: ameliorant, coastal sediment, crop yield, post gold mining

1. Introduction

Apart from being one of the pillars of a country's economy, gold mining activities also contribute greatly to the rate of land degradation [1]. Furthermore, Ref. [2] explained that the result of the mining process has caused soil damage, water pollution, and the destruction of natural vegetation. If the land is left without reclamation activities, it will become critical land. Physically, the topsoil is dominated by sand particles so that the soil becomes very porous [3]. Soil that is dominated by sand causes some of the chemical properties of soil in post-mining land to be low in its ability to hold water and nutrients, have high acidity and low cation exchange capacity and base saturation [4]. Further, Ref. [5] explained that during the mining process it will destroy vegetation and some macro and micro-fauna that play a role in the processes of decomposition of organic matter and the cycle of nutrients in the soil.

Acidic soil is less able to support plant growth because some macro nutrient availability decreases if the soil pH becomes acidic. Macronutrients consisting of nitrogen, phosphate, potassium, calcium, magnesium, and sulfur, are not available or dissolve at acidic pH [6]. This is in contrast to micro-nutrients other than molybdenum which are more soluble or readily available at low pH. The level of solubility of these nutrients is often ignored in agriculture, especially by farmers who are still cultivating in traditional ways. By considering the level of solubility, a plant that is cultivated on acid soil, the nutrients that are available in large quantities are micro nutrients [7]. In fact, micro-nutrient elements that are actually only a few needed by plants are actually available in large quantities, so that they have the potential to cause poisoning to plants, for example plants become poisoned with iron (Fe) or aluminum (Al).

The high availability of micro-nutrients in acid soils also results in high bonds between soil ions. Iron, manganese and aluminum elements will bind strongly to macro nutrients, especially phosphorus. This results in the low availability of macro nutrients in acid soils. One of the ways to increase low soil pH is by liming the right amount, so that the macro nutrients needed by plants are available in large quantities and can be directly absorbed by plant roots. One of the constraints of liming is that the lime material must be imported from outside the area, so when it is needed lime is not available and the price is relatively expensive. Besides that, agricultural lime is inefficient because of its low residual level. One of the alternatives to limestone is coastal sediment which is abundant and widespread on the coast. Ref. [8] shows that coastal sediment as an ameliorant can replace the role of lime in increasing soil pH.

Utilization of coastal sediment must be carefully managed because it needs to be remembered that coastal sediment has a high level of salinity which can disrupt plant physiology and even cause death in these plants. However, it should be noted that in using coastal sediment, it is not necessary to use sediment that has been contaminated by heavy metals such as lead (Pb), mercury (Hg) and other heavy metals. Metals do not directly harm plants, but it is feared that the results of plant production if consumed will have an impact on human health [9]. Coastal sediment as an ameliorant can replace the role of lime in increasing pH and base saturation in peat soils [10]. In sandy soil/post gold mining soil which is dominated by sand fraction, application of coastal sediment can improve some of the soil properties. The addition of coastal sediment on sandy soil/land after gold mining, in addition to reducing soil acidity, can also reduce CEC, increase base saturation and the availability of cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Mn^{2+} and Fe^{2+}). Based on the description above, this chapter aims to explain the use of coastal sediment as an ameliorant in land management after gold mining for plant cultivation. This study aims to obtain the best dosage for coastal sediment to improve soil properties, growth and crop yields in post-gold mining land.

2. Charateristic of coastal sediment

Coastal Sediment is a material that is deposited by water (rivers and seas) in the form of a mixture of alluvial soil and organic matter. It is formed through the process of alluviation and collusion on land with long acid reactions, dissolving and carrying weak alkaline elements (Al, Fe, Mn) through the process of erosion and/or leaching. When alluvial/coluvial material finally settles in the sea, then marine silt deposits contain weak bases, Al, Fe, and Mn mixed with the strong bases Na, Ca, and Mg, which are contained in the sea. Weak basic elements (and their combination with weak acidic compounds) produce compounds that are "buffered", have a pH dependent ionic charge (pH dependence charge), positive (+) at low pH (acid reaction) and negative (−) at low pH. high pH (base reaction).

Buffer compounds increase the carrying capacity of nutrients, thereby increasing plant growth and productivity. Thus, the utilization of coastal sediment from fertilization/silication deposits has the potential to ameliorate acid soil. Coastal sediment acts as an ameliorant for the improvement of the physical and chemical (physico-chemical) components of the soil. The potential of coastal sediment in amelioration of physico-chemical properties needs to be assisted by ameliorant of soil biological characteristics. In agricultural practice, biological ameliorant is manure, which is rich in soil fertilizing microorganisms.

Coastal sediment is a sediment resulting from sedimentation of eroded materials from upland through river flows that are deposited around the coast. The nutrient content in coastal sediment varies greatly depending on the type of soil and the conditions of the area of origin of the sediment. Some of the chemical properties of coastal sediment taken from 3 locations (Kijing Beach; location I, Rasau Jaya Beach; location II and Muara Sungai Singkawang Beach; location III) can be seen in **Table 1**.

The results of particle analysis showed that the three coastal sediment from each location had different content of sand, silt and clay. The highest clay content was found in location II which was 56.47%. Thus the coastal sediment from Rasau Beach is suitable for application on gold ex-mining lands which in addition to increasing the pH will also improve several other soil properties. Especially to reduce the very high porosity of the used gold ex-mining soil and at the same time increase the holding capacity of soil water.

The highest pH value of coastal sediment is found in coastal sediment from Kijing Beach, which reaches 8.13 (**Table 1**), while coastal sediment from Rasau Beach and Singkawang River Estuary is only 7.72 and 7.14, respectively. Based on the pH data, coastal sediment from Kijing Beach can be used on all types of soil in the West Kalimantan Province with a relatively small amount compared to coastal sediment from other locations to raise the pH. Based on the nutrient content, each coastal sediment from the three locations has different advantages. Coastal sediment from location I had the highest total nitrogen content of 7.26%, while at locations II and III were 0.98 and 0.27%, respectively. Coastal sediment from location II has the highest P content than coastal sediment at locations I and III. The P content at location II was 10.24 ppm, while at locations I and III were 3.45 and 9.65 ppm, respectively. Coastal sediment from location II has the highest potassium content of 5.01 cmol (+) kg^{-1}, while at locations I and III are 1.71 and 3.76 cmol (+) kg^{-1}, respectively.

Soil chemical parameters	**Coastal sediment**		
	Location I	**Location II**	**Location II**
Tekstur			
Sand (%)	10,20	5,31	1,31
Silt (%)	51,85	38,22	44,79
Clay (%)	37,95	56,47	53,90
pH	8,13	7,72	7,14
C-organic (%)	1,96	1,18	2,05
N-total (%)	7,26	0,98	0,27
P Bray I (ppm)	3,45	10,24	9,65
K (cmol(+)kg^{-1})	1,71	5,01	3,76
Ca (cmol(+)kg^{-1})	14,62	65,10	11,44
Mg (cmol(+)kg^{-1})	1,73	10,24	3,81
Na (cmol(+)kg^{-1}	2,65	36,03	34,85
CEC (cmol$^{(+)}$$kg^{-1}$)	15,33	15,82	11,55
Base saturation (%)	>100	>100	>100

Table 1.
Characteristics of coastal sediment from several locations in West Kalimantan.

Coastal sediment from locations II and III has a higher sodium content than coastal sediment from location I. At location I the Na content is only 2.65 cmol (+) kg^{-1}, while at locations II and III the coastal sediment contains Na respectively 36.03 and 34.85 cmol (+) kg^{-1}, respectively. The Na content of 15 times from coastal sediment in location I is dangerous because Na has a bad effect on several soil properties [11]. Thus, in the use of coastal sediment from locations II and III, it is necessary to reduce Na by washing so that the Na content is lower.

The high Ca content of coastal sediment at location II (65.10 cmol (+) kg^{-1}) is not only a source of nutrients but also to maintain the balance of nutrients in the soil [12]. The base saturation (BS) data of coastal sediment is more than 100% so that the application of coastal sedimentis expected to increase soil pH and BS. Based on the comparison data of several chemical properties of the soil, coastal sediment from location I, namely Kijing beach, is the best coastal sediment as an alternative to lime compared to coastal sediment from locations II and III.

3. Characteristic of post-mining land

Land at the post-mining site without a permit has suffered considerable damage. Soil damage from physical, chemical and biological characteristics causes the soil to be unable to support optimal plant growth, so that this land is left to become abandoned land [13]. The current condition of the post-mining land without permits is over grown with shrubs with that grass as the dominant plant with several basins from the former mining activity.

Some of the chemical and physical properties of the soil used in the study are listed in **Table 2**. These characteristics are properties of the soil in post-gold mining land in Mandor Sub-District, Landak Regency, West Kalimantan Province. These soil properties illustrate some of the problems in the land after the gold mining from the physical and chemical properties of the soil. The soil texture class is classified as sand because soil particles are dominated by the sand fraction which reaches 91.53%, while the silt and clay fractions are only 8.11% and 0.36%, respectively [14]. The percentage of the sand fraction that reaches more than 90% characterizes sandy soils or in mining terms it is called tailings.

Soil whose particle fraction is dominated by sand has a high permeability, this will cause the leaching rate of nutrients in the soil to be very high [15]. As a result, the availability of the nutrient is low to very low. **Table 2** shows some properties of soil in post gold mining at Mandor Sub District i.e. the total nutrient content of N (0.02%), Ca (0.13 cmol (+) kg^{-1}), Mg (0.38 cmol (+) kg^{-1}) and Na (0.09 cmol (+) kg^{-1}) available is very low, while P and K of 6.64 ppm and 0.15 cmol (+) $kg\text{-}^{1}$ respectively are classified as low.

Potassium available in the soil in people's post gold mining land of 0.15 cmol (+) kg^{-1} is low. Generally the sandy soil is sufficiently K, but most of it is only in the form not yet available to plants, K is still in primary minerals such as feldspar and mica in sand particles. The very low nutrient content in the soil in post community gold mining land as mentioned above is also caused by the low nutrient binding sand soil, which is reflected in the very low of CEC value of 3.54 cmol (+) kg^{-1}.

The very low value of the CEC on this soil is due to several things, including: (1) The low clay fraction (0.36%) which is a source of negative charges; (2) The organic matter content is very low, which is reflected in the low C-organic value, namely 0.01%. Very low soil organic matter can be caused by the fast rate of decomposition of organic matter in sandy soils due to the high temperature and aerobic atmosphere [16]. The soil pH value in the post-gold mining land area of 5.63 is classified as

	Location I		Location II	
Soil properties	**Value**	**Level**	**Value**	**Level**
pH H_2O 1:2	4,9	Acid	5,63	slightly acid
pH KCl 1:2	4,3	Very Acid	4,21	Very Acid
C-Org (%)	2,59	Moderate	0,01	Very low
N Total (%)	0,31	Moderate	0,02	Very low
P Bray I (ppm)	10,19	High	6,64	Low
Ekstract NH_4OAc 1 N pH 7				
K (cmol(+)kg^{-1})	0,23	Low	0,15	Low
Ca (cmol(+)kg^{-1})	1,68	Very low	0,13	Very low
Mg (cmol(+)kg^{-1})	1,05	Moderate	0,38	Very low
Na (cmol(+)kg^{-1}	0,26	Low	0,09	Very low
CEC (cmol(+)kg^{-1})	10,64	Low	3,54	Very low
Base saturation (%)	29,61	Low	21,74	Low
Texture				
Sand (%)	86	Sand	91,53	Sand
Silt (%)	12		8,11	
Clay (%)	2		0,36	

Note: Marking according to the Soil Research Institute (2005): Location I is in Singkawang Sub-District and location II is in Mandor Sub-District.

Table 2.
Soil characteristics of post gold mining land in some location.

slightly acidic. Soil pH value will be a limiting factor for plant cultivation, so that the growth of plants is less than optimal [17]. One of the alternatives to increase the pH by applying coastal sediment. Besides being able to increase the pH and availability of several nutrients, it can improve some of the physical properties of the soil in post gold mining land. This is because the coastal sediment contains 37.95% clay.

The results of the analysis of several soil properties indicate that the soil in the post-mining area of gold without a permit in Central Singkawang District has decreased its fertility. This is indicated by the very low ability of the soil to bind nutrients and water. The ability of soil to bind water and soil nutrients can be seen based on the very low value of the cation exchange capacity (CEC), namely 4.74 cmol (+) kg^{-1} (**Table 2**). In addition, the low fertility level can also be seen from the texture of the soil, namely sand. Soil whose mineral fraction is dominated by sand will cause the ability to store water and nutrients to be low because sand has a low negative charge [18]. Soil whose particle fraction is dominated by sand has a high permeability, this will cause the leaching rate of nutrients in the soil to be very high. As a result, the availability of nutrients becomes low to very low. The very low CEC value in this soil is caused by several reasons, including: (1) it does not contain clay fraction (0.00%) which is a source of negative soil charge; (2) The organic matter content is very low as indicated by the low C-organic value, namely 0.21%. Very low soil organic matter can be caused by the fast rate of decomposition of organic matter in sandy soils due to the high temperature and aerobic atmosphere. The results of the analysis in **Table 1** show that the organic matter in the sand has been further decomposed with a C/N ratio value of 8.35.

The soil pH value in the post-gold mining land area of 4.9 is considered acidic. Soil pH value will be a limiting factor for plant cultivation because in acid soils some nutrients are not available, for example K, Ca and Mg so that they cannot provide optimal nutrients for plant growth [19].

Community gold mining produces mercury as the main pollutant that will threaten the sustainability of the ecosystem. Mercury can damage the environment because of its low solubility in water and is easily absorbed and accumulated in the tissues of organisms through bioaccumulation and biomagnification processes [20]. Mercury levels in 4–5 year old gold mining land is 0.020 ppm, 6–10 year old gold mining land is 0.050 ppm and 0.042 year old gold mining land is 0.042 with an average grade of 0.037 ppm. Mercury and its derivatives are one of the deadliest pollutants in the history of human civilization [21].

4. The role of coastal sediment in increasing growth and crop yields in post-mining land

The concentration of several nutrients in the sorghum plant tissue due to coastal sediment addition can be seen in **Table 3**. The variations of N, P, K, Ca and Mg contents in the sorghum plant from different provision of coastal sediment were considerable at several doses level, especially if compared with control. The Ca concentration in sorghum plant that were given coastal sediment at all doses showed increased compared to control (**Figure 1**). The increasing of concentration of Ca in the sorghum crop due to coastal sediment addition caused by coastal sediment many contain Ca. Research result of [22] indicates that the coastal sediment contains Ca of 14.62 cmol (+) kg^{-1}.

The provision of coastal sediment is able to increase the concentration of P in the sorghum plant, the highest concentration of P at treatment of coastal sediment addition at a dose 60 t ha^{-1}. The concentration of P elements on all the addition of coastal sediment is significant difference with control. This is due to the addition of coastal sediment can increase soil pH, according to [23] provision of coastal sediment increase significantly soil pH because it contained high cations. The higher soil pH value then the availability of P will be higher so that sorghum plant can absorb more P elements.

Table 3 shows the uptake some nutrients of sorghum plants in post gold mining land. Absorption of nutrients at all doses of coastal sediment application

Treatment	**Uptake nutrients**				
	N	**P**	**K**	**Ca**	**Mg**
	(mg)				
Rates of coastal sediment					
0 t ha^{-1}	146.9 b	0.8 c	153.5 b	25.6 c	19.6 b
20 t ha^{-1}	390.2 a	1.4 ab	421.4 a	87.3 a	44.3 a
40 t ha^{-1}	296.4 ab	1.2 b	262.2 b	52.2 bc	29.8 ab
60 t ha^{-1}	400.7 a	1.5 a	413.0 a	83.4 ab	45.5 a
80 t ha^{-1}	239.6 ab	1.3 ab	292.5 ab	61.6 ab	31.1 ab

Description: Numbers followed by the same letters in the same column indicate no significant differences at the Duncan test at 5% level of significance.

Table 3.
Effect of coastal sediment application on some uptake nutrient by sorghum.

was higher than control. Uptake of N nutrients due to giving of coastal sediment ranges from 239.6–400.7 mg, while the control of only 146.9 mg of N was absorbed by the Sorghum plant. The phosphorus and calcium uptake in tissue of sorghum as measured after harvesting were significantly increased by coastal sediment application.

The provision of coastal sediment of dosage at 60 t ha^{-1} increased the highest P uptake by sorghum. Application of coastal sediment at dose 60 t ha^{-1} increase the highest uptake of P with a value of 1.5 mg, when compared with the absorption of P without the provision of coastal sediment then the absorption of P increased by 46.67%. Ref. [24] states that on acid soil increased pH will increase the absorption of P plants. **Table 2** also showed that the addition of coastal sediment at a dose of 60 t ha^{-1} can increase the highest Mg uptake, which is 45.5 mg. Increased absorption of Mg in the application of coastal sediment dose at 60 t ha^{-1} compared to a control of 56.92% (**Figure 2**).

The effect of coastal sediment application on the yield of sorghum crops is known from the number of seeds per plant (NSP), weight per plant (WPP), and weight per 100 seed (W100S). **Table 4** shows that the provision of coastal sediment at all dosages differs significantly against the number of seeds per plant than the control. The NSP value of coastal sediment addition ranged from 1362 to 2082 seeds,

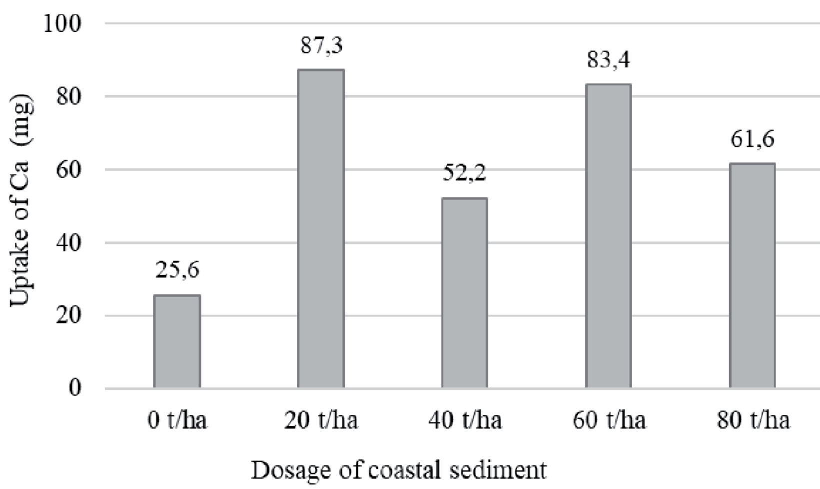

Figure 1.
Plant Ca uptake at several dosage of coastal sediment addition.

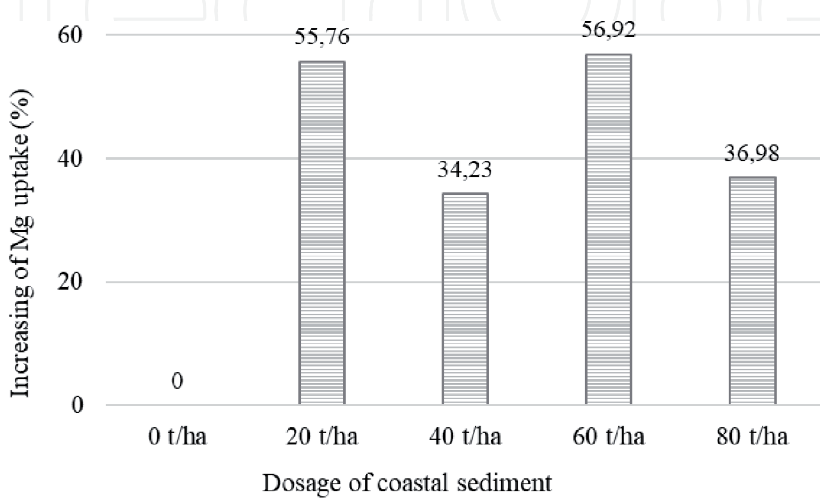

Figure 2.
The percentage of increased Mg uptake due to the provision of coastal sediment at several doses.

Treatment	NSP	WPP	W100S
Rates of coastal sediment			
0 t ha^{-1}	683 c	14.4 c	2.11 b
20 t ha^{-1}	1711 ab	37.4 ab	2.4 ab
40 t ha^{-1}	1362 b	32.2 b	2.47 a
60 t ha^{-1}	2082 a	48.9 a	2.59 a
80 t ha^{-1}	1881 ab	43.3 ab	2.50 a

Description: Numbers followed by the same letters in the same column indicate no significant differences at the Duncan test at 5% level of significance.

Table 4.
Effect of ameliorant on some yield sorghum parameter.

while the control only has an NSP of 683 seeds. Likewise, for WPP parameters, the treatment of coastal sediment addition at all doses is significantly different with the control. It increases in the amount of weight per plant between 55.28–70.55%.

The weight per 100 seed parameters also shows an increase in sorghum plant with addition of coastal sediment. The weight increase per 100 seeds appears to be a distinct significant start of coastal sediment application at doses of 40 t ha^{-1}, while at doses of 20 t ha^{-1} was not differ from the control. **Table 4** shows that on all three parameters, the provision of coastal sediment doses 60 t ha^{-1} has the highest value. Then at a higher dose, i.e. 80 t ha^{-1} precisely the three parameters indicate the decline. This means the dosing of coastal sediment for the sorghum plant in the post gold mining land at a dose above 60 t ha^{-1} began to decrease the yield of sorghum crops. Suspected with the provision of coastal sediment that is too high will interfere with the balance of nutrients in the soil, especially because of the influence of the sodium elements are too much. The coastal sediment contains Na which is quite high, namely 3.24 cmol (+) kg^{-1}. One of the bad influences of Na is that it can reduce the absorption of other positively charged nutrients, such as K, Ca and Mg [25].

5. Final remarks

The post gold mining land has the potential for the development of crops production with the provision of coastal sediment ameliorant. It can increase the uptake of nutrients N, P, K, Ca and Mg, as well as crop results. The optimum dose of coastal sediment giving to the sorghum plant in the post gold mining land is 60 t ha^{-1}.

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