Reclamation of Dispersive Soil from Yedwingaung Village, near Yemyatkyi In, Sagaing Region

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Abstract

Salt-affected soils have been attended to recognize not only in myanmar but also in all over the world. The aim of this research is to reclam the solt-affected soil from Yedwingaung village in the vicinity of Yemyatkyi In, Sagaing region by applying soil amendments. To get representative soil samples of this uncultivated area, 20 different sites were selected and collected equal amount of soil from each site. Gypsum as inorganic amendment and vermicompost as organic amendment were utilized and tested in practice by pot experiments. Physicochemical characteristic properties (eg. pH, Electrical Conductivity, Sodium Adsorption Ratio, Exchangeable Sodium Percentage) of these soils were investigated. Fourier Transform Infrared, Energy Dispersive X-Ray Spectroscopy and Scanning Electron Microscopy were also utilized for characterization. According to the values of pH, Exchangeable Sodium Percentage, Sodium Adsorption Ratio and base saturation percent, all soils were represented as dispersive. Then the effeteness of amendments by two strategies were determined by comparing the properties of soils. The improvement of soil microbial activities with the use of treatment were also pointed out by basal soil respiration indicator. Although the dispersive properties had not been completely disappeared after treatments, it was cleared that other qualities of soils were developing. Therefore the applied amendments in this soil reclamation can ameliorate the calcareous dispersive soil by some extant.

Key words: Electrical Conductivity, Sodium Adsorption Ratio, Exchangeable Sodium Percentage. Fourier Transform Infrared, Energy Dispersive X-Ray Spectroscopy and Scanning Electron Microscopy

Introduction

In general, soil is composed of sand, silt, humus and clays. Sand and silt are siliceous, and are coarse in texture. They are relatively inactive from ionic exchange point of view. On the other hand, humus and clays, which contribute to the fines, are highly surface active particles. They are negatively charged in the aqueous environment. Consequently, they readily attract and hold positively charged ionic species and repel negatively charged ionic species. There are great variations in the amounts of the various elements that are present in the soil and plants. As can be noted, sodium is not included in this list of essential nutrients in soil. In fact, the presence of Na^+ is particularly detrimental, as it has toxic effect on plants and vegetation. The primary source of Na^+ in soil is from its salt content. As Na^+ being monovalent is not weakly adsorbed on the soil particles, it is inefficient in neutralizing their negative charge sites. It, consequently, tends to disintegrate the soil structure and reduces the soil permeability and tilth. This, in turn, adversely affects the seed germination and the overall plant growth. The term, 'salt-affected' refers to soils with substantial enough salt concentrations to affect plant health, soil properties, water quality and other land and soil resource uses. Many soils in the world Green Plants are affected by salts, both natural and human-induced. Since salt-affected soils can substantially reduce land value and productivity, learning how to identify and manage salt problems is important for many agricultural producers, consultants and land managers. Effective management of salinity or sodicity problem requires correct diagnosis of the problem. Understanding the soil-salinization processes and limitations to crop production is the

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key to improvements in crop productivity related to salinity and sodicity. Although several treatments and managements practices can reduce salt levels in the soil, there are some situations where it is either impossible or to costly to attain desirably low soil-salinity levels.[3] In the present study, the soil from Yedwingaung village, near Yemyatkyi In, Sagaing region was selected to reduce its salinity in short term by applying gypsum and vermicompost.

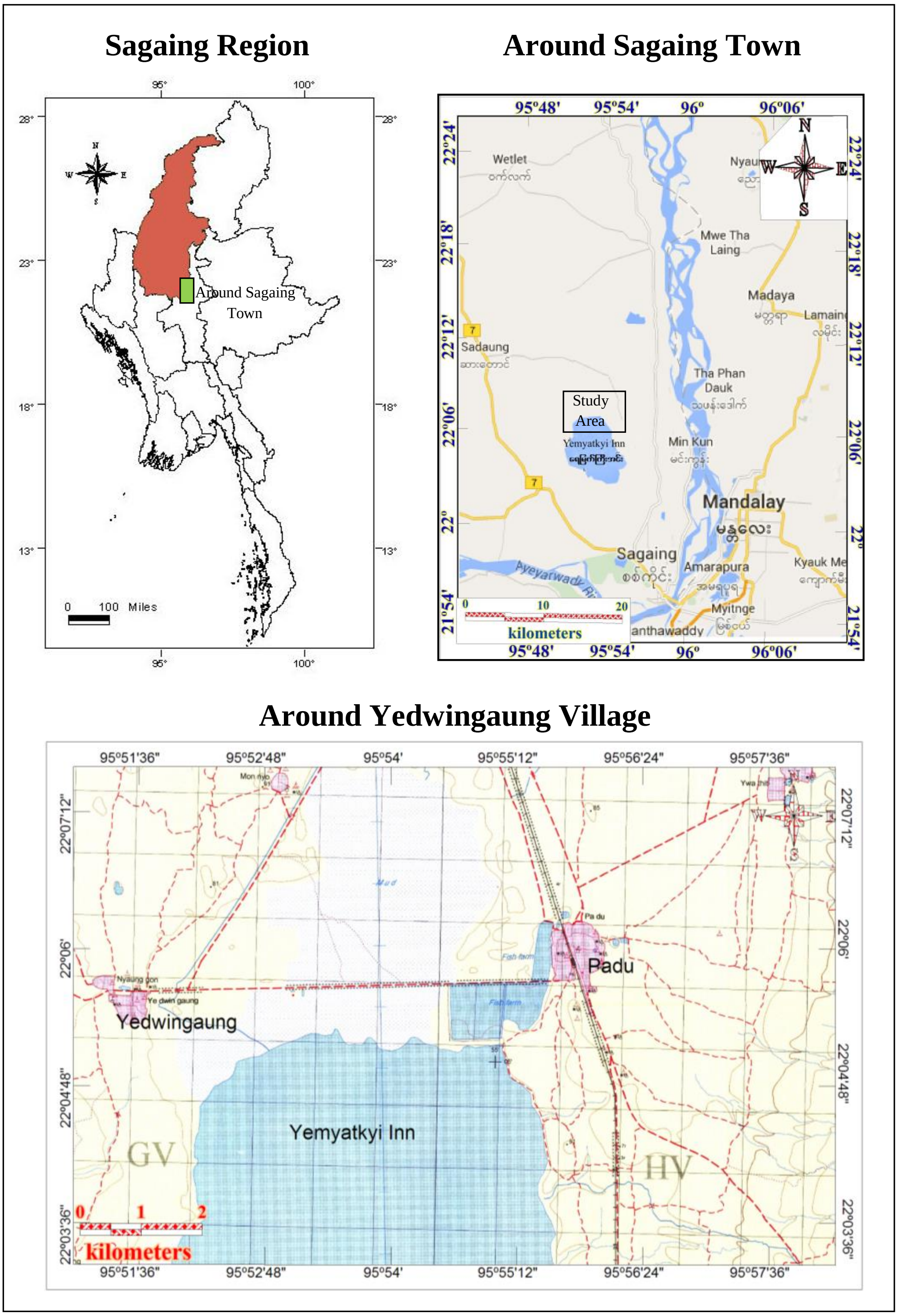

Figure 1. Location Map of the Study Area

Salt-Affected Soils

What are salts and how do they accumulate in soil? A salt is a water-soluble compound that, in soil, may include calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), hydrogen carbonate (HCO_3^{-}), or sulfate (SO_4^{2-}). For example, Ca^{2+} and SO_4^{2-} form to make the salt gypsum ($CaSO_4 \cdot 2H_2O$). Salts in soil can develop from the weathering of primary minerals or be deposited by wind or water that carries salts from other locations. Salt-affected areas generally occur in semi-arid and arid climates where precipitation is not adequate to leach salts, causing them to remain in the soil profile. Salinization, the process of salt accumulation, most often occurs where surrounding soil or underlying parent material contains high levels of soluble minerals, where drainage through the soil is poor, where water ponds and evaporates, or where shallow water tables allow salty ground water to move upward and deposit salts due to evaporation. Salinization can also occur when irrigation water containing high levels of soluble salts is applied to the land over a prolonged period. Additionally, certain fertilizers, amendments, and manure can contribute to salt accumulation in localized areas.

Properties of Salt-Affected Soils

Salt-affected soils can be broken into three classes based on general EC, SAR, ESP, and pH guidelines: saline, sodic and saline-sodic. Properties of each of these soils are discussed below.

Table 1. Salt-affected Soil Classification

Soil Classification	EC (mmhos/cm)	SAR	ESP	pH
Saline	> 4.0	< 12	< 15	< 8.5
Sodic	< 4.0	> 12	>15	> 8.5
Saline-sodic	> 4.0	> 12	> 12	< 8.5

Managing Sodic and Saline-Sodic Soils
Reclamation

Reclaiming sodic and saline-sodic soils requires a different approach than saline soils and can be considerably more cost. Prior to leaching, excess Na^{+} needs to be replaced from the exchange site by another cation, namely Ca^{2+} or Mg^{2+}. This is done by adding an amendment that either directly or indirectly releases exchangeable Ca^{2+} or Mg^{2+}. Because Ca^{2+} and Mg^{2+} have a stronger charge than Na^{+}, they will replace Na^{+} on exchange sites, causing Na^{+} to be released to the soil solution and be susceptible to removal by leaching. Amendments used to correct sodicity include gypsum ($CaSO_4 \cdot 2H_2O$), lime ($CaCO_3$), calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), sulfur and sulfuric acid materials and organic amendments. The most common and economical amendment used on sodic soils is gypsum, which can be applied dry or with irrigation water. Gypsum is slow reacting, but will react in the soil for a long period of time. Fine gypsum (passing through a 60 mesh) should be used to maximize reactivity and effectiveness. Adding gypsum or lime to a soil that already has gypsum and/or lime present will not increase Ca^{2+} solubility, an outcome that could potentially limit their effectiveness as amendments.

For amendments to be effective, water needs to be applied to leach the Na^{+} that is pushed off exchange sites by Ca^{2+}. Leaching and drainage in sodic soils can be slow due to poor structure and limited water movement associated with sodic soils. For sodic soils with low EC, saline water may be appropriate for the initial stages of reclamation to provide additional Ca^{2+} to promote flocculation, and thus increase permeability. Tillage may help break up surface crusts and increase water infiltration into the soil. Establishing a salt-tolerant crop or forage shortly after reclamation has begun will also increase the effectiveness of reclamation efforts. Saline-sodic soils should be amended by first addressing the excess Na^+ problem and then the excessive salt problem. If soluble salts are leached prior to the removal of Na^+ from exchange sites, sodic soil properties, such as dispersion, can result. Therefore, a Ca^{2+} amendment should be applied to replace Na^+, and then excessive water applied to leach the Na^+ and other salts.

Experimental

Sample Collection

20 subsamples were collected at the depth of (0-15 cm) from an uncultivated area which is located in the vicinity of Yedwingaung village near Yemyatkyi In, Sagaing region. By combining thoroughly these subsoils, composite soil sample was made to get a representative soil of this area. Physicochemical analyses were performed on air dried soil samples and microbial respiration analyses were carried out on field moist soil samples.

Reclamation Design

The experiment was set up in five plastic pots (26 cm diameter × 23 cm high). Five holes (5 mm in diameter) were made in their bottoms to leach water. A layer of plastic screen was laid at their bottoms. Then the pot experiments were performed on original soil, gypsum and vermicompost amended soils. 10 kg of soils were mixed with different ratios of gypsum and vermicompost and these combination ratios are shown below.

Sample 1. original summer soil
Sample 2. original winter soil (control)
Sample 3. original soil (10 kg) + gypsum (60 g)
Sample 4. original soil (10 kg) + gypsum (100 g)
Sample 5. original soil (10 kg) + vermicompost (60 g)
Sample 6. original soil (10 kg) + vermicompost (100 g)

Each 10 kg soil sample was thoroughly mixed with gypsum (60 and 100 g) and vermicompost (60 and 100 g) respectively. The resulting combined soil samples were placed in the pots and added with calculated amount of water according to field capacity method.

After compositing 10 days, the soils from all pots were irrigated by using equal amount of water in order to leach the soluble salts. The duration taken for this leaching process was 21 days.

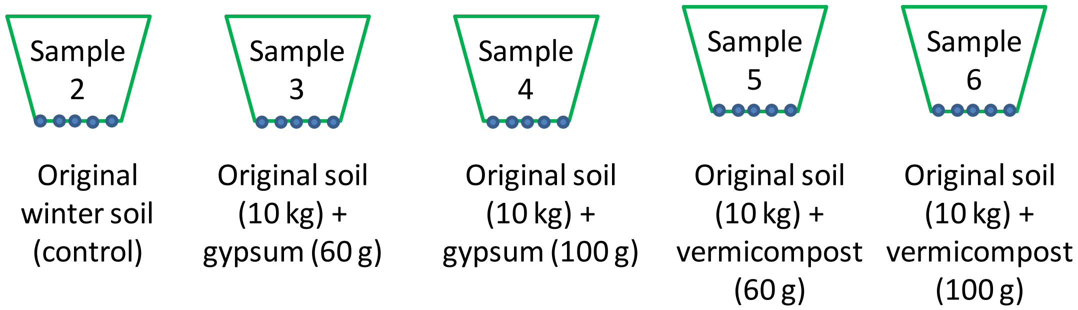

Figure 2. Study Site

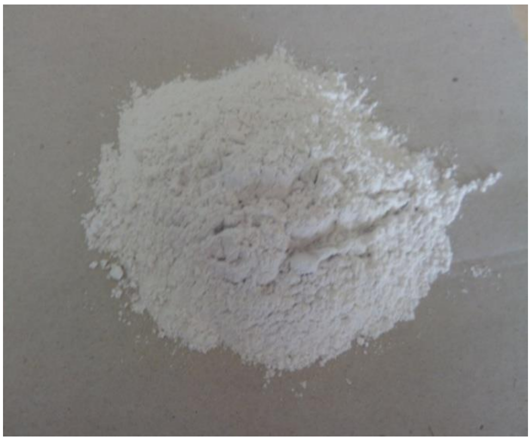

Figure 3. Gypsum **Figure 4. Vermicompost**

Procedure

Basal soil respiration was determined by the titrimetric method (Anderson, 1982). This method is based on the determination of CO_2 evolution from incubated soil. Soil was added to the 1000 cm^3 measuring cylinder. The cylinder was bumped two or three times on the laboratory bench to ensure soil settled down in the cylinder. Water was slowly added to wet the top half of soil in the cylinder. Top of the cylinder was sealed with paraffin to control evaporation. The cylinder was allowed to stand for 24 hours. The top 30 cm and bottom 30 cm of wet soil in the cylinder was discarded. Soil from the middle of the wet portion in the cylinder was collected as field moist soil sample. Field moist soil was placed in an airtight jar containing a vial with 15 cm^3 of 1.0 M NaOH and incubated at 28°C. After one day of incubation, the NaOH vial was removed from the jar, excess 0.5 M $BaCl_2$ and phenolphthalein added to precipitate carbonate out from the NaOH solution as insoluble barium carbonate, and finally the excess NaOH was titrated out with 0.5M HCl. Soil respiration as CO_2 – C was computed from the titration value according to the following equation of Anderson (1982):

CO_2 – C (mg) = (B–V) ME

where B is the volume (cm^3) of acid (HCl) used to titrate the alkali (NaOH) of a blank solution (not incubated with soil), V is the volume (cm^3) of acid used to titrate the alkali solution (incubated with the soil sample), M is the molarity of the acid (HCl), and E is the equivalent weight of CO_2 –C.

Figure 5. Blank and Soil Bottles Containing NaOH Vials

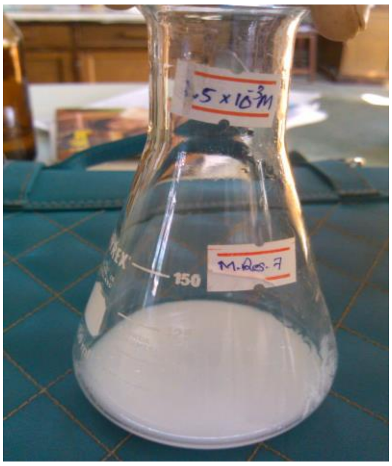

Figure 6. Addition of $BaCl_2$ to NaOH Removed from Incubated Bottle

Figure 7. Addition of Phenolphthalein Indicator

Figure 8. Titration with HCl

Results and Discussion

Physicochemical Properties of Soil Samples

Table 2. Physicochemical Analysis

Sample	pH	Moisture Content (%)	EC (mmhos/cm)	TDS (mg/L)	Colour
1	9.18	3.25	0.787	503.68	Light Gray
2	10.31	1.57	0.676	432.64	Light Gray
3	9.47	1.21	1.285	822.4	Light Gray
4	9.18	1.63	0.756	483.84	Light Gray
5	11.15	1.37	0.581	371.84	Dark Gray
6	10.52	1.65	0.608	389.12	Dark Gray

Among treatments, sample 5 and 6 (11.15 and 10.52) showed the greater pH than the original winter control soil sample while the depletion of pH associated with the sample 3 (9.47), and sample 4 (9.18). The percentage of moisture contents did not differ significantly in all soils. Though gypsum treatments rander the increased amount of electrical conductivity (1.285 and 0.756), the application of vermicompost resulted the lower electrical conductivity than the control soil. Total dissolved solids (TDS) of the soils can be calculated by multiplying m mhos/cm electrical conductivity with 640. There was no significant of vermicompost changed toward a little dark.

Table 3. Textural Analysis

Sample	% Composition			
	Sand (%)	Silt (%)	Clay (%)	Texture
1	70.5	11.5	18	Sandy Loam
2	59	29	12	Sandy Loam
3	74	14	12	Sandy Loam
4	74	14	12	Sandy Loam
5	74	14	12	Sandy Loam
6	64	29	12	Sandy Loam

According to textural analysis, all soils were lied in the class of sandy loam texture.

Table 4. Available NPK

Sample	Available N		Available P		Available K	
	mg/kg	rating	mg/kg	rating	mg/kg	rating
1	7	Very Low	7	Low	70	Low
2	7	Very Low	7	Low	70	Low
3	7	Very Low	7	Low	70	Low
4	7	Very Low	7	Low	70	Low
5	10	Very Low	13	Medium	81	Low
6	12	Very Low	15	Medium	88	Low

Table 5. Exchangeable Cation Analysis

Sam-ple	meq/ 100 g of soil							SAR	ESP (%)	EMgP (%)	Remark
	Na^+	Ca^{++}	Mg^{++}	K^+	Al^{+++}	H^+	CEC				
1	4.57	N.D	18.33	1.32	N.D	N.D	24.22	4.78	18.87	75.68	Dispersive soil
2	4.52	1.10	8.89	0.40	N.D	N.D	14.91	6.39	30.32	59.62	Dispersive soil
3	3.57	1.30	8.99	0.51	N.D	N.D	14.37	5.22	24.84	64.56	Dispersive soil
4	3.18	1.34	9.51	0.86	N.D	N.D	14.89	4.31	21.36	63.87	Dispersive soil
5	4.50	1.25	5.60	0.43	N.D	N.D	11.79	2.43	38.25	47.49	Dispersive soil
6	4.31	2.05	6.40	0.43	N.D	N.D	13.19	2.33	32.68	48.52	Dispersive soil

pH	ESP (ESP+EMgP=15)	Base saturation %	SAR	Remark
> 7.8	ESP > 8	> 80	>2	Dispersive

$$\text{Base saturation \%} = \frac{\text{CEC} - [\text{Al}^{3+} + \text{H}^{+}]}{\text{CEC}} \times 100$$

$$= 100\ \%$$

Depletion amounts could be seen in the exchangeable Na^+ analyses with two amendments but gypsum caused more reduction Na^+ than vermicompost. In the case of Ca^{++}, the higher amount of Ca^{++} can be given not only gypsum but also vermicompost. Increasing amount of Mg^{++} could be detected with the use of gypsum and decreasing amount of Mg^{++} related with the application of vermicompost. Both two remediations responsed the reduction effect on exchangeable K^+ within the duration of this research. Two approaches which were used in these analyses resulted the drop CEC and therefore it could be observed that the undesired Na^+ was replaced by Ca^{++}, Mg^{++} and K^+. The decline in Na^+ was the main source of decreasing CEC. Although the application of more gypsum (100 g) and vermicompost (100 g) obtained higher CEC compared with gypsum (60 g) and vermicompost (60 g), the better effect was related with the vermicompost. SAR data also indicated more effective of vermicompost than gypsum. Other important parameter in the assessment of salinity is ESP. Similarly, effective increasing ESP could be found together with the utilization of vermicompost. It was pointed out the organic amendment dealt with better response than inorganic amendment.

Table 6. Water Soluble Salt Extraction

No.	Parameter (meq /100 g of soil)	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
1	Cl^-	5.27	1.40	0.80	1.07	1.03	0.71
2	$SO_4^=$	3.70	0.10	0.86	1.04	0.66	0.20
3	$CO_3^=$	2.00	1.14	0.32	0.24	0.41	0.39
4	HCO_3^-	26.00	3.74	1.46	0.89	3.08	1.77

There was an interaction for water soluble salt between soils and treatments, indicating that Cl^-, $CO_3^=$ and HCO_3^- were affected in each soil by gypsum and vermicompost application.

Biological Properties of Soil Samples

Table (7) Soil Microbial Respiration

Sample	HCl (M)	NaOH (cm^3)	HCl (cm^3)		B-V (cm^3)	EqC	Eq CO_2	mgC/ 100 g soil (B-V) *6* HCl	mg CO_2/100 g soil (B-V) *22* HCl
			Blank (B)	(V)					
2	0.5	15	30.5	30.30	0.2	6	22	0.60	2.20
3	0.5	15	30.5	30.25	0.25	6	22	0.75	2.75
4	0.5	15	30.5	30.25	0.25	6	22	0.75	2.75
5	0.5	15	30.5	30.20	0.30	6	22	0.90	3.30
6	0.5	15	30.5	30.18	0.32	6	22	0.96	3.52

More soil respiration by microorganism was concerned with both organic and inorganic treatments but the better results dealt with organic treatments. Variability in soil respiration mainly depended on weather variables (Kucera and Kirkham 1971) and soil moisture (Gupta and Singh 1981), along with the salt content of salt-affected soils (Garcia and Hernanadez 1996). The similar responses in soil microbial carbon also informed that two strategies applied in this research promoted the soil quality. The elemental content of all soil samples were determined using EDS. These analyses showed that all soils are mainly composed of Si, Fe, Ca, K, Ti, Zr and Sr respectively.

Table 8. Characteristic Absorption Bands of Samples

Wave number	Assignment of Functional Group
3616 cm^{-1}	O–H stretching vibration
3448, 3460 cm^{-1}	stretching vibration of water saturated with various exchangeable cation eg. (K^+, Mg^{2+}, Ca^{2+}, NH_4^+)
1600, 1624, 1622 cm^{-1}	the overtone of the HOH angle deformation band
1031 cm^{-1}	$Si\text{-}O^-$ vibration
466 cm^{-1}	Fe–O bending vibration

All soil samples produced similar pattern in their FT-IR spectrum and therefore the resulting wave numbers and theirs assignments were generalized in the above Table (8). Many metals bonded with oxygen were present in all soil samples and FT-IR analysis showed the presence of O-H, Fe–O, Si–O–Si and Si–O bonds. The bonds, which were centered at 3500 cm^{-1} refer to water molecular associated with Na and Ca. The feature near 3600 cm^{-1} lines well separated from those at most other mineral bands. Other features appearing in the spectrum belong to a variety of Fe-O and Si-O stretching and bending vibrations.

Conclusion

All soils gave greater than values of SAR 12, ESP 15, pH 8.5 and less than EC 4 and therefore they could be classified as sodic soils (or) alkali soils. Before leaching, excess Na^+ of these were replaced by another cation, Ca^{2+} or Mg^{2+} from gypsum and vermicompost amendments. These amendments caused to increased the amount of exchangeable K^+, Ca^{2+}, Mg^{2+} and by decreasing Na^+. The application of vermicompost not only decreased SAR and EC but also increased pH and ESP whereas gypsum not only decreased SAR, pH and ESP but also increased EC. Although medium amount of P was obtained with the use of vermicompost, other nutrients, N and K were found as low level with both amendments in all soils. The higher amount of soil respiration associated with the two treatments than the original alkali soil. Both gypsum and vermicompost can contribute to develop soil properties but vermicompost gave the better activities on this dispersive alkali soil. Characterization by Fourier Transform Infrared and Energy Dispersive X-Ray Spectroscopic data did not offer significant variations among the properties of five soils samples. However, the progress of soil structure by the use of vermicompost could be seen clearly in the SEM photograms. There is still needed to conduct long term reclamation and assessment by applying other advanced chemical, physical and biological remediation techniques in future.

Acknowledgements

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စစ်ကိုင်းတိုင်းဒေသကြီး၊ ရေမျက်ကြီးအင်းအနီးရ ရေတွင်းကောင်းကျေးရွာမှ ဆားဓါတ်ပါဝင်မှုများခြင်းကြောင့် ဖွယ်သော မြေ၏ အရည်အသွေးကို ပြုပြင်ထိန်းသိမ်းခြင်း

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ရတနာပုံတက္ကသိုလ်

သုတေသနအကျဉ်းချုပ်

ဆားဓါတ်ပါဝင်မှုများသောမြေများကို မြန်မာပြည်တွင်သာမက ကမ္ဘာတစ်ဝှမ်းလုံးမှာပင် သတိပြုမိလာကြသည်။ ဤသုတေသန၏ရည်ရွယ်ချက်မှာစစ်ကိုင်းတိုင်းဒေသကြီး၊ရေမျက်ကြီးအင်းအနီးရှိ ရေတွင်းကောင်းကျေးရွာမှ ဆားဓါတ်ပါဝင်မှုများသော မြေကို ပြုပြင်ထိန်းသိမ်းရန်ဖြစ်သည်။ ထွန်ယက်စိုက်ပျိုးခြင်း မပြုလုပ်နိုင်သော ထိုဒေသကို ကိုယ်စားပြုသည့် မြေနမူနာများရရှိနိုင်ရန် နေရာ (၂၀) ကိုရွေးချယ်ပြီး နေရာတိုင်းမှ တူညီသောမြေပမာဏကိုကောက်ယူခဲ့သည်။ ဂျစ်ပဆန် ကို အင်အော်ဂဲနစ် နှင့်ဆိုင်သော ပြုပြင်သည့်ပစ္စည်းအဖြစ်လည်းကောင်း တီကျစ်စာကို အော်ဂဲနစ်နှင့်ဆိုင်သော ပြုပြင်သည့်ပစ္စည်းအဖြစ် လည်းကောင်းအသုံးပြုပြီး အိုးများတွင်ထည့်ကာ လက်တွေ့လေ့လာစမ်းသပ်ခဲ့သည်။ မြေများ၏ရုပ်ပိုင်းဆိုင်ရာ၊ ဒြပ်ပိုင်းဆိုင်ရာ ဂုဏ်သတ္တိများ ကိုလည်း လေ့လာစစ်ဆေးခဲ့သည်။ ခေတ်မီနည်းပညာရပ်များကိုအသုံးပြုပြီးမြေကို ဓာတ်ခွဲလေ့လာမှုများပြုလုပ်ခဲ့သည်။ လေ့လာ တွေ့ရှိချက်များက ထိုမြေသည်ဆားပါဝင်မှုများခြင်းကြောင့် ဖွယ်သော မြေကြီးဖြစ်ကြောင်းညွှန်ပြခဲ့သည်။ ထို့နောက်နည်းလမ်းနှစ်သွယ်သုံးခြင်းအားဖြင့် ပြုပြင်ပစ္စည်းများ၏ အကျိုးရှိမှုကိုလည်း မြေ၏ ဂုဏ်သတ္တိကို နှိုင်းယှဉ်ကြည့်ခြင်းအားဖြင့်လေ့လာခဲ့သည်။ မြေ မိုက်ခရိုအော်ဂနစ်ဇင်များ၏ လုပ်ဆောင်ချက် တိုးတက်မှုများကို လည်း မြေ အသက်ရှူမှု အညွှန်းပစ္စည်းကိုသုံးပြီးညွှန်ပြနိုင်ခဲ့သည်။ စမ်းသပ်ချက်များပြီးသောအခါ ဖွယ်သော ဂုဏ်သတ္တိသည် အပြီးတိုင် ပျောက်ကွယ်သွားခြင်းမရှိသော်လည်း မြေ၏အရည်အသွေးများတိုးတက်လာကြောင်း ထင်ရှားခဲ့သည်။ ထို့ကြောင့် အသုံးပြုခဲ့သော ပြုပြင်ပစ္စည်းများသည် ဆားဓာတ်ပါဝင်မှုများပြီး ဖွယ်သောမြေကြီးကို ပကောင်းလာအောင် အတိုင်းအတာတစ်ခုအထိ ပြုပြင်နိုင်ခဲ့သည်။