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Physico-chemical Characteristics of Disturbed Soils Affected by Accumulate of Different Texture in South Korea

(Pencirian Fisiko-Kimia Tanih Terganggu Akibat Pengumpulan Tekstur Berbeza di Korea Selatan)

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ABSTRACT

Anthropogenically disturbed soils have unique properties. In most of the ecosystems, especially under disturbed soil conditions, the soil properties are controlled by the accumulated materials. However, the equilibrium between the already present soil mass and the accumulated soil mass is very fragile and is affected by many factors. There are diversity of views about their identification and interpretations. This paper reports on the physico-chemical properties of the investigated sites under different texture soil accumulate. Three sites namely Chung-nam university field (Site-I), Chung-buk Geosan (Site-II) and Yong-in (Site-III) were investigated for diversity in physico-chemical properties. In situ *and* ex situ *physical and chemical properties were determined and comparisons were made for soil profiles examined at three sites. The classification of disturbed soils largely depends upon the system followed for classification. The objectives of this paper were to compare the properties of the disturbed soils and to classify for further research investigations of such soils. Abrupt change in electrical conductivity at Site-III was recorded ranged between 10.7 dS m^{-1} and 1.1 dS m^{-1} below 20 cm depth. Sudden and abrupt changes in infiltration rates at all sites were also calculated. The data suggested that the soil texture of the accumulated soil had also affected the properties of the underlying soil. Apparently, the difference in the properties seems to be the result of overlying soil accumulates with different texture. The disturbed soils need to be studied in detail and groupings be made on the basis of genesis and similarities.*

Keywords: Soil accumulates; soil properties; soil texture

ABSTRAK

Tanih terganggu akibat kegiatan manusia mempunyai sifat-sifat tersendiri. Untuk kebanyakan ekosistem, khususnya keadaan tanih terganggu, sifat tanih dikawal oleh bahan terkumpul. Tetapi keseimbangan di antara jasad tanih sedia ada dan jasad tanih terkumpul adalah rapuh dan dipengaruhi beberapa faktor. Terdapat juga pandangan berbeza tentang penentuan dan penafsirannya. Makalah ini melaporkan pencirian fiziko-kimia tapak-tapak penyiasatan dengan tekstur tanih berbeza terkumpul. Tiga tapak tersebut ialah padang di Universiti Chung-nam (tapak I), Geosan Chung-buk (tapak II) dan Yong-in (tapak III) dan kepelbagaian sifat fiziko-kimia disiasat. Sifat fizis dan kimia in situ *dan* ex situ *ditentukan dan perbandingan di antara tiga tapak siasatan dilakukan. Pengelasan tanih terganggu bergantung juga kepada sistem pengelasan yang dipakai. Objektif kertas ini ialah perbandingan sifat-sifat tanih terganggu serta pengelasannya untuk penyelidikan seterusnya terhadap tanih-tanih ini. Perubahan mendadak kekonduksian elektrik di tapak III dirakamkan di antara 10.7 dS m^{-1} dan 1.1 dS m^{-1} pada kedalaman 20 cm. Perubahan mendadak kadar penyusupan di semua tapak juga ditentukan. Data menunjukkan bahawa tekstur tanih terkumpul juga mempengaruh tanih yang wujud di bawahnya. Perbezaan sifat adalah hasil pengumpulan tanih atas dengan tekstur yang berbeza. Tanih terganggu perlu dikaji secara terperinci dan pengumpulannya perlu dilakukan berdasarkan genesis dan keserupaan.*

Kata kunci: Sifat tanih; tanih terkumpul; tekstur tanih

INTRODUCTION

The soil properties exhibit a great spatial and temporal variability. Majority of soil investigations in urban areas have been focusing on the human-constructed soils which were highly disturbed (e.g. Craul & Klein 1980; Jim 1993; Jim 1998; Patterson et al. 1980; Short et al. 1986). These were mostly termed as “unban soil” and were highly disturbed with very low fertility status (Craul 1992). Other important factors have got little attention. The soil characteristics may have strong variations across any landscape, not only the disturbed but also the relatively undisturbed soils, modified by certain environmental and management factors (Pouyat et al. 2003). The urban environmental and soil management factors also play major role in affecting soil properties aided with other soil disturbances (Taboada-Castro et al. 2009). Craul

(1992) and Jim (1998) described the direct effects such as incorporation of anthropic material, physical disturbances and coverage of soil by impervious surfaces.

The assessment of disturbed soils requires the investigation of the whole system because the properties may mislead due to the fact that they have been recovered for the past few years (Taboada-Castro et al. 2009). Hart et al. (1989) reported, after 10-25 years, that easily mineralizable pool of nitrogen had almost fully recovered in mined soils. On the other hand, the total nitrogen and total carbon were slower in recovery. Agricultural soils have often been used by some other aggressive technologies of urban planning, industrial uses and mine industries which caused the replacement and/or displacement of the soils and soil settlement at other places again causing soil and profile disturbance (Banov et al. 2010). This replacement and/or displacement of the soils has been becoming a major concern during the recent time and 6-8 million hectare soils have been granted for roads, settlement and other infrastructure.

The resulting changes in the soil properties make it unpredictable for plant growth under specific agro-ecological conditions. Because, during the development of soil and ecosystem, weathering causes nutrient levels changes to occur and the soil hydrological properties are also affected due to development. These changes also cause changes in the soil reaction and the availability of different nutrient elements (Abd-Rahim et al. 2011; Allen & Fanning 1988). Smeck (1985) reported alteration of the soil morphological characteristics in response to the weathering forces of their environment and results in associations between great groups of soil classification and nutrient distribution in soils. Factors typically considered causing infiltration rate variations are texture and moisture. It may be noted that the age since soil disturbance and the soil cover conditions may be used to explain some of the variation. But the non-availability of the evenly represented data at test sites does not let statistical examinations to be performed. There are few literature data available, but on the limited information available the soil properties associated with disturbed and accumulated soils be compared and discussed. But, these types of soils are increasing in terms of area due to recent industrialization and urbanization.

Keeping in view the importance and extent of disturbed soils, the present investigations were carried to compare the physico-chemical properties of these disturbed soils for further research and guidelines.

Materials and Methods

Study Area and Location

The present investigations were carried out at three sites namely Chung-nam University (Site-I), Chung-buk Geosan (Site-II) and Yong-in (Site-III). The Site-I was open field while Site-II and Site-III were green houses. These sites were selected because of accumulated soil at all sites (soil accumulated sites) but the textures of the overlying soils were different. South Korean map showing the location of investigated sites and their GPS coordinates is presented in Figure 1.

FIGURE 1. Korean map showing the location of the investigated sites along with the GPS coordinates viz. Site-I (Chung-nam University, 36° 22′031″ N and 127° 21′226″ E), Site-II (Chung-buk Geosan, 36° 49′341″ N and 127° 46′144″ E) and Site-III (Yong-in, 37° 20′816″ N and 127° 14′772″ E)

Soil Layers

At each site the disturbed soil profile was described individually. The soil profile was divided into different layers based on the similarity of the soil properties or genesis. This layering was largely influenced by the soil texture, soil color, hardness, and organic matter content. Soil color of each layer was determined by Munsell® soil color chart according to U.S. Dept. Agriculture Handbook 18-Soil Survey Manual. The pictorial representation of soil profile differentiating different soil layers is presented in Figure 2. It is shown that the first two layers (up to 75 cm depth) constituted the accumulated soil at Chung-nam University field (Figure 2(a)), and at Chung-buk Geosan the accumulated soil layers are differentiated up to 40 cm (Figure 2(b)). At Yong-in, the first three soil layers (up to 70 cm depth) constituted accumulated soil layers (Figure 2c).

In-situ Measurements

Infiltration rate and field saturated hydraulic conductivity were in-situ measured with Disc tension infiltrometer (Soil

Moisture, USA), and Guelph permeameter (Soil Moisture, USA), respectively. Soil samples were taken and brought to the laboratory to determine the soil water contents by gravimetric method. Yamanaka hardness was measured with push-cone (DIK-5553, Japan), one of hand-push type hardness meter. Soil shear strength was measured with field inspection vane tester (*Eijkelkamp*, Netherland). Soil temperature was determined by potable sensors of type WET-1 (Delta-T devices, UK).

The soil cores and bulk samples were taken from individual soil layers and brought to the laboratory for further determinations. Bulk density was measured using the intact 3 inches soil samples using methods described by Klute et al. (1986).

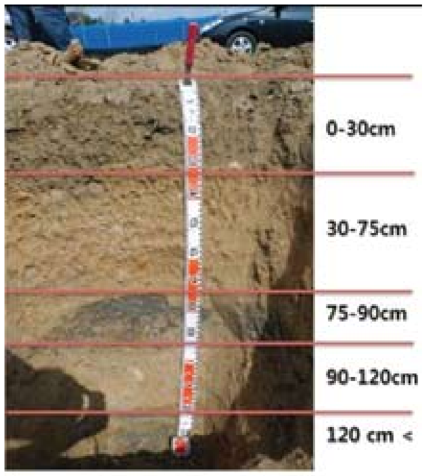
LABORATORY METHODS

All analyses were carried out on the fine earth fraction (< 2 mm). Particle-size analysis was performed by the hydrometer method after dispersion with Na-hexametaphosphate (Klute et al. 1986). Soil pH was measured potentiometrically in H_2O (1:5 w/v) with a pH meter (Orion, USA). The electrical conductivity (EC) was determined as the EC (1:5) value in supernatant 1:5 soil:water solution multiplied by the correction factor of 5 (NIAST 2000). Organic carbon was determined by wet digestion method as described in Tyurin (1931) and expressed as organic matter (OM) using Van Bemmelen factor 1.724. The cation exchange capacity (CEC) and the exchangeable cations were determined by the extraction using 1N NH_4OAc solution buffered at pH 7 followed as Sumner and Miller (1996). The cations in 1N NH_4OAc extracts were measured with ICP (GBC, Australia). For determining available P_2O_5, the extracting phosphate was followed with the Lancaster method described by Alban et al. (1964) and then molybdate-reactive phosphorus in the extract was measured with Kuo (1996).

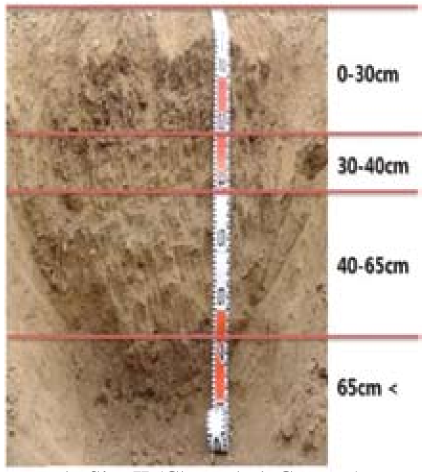
RESULTS AND DISCUSSION

SOIL PROFILE DESCRIPTION

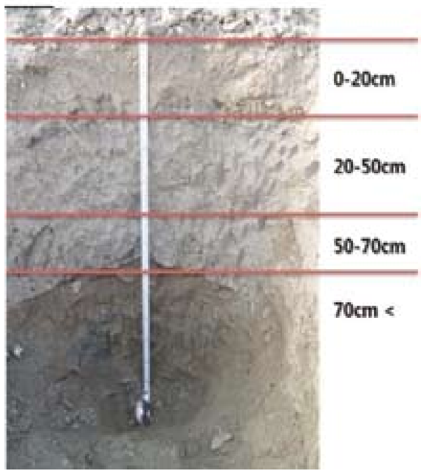
The soil profiles differentiated by different soil layers are presented (Figure 2). At Site-I, the upper 75 cm soil layers are made up of accumulated soil and clearly evident from the differences in soil colour (Figure 2(a)). At Site-II, the upper two layers (up to 40 cm soil depth) constitute the accumulated soil (Figure 2(b)). At Yong-in (Site-III) the first three soil layers (up to 70 cm depth) constitute the accumulated soil (Figure 2(c)). A comparison of the soil layers at these investigated sites also depicts change in soil texture between accumulated and the original soils (Table 1).



a. Site-I (Chung-nam University field)



b. Site-II (Chung-buk Geosan)



c. Site-III (Yong-in)

FIGURE 2. Profile pictures showing different soil layers at the investigated sites

PHYSICAL PROPERTIES

The Site-I exhibited sharp increase in bulk density and it ranged between 1.47 Mg m^{-3} at 0-30 cm depth and 1.80 Mg m^{-3} at 30-75 cm along with increase in soil shear strength down the profile. The hardness also increased down the profile (Table 1). The infiltration decreased abruptly to 0.1 cm hr^{-1} below 30 cm depth. The data for Site-II revealed that with increasing depth, the hardness also increased and the maximum (28.3 mm) was recorded below 65 cm soil depth (Table 1). The same is also true for bulk density and the maximum (1.65 Mg m^{-3}) was recorded at depth below 65 cm. The upper soil layer (0-30 cm) has the maximum infiltration (0.37 cm hr^{-1}) and it decreased with the increasing soil depth. Shear strength of the upper soil layer (0-30 cm) was recorded to be 10.7 kPa. For Site-III, the data (Table 1) revealed that the maximum soil water content (37.8%) was recorded at soil depth of 20-50 cm. The maximum hardness was also measured at the same depth (20-50 cm) but abrupt changes in case of hardness were also noted *i.e.* increasing hardness from surface layer of 0-20 cm up to 20-50 cm and then decrease in hardness again at lower soil depths of 50-70 cm (16.7 mm) and more than 70 cm (13.0 mm). The infiltration decreased with increasing soil depth. The upper soil layer (0-20 cm) had an infiltration of 0.10 cm hr^{-1} before rotary tillage and 3.54 cm hr^{-1} after rotary tillage.

Texture and moisture are the factors typically considered causing infiltration rate variations (Pitt 1987). The variability in infiltration rates and bulk density reveals that the effect of the texture of the accumulated soil is overwhelming (Abrisqueta et al. 2006). The age since disturbance and soil cover conditions may explain some of the variation in case of disturbed soils, but uneven representation of these conditions at the investigated sites made statistical analysis of these factors difficult to perform. The interrelationships among soil-environmental properties are considered to be typically non-linear and are affected by certain other environmental factors, as soil and air temperature, wind speed and solar radiation. Kooistra et al. (1984) reported changes in bulk density of disturbed and undisturbed soils and reported undisturbed plough pan bulk density to be 1.70 Mg m^{-3} at 31-33 cm depth and then decreased while the disturbed soil had a bulk density of 1.58 Mg m^{-3} at the same depth and was almost uniform down the profile. This is not in agreement with the present studies, where the disturbed soils have higher variations in bulk density down the profile at all three sites. Hartman et al. (2004) reported that natural and human soil disturbances are common and help to determine the fate of soil genesis and soil distribution. These disturbances usually interrupt soil development processes and provide fresh materials for ongoing or new pedogenic process (DeJong et al. 1983; Scalenghe et al. 2002), and the Korean climate is not an exception.

CHEMICAL PROPERTIES

Table 2 shows the chemical properties of disturbed soils at three locations. These are the first results from South Korea on the properties of disturbed soils under various uses. Very few literature data availability makes it difficult to compare different types of soils. But it can be said that the concentrations of different plant nutrients and the organic matter is highly variable in disturbed soils (Pastor et al. 1993). A slight decrease in electrical conductivity (EC) was observed down the soil profile at Site-I (0.28 dS m^{-1} at 0-30 cm and 0.15 dS m^{-1} below 120 cm). On the other hand, sharp decrease in EC was recorded at Site-III down the profile (10.7 dS m^{-1} at 0-20 cm to 1.1 dS m^{-1} at soil depth of 20-50 cm (Table 2). Decreasing trend was also observed down the profile for P_2O_5 and CEC except for 75-90 cm deep soil layer (Table 2), where these increased

TABLE 1. Physical properties of soil accumulated sites

Soil Depth	SWC	Soil Temp	Yamanaka Hardness	Shear strength	Bulk density	Infiltration	Soil texture
cm	%	°C	mm	kPa	Mg m^{-3}	cm hr^{-1}	
a. Site-I (Chung-nam University field)							
0-30	28.4	13.6	9.3	16.3	1.47	1.6	SL
30-75	28.9	11.8	23.7	56.0	1.80	0.1	SL
75-90	30.1	11.0	24.0	71.7	1.76	0.1	SL
90-120	25.2	10.9	24.3	NA	NA	NA	SL
120 <	31.3	10.9	24.0	75.3	NA	NA	L
b. Site-II (Chung–buk Geosan)							
0-30	15.5	15.5	15.0	10.7	1.36	0.37	L
30-40	20.4	15.2	27.0	130 <	NA	NA	
40-65	14.1	16.1	28.0	130 <	1.62	0.29	SL
65 <	NA	NA	28.3	130 <	1.65	0.00001 >	SL
c. Site-II (Yong-in)							
0-20	29.1	13.7	10.7	12.7	1.07	0.10*/3.54**	SiL
20-50	37.8	12.3	22.0	94.7	1.51	0.30	SiL
50-70	36.5	11.1	16.7	46.0	1.49	0.002	SiL
70 <	16.5	11.4	13.0	9.0	1.63	0.0004	LS

SWC = soil water content expressed on volume basis; NA = Not analyzed; SL = sandy loam; L = Loam; SiL – silt loam; LS = loamy sand; * and ** represents before and after rotary tillage, respectively than the above layers. Variation was also recorded in case of soil pH in different soil layers.

The pH at Site-II increased from 4.7 (0-30 cm) to 6.4 (>65 cm), whereas, EC decreased with increasing soil depth and the maximum (0.4 dS m^{-1}) was recorded at upper layer (0-30 cm). Organic matter content also decreased with increasing soil depth (Table 2). The same is the case with CEC and P_2O_5 but more concentrations of Ca^{+2} and Mg^{+2} were observed in lower soil depths. The reason of more hardness and less infiltration may be the less organic matter and higher bulk density in the lower soil layers. The chemical characteristics Site-III had decreasing trend with increasing soil depth. The pH decreased from 8.2 (0-20 cm) to 6.8 (>70 cm) although the soil layer (20-50 cm) recorded the maximum pH of 9.1 (Table 2). The concentration of all exchangeable cations (K^+, Mg^{+2} and Na^+) also decreased with increasing depths with the exception of Ca. The concentration of Ca^{+2} increased at soil depths of 20-50 cm (16.8 $cmol^+ kg^{-1}$) and 50-70 (16.4 $cmol^+ kg^{-1}$) than the surface layer (14.0 $cmol^+ kg^{-1}$). Very abrupt decrease in soil P_2O_5 concentration was noted with increasing soil depth. The surface layer concentration of P_2O_5 was 1961 mg kg^{-1} and at 50-70 cm depth was only 10 mg kg^{-1} (Table 2).

The data showed that the Na concentration low in all three sites except the surface layer of Site-III (3.2 mg kg^{-1}) and the concentration of P_2O_5 was higher and variable at Site-I than the other sites (Table 2). The traditional use of soil for different crops, application of fertilizers and overlying soil pressure have caused the fragile soil properties (Pastor et al. 1993). Pastor and Garcia-Cabeza (1990) related the variation in the concentration of different anions with the rainfall.

Soil organic matter is considered critical component of soil fertility and productivity (Ibrahim et al. 2011; Sarwar et al. 2010), because it directly affects soil physical structure, water movement and root penetration and indirectly to soil microbial activity (Zabinski et al. 2002). The present data also supported their findings because the variation in organic matter at all the sites is affecting other properties (Table 1 and 2). Chambers (1997) described the soil characteristics as the most important indicators of recovery potential at certain site. Monti and Mackintosh (1979) and Marion and Cole (1996) reported a higher bulk density on disturbed versus undisturbed soils and present investigations also support this hypothesis and higher bulk density was recorded influenced by accumulate texture (Zabinski & Cole 2000). The soil water contents were also lower in disturbed soils when compared with undisturbed soils. On the other hand the soil moisture content is also related with the percentage of soil organic matter (Iqbal et al. 2008). Increase in bulk density and decrease in organic matter reduce the water infiltration down the profile in disturbed soils (Tables 1 and 2) as described by Whisenant (1999). Monti and Mackintosh (1979) also described that site degradation may lead to reduced soil water, reduced fertility and increased surface temperatures caused by deterioration in soil structure (Kevan et al. 1995).

Under high elevation systems, one of the most important aspects of disturbance is the severity of the disturbance in relationship to the soil environment

TABLE 2. Chemical properties of soils accumulated sites

Soil depth	pH	EC	OM	P_2O_5	CEC	Exchangeable cations			
						Ca^{2+}	K^+	Mg^{2+}	Na^+
cm	1:5	dS m^{-1}	g kg^{-1}	mg kg^{-1}		$cmol^+ kg^{-1}$			
a. Site-I (Chung-nam University field)									
0-30	7.59	0.28	10.2	257	6.1	4.8	0.17	1.3	0.14
30-75	6.11	0.22	2.8	49	5.3	3.1	0.12	0.8	0.14
75-90	6.85	0.20	19.8	146	8.1	5.7	0.17	0.9	0.13
90-120	7.17	0.15	1.7	20	3.3	3.5	0.07	0.6	0.08
120 <	6.46	0.15	5.0	30	10.5	4.7	0.16	2.5	0.16
b. Site-II (Chung–buk Geosan)									
0-30	NA	NA	NA	2.4	NA	NA	0.7	0.6	0.1
30-40	NA	NA	NA	NA	NA	NA	NA	NA	NA
40-65	6.0	0.1	4.9	3.8	6.9	40.7	0.2	1.3	0.1
65 <	6.4	0.1	4.2	3.4	5.7	34.7	0.1	0.8	0.1
c. Site-III(Yong-in)									
0-20	8.2	10.7	37.0	14.0	5.9	1961	6.8	6.4	3.2
20-50	9.1	1.1	5.9	16.8	5.3	13	0.5	0.4	0.6
50-70	8.9	1.4	5.1	16.4	5.3	10	0.6	1.0	0.5
70 <	6.8	0.2	13.6	2.0	8.0	138	0.3	0.3	0.1

EC = electrical conductivity; OM = organic matter; CEC = cation exchange capacity; NA = not analyzed; P_2O_5 = available

(Bradshaw 1997). The climatic factor may be the most important in limiting restoration along with soil physical and chemical characteristics (Marion & Cole 1996). Soil physical and chemical may be more pronounced between disturbed soils when compared with undisturbed soils. Sometimes the differences in soil organic matter and other chemical components are not significant. In the present study the concentrations of different plant nutrints are not so high in accumulated soils and these may need heavy input in the form of compost and fertilizations.

CONCLUSION

The disturbed and accumulated soils are increasing in area around the globe and they exhibit a great diversity in their physico-chemical properties. This great diversity needs to examine their properties in details and proper management practices may be suggested for optimum uses on sustainable bases. The present results clearly demonstrated the effect of soil disturbance and soils accumulate on soil properties and spatial variation under the influence of texture.

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