The Issues of Topsoil Preservation in Land Development Projects

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토지개발사업의 표토보존에 있어서의 과제

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ABSTRACT

대규모 개발사업을 시행함에 있어 우리는 종종 무의식적으로 토양층을 교란시키게 된다. 식물 성장에 있어 토양은 영양분을 공급하는 중요한 역할을 하고 특히 토양 중 표토층은 식물 생장에 필요한 많은 영양성분을 갖고 있으므로 토양층의 파괴는 식재된 수목의 하자와 직접 연결된다. 살아있는 식물을 다루는 조경공사에서는 공사 후 높은 하자율을 걱정하기에 앞서 수목의 원활한 활착을 위해 토양을 건강하게 유지하도록 노력해야 한다. 본 연구에서는 수목과 토양의 생리학적 관계 및 토양의 기본적인 성질과 표토의 중요성, 표토의 특성을 유지하는 방안 등에 대해 고찰하고 사례연구로 한국토지공사에서 시행한 용인 동백지구의 표토 활용사례를 검토하여 문제점을 파악하고 보다 효과적인 표토층 보존을 위한 방향을 제시하고자 한다.

수목의 성장률, 건강도, 수형 등은 직접적으로 토양의 질과 연결되고 양질의 토양은 수목의 원활한 생장을 가져와 결국 수준 높은 경관을 형성할 수 있게 된다. 본 연구를 통해 수목과 토양의 생리학적 관계를 파악하고 수목의 성장에 적정한 환경을 제공함으로써 불량한 토양으로 인한 수목의 하자율을 사전에 방지하고 수목의 건강성을 유지하는 방안 설정에 도움이 되고자 한다.

Key Words. Soil Collection, Accumulation, Management, Reusing

I. Introduction

When huge residential or industrial areas are developed, the soil properties are unintentionally disturbed. The disturbed infertile land causes deaths of plants and high defect rates in landscape planting. To solve the problem, we have to preserve and re-use healthy soil for plants from the original soil.

The person who handles plants should know the soil structure and properties to keep soil healthy for plants. Rich Koenig(1997) says that the growth rate, health, and visual appearance of landscape plants are directly related to soil quality, then quality topsoil is the basis for quality landscape.

In this paper we studied soil properties, the physiological relationship between soil and plants, the role of topsoil, and the method to keep topsoil for the landscape planting. we also review the criteria in the topsoil re-use of the Korea Land Corporation, and analyze the topsoil reuse process of Dong-Back Project.

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II. The Characteristics of Topsoil

1. Soil Properties

1) Basic soil structure

Soil is differentiated into layers called horizon. The surface layer(the O horizon) is called the organic horizon. This thin horizon is composed of various organic matter. Under O horizon, there is A horizon which is usually darker than the subsurface layer and has decomposed organic matter. A horizon contains most nutrients, roots, and soil organisms, therefore A horizon is regarded as topsoil. Beneath A horizon there is B horizon, which is mixed with several materials and compiled of diverse matter. C horizon is under B horizon which is not affected by the soil formation reaction. The bottom horizon is called R horizon. The C and B horizons compose the subsoil. Subsoil horizons have higher levels of clay, salt, and lime than topsoil. These properties make subsoil poor quality substitutes for true topsoil(http://plaza4.snut.ac.kr/%7Erecycle/soil_pollu/soil_02.htm).

2) Soil texture

Preston Sullivan(2004) says that soils are made of four components: minerals, air, water, and organic matter. And he also asserts in most soils, minerals represent around 45% of the total volume, water and air about 25% each, and organic matter from 2 to 5%. He says that the mineral portion consists of three distinct particle sizes classified as sand, silt, or clay. Sand is the largest size particle that can be considered soil, and silt particles are much smaller than sand. The smallest of all the soil particles is clay. The textural designation of soil is derived from relative portions of sand, silt and clay.

3) Definition of topsoil

Preston Sullivan(2004) insists that native soils are covered with a layer of plant litter and/or growing plants throughout the year. He says beneath the surface litter layer, a rich complexity of soil organisms decompose plant residue and dead roots in A horizon only, then release their stored nutrients slowly over time.

In his book, he insists that this layer is topsoil, which commonly ranges in thickness from 2 to 10inches. Four main chemical and physical properties influence topsoil quality: soluble salts, pH, texture, and organic matter. ① Soluble salts: high levels of soluble salts make it difficult for plants to absorb water and can have direct toxic effects on many landscape plants. Electrical conductivity of the soil solution (EC) is the measurement for soluble salts. Only plants with moderate salinity tolerance grow well in soils with an EC near 4ds/m, ② pH: between 5.5 and 7.5, ③ Texture: a mixture of sand, silt, and clay is desirable, ideal type is loam and silt loam(less than 70% silt), ④ Organic matter: the higher the level of organic matter, the better the soil quality; ideal type is greater than or equal to 2%.

4) Impacts of soil factors to plants

Deficiencies of essential macro-nutrients and micro-nutrients of soil, as well as nutrient imbalances, may lower the rate of photosynthesis. In mineral deficient leaves, the rate of net photosynthesis may be reduced by depressed chlorophyll synthesis, decreased capacity for photosynthetic electron transport, lowered activity of carboxylating and other enzymes, decreased stomatal conductance, and increased respiration(Kozlowski and Pallardy, 1997). In soil salinity, compared to solute-free soil, the presence of salt in salinized soil reduced water evaporation. Compaction increased soil water evaporation in comparison with a non compacted soil condition. Solute accumulated at the soil surface in response to evaporation.

2. Relationship between Soil and Plant

1) Physiological features of plant

Plants take water and minerals from the soil via roots. In the heavy clay soils of the North Carolina piedmont, Colie found 90% of the small roots under oak and pine trees stands in the upper 12cm of soil (Kozlowski and Pallardy, 1997). In Texas, more than half the root growth of 2-year-old loblolly pines was in the upper 7.5cm, and over 70% of the root weight was in the upper 15cm of soil. Maximum xylem production in roots typically occurs near the soil line. Hence, annual xylem increments taper rapidly below the soil line and gradually beyond to the root tip(Kozlowski and Pallardy, 1997).

2) Water absorption of plant

In moist soil, the rate of water absorption is controlled primarily by two factors: the rate of transpiration in the root xylem, and the efficiency of root systems as absorbing surfaces(Kozlowski and Pallardy, 1997). Essentially all the water that is absorbed by roots moves upward through the stem and branches to the leaves in the xylem. Success of all kinds of plants with respect to water and mineral absorption depends on the extent and permeability of roots. Root systems often are concentrated at shallow depths. The root density is often greatest in the first 30cm below the soil surface (Kozlowski and Pallardy, 1997).

3) Nutrient matter of the soil for plant

Plants need carbon, hydrogen, and oxygen to grow. Besides these elements plants need large quantities of nutrients. These are nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, and called macro-nutrients. Bert Cregg(2003) insists in his book that micro-nutrients are also needed but only in very small amounts. They include iron, manganese, copper, zinc, and molybdenum. Carbon, hydrogen, and oxygen are provided by air and water. Also Sullivan says that five tons of topsoil can easily contain 100pounds of nitrogen, 60pounds of phosphate, 45pounds of potash, 2pounds of calcium, 10pounds of magnesium, and 8 pounds of sulfur. All of the remaining elements must be supplied by the soil.

4) Nutrient absorption of plant

Stell(1998) insists that Nutrient availability is a constant give and take. In addition to sources supplying nutrients and the removal of them, there are several interacting factors that affect supply and demand. Most nutrients come from the rocks, that weathered parent material and eventually become mineral particles. Once nutrients are broken down and available, they may be stored in the soil's nutrient reserves. Organic matter supplies many of the same nutrients plus nitrogen, which rarely occurs in mineral form. Organic matter is the remains of animals and plants, which contain many different chemical elements in their cells. As microorganisms break down organic matter, these elements are returned to the soil.

III. The Handling of Topsoil

1. Preservation of Topsoil

Topsoil should be scraped off the surface and stockpiled before excavation. It should be protected from heavy compaction during construction. To preserve the topsoil, first, scrape soil around 30cm from the surface, at the time we should be alert not to mix with subsoil. Second, locate the topsoil at place where the heavy construction equipments do not to impair the topsoil. Third, stabilize the topsoil place and protect before re-using by covering mat not to lose in the wind or rain.

2. Replacement of Topsoil

Replacement of topsoil means the replacement or redistribution of topsoil or topsoil substitute material to all areas where topsoil was actually removed to provide adequate vegetative cover and stabilization of soil condition(http://www.co.ozaukee. wi.us/ordinances/ord%2011_01.htm).

Topsoil should be re-spread so as to provide at least 6inches of cover originally existing on the site or a minimum of 4inches of cover if the original cover was less. The site should be stabilized by seeding. Topsoil or topsoil substitute material redistribution may not be performed during or immediately after a precipitation event until the soils have sufficiently dried(http://www.co.ozaukee.wi.us/ordinances/ord%2011_01.htm).

3. Soil Amendments

Soil amendments are materials which are worked into the soil to enhance the soil's properties such as water retention, permeability, water infiltration, drainage, aeration and structure. There are two broad categories of soil amendment: organic and inorganic. Organic amendments come from something that is or was alive such as wood chips, grass clipping, compost, manure, and wood ash. Inorganic amendments are either mined or man-made such as vermiculate, perlite, pea gravel and sand(http://www.ext.colostate.edu/Pubs/Garden/07235.html). Soil amendments range greatly, but the most popular things are compost, peat moss, redwood sawdust or a variety of manures so amendment can provide physical, biological and nutrient improvements to soils. It is generally recognized that these improvements are more beneficial in the short-term rather than long-term.

Ⅳ. Case Study

In this part, we analyzed how to recycle topsoil in the construction field for the best condition of landscape planting. In Korea Land Corporation, actually the term of 'biokto'(肥沃土) is the same as topsoil. Usually topsoil has to be accumulated at the early stage of construction process, so the collected topsoil needs to be kept in a certain place. We will first analyze the criteria of topsoil preservation used at the Korea Land Corporation, and then review the topsoil reuse process in a land development project.

1. The Process and Criteria of Topsoil Preservation at the Korea Land Corporation

1) Soil survey

It is necessary to investigate the chemical and physical properties of soil, and then estimate the available amount of topsoil at the early stage of construction.

2) Topsoil preservation plan

At the next stage, required amount of topsoil for landscape planting is estimated and the preservation site is selected. A distribution plan of topsoil is also necessary. Based on this plan, the method of collection, movement, accumulation, management, and use of topsoil is decided.

3) Topsoil collection

In collecting topsoil, it is better to use human power rather than machine equipment. In case of big construction project it should be careful not to be mixed with subsoil.

(1) Field clearance

To collect the real and clean topsoil, all kinds of waste, pieces of wood and roots on the soil surface should be removed.

(2) Collection thickness

The topsoil collection thickness is different according to the location of topsoil. For the mountain soil, the collection thickness is about 15cm, and for the farm soil, the thickness is around 9~30cm. The average collection thickness is about 15cm from the surface. In the collection process it is very important not to mix the collected topsoil with subsoil.

(3) Accumulation and management

The preservation site for the collected topsoil should be selected not to disturb other construction process. The height of piled topsoil should be less than 1.3m, to avoid compacting. After accumulation, vinyl or mat is used to protect topsoil from being swept by rain or wind. Erosion is another important problem, so drainage should be considered around the topsoil preservation site.

2. Yong-In Dong-Back Project Case Study

1) Project outline

- Location: Kyeong Gi Province, Yong In City, Ki Heung Gu
- Area: 3,305,000m^2
- Construction cost: 1,182,490million won
- Project period: 1999. 12~2006. 12
- Planned population: 51,646person

2) Topsoil reusing process

The original site of the Dong Back Project has an excellent natural condition. The collecting and recycling of 93,373m^3 of topsoil were asked by the Environment Impact Assessment Statement. The topsoil was collected before construction from the original site and then reused in landscape planting(Refer to Figure 2).

The chemical properties of soil in Dong-Back site are listed in the Table 1.

Topsoil accumulation sites were located at three different

Figure 1. Dong Back site (before development)

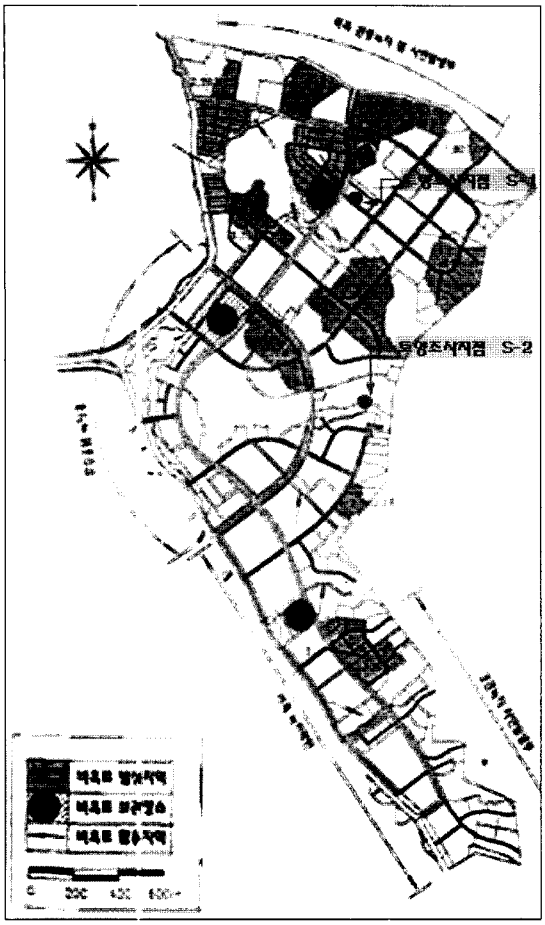

Figure 2. Topsoil accumulation sites and soil survey points

Table1. Physical and chemical properties of soil in Dong Back

Point	S-1	S-2
Soil characteristic	L~SiL	SL~SiCL
pH	6.15	5.70
Organic matter(%)	5.48	3.06
P(ppm)	1.64	3.44
N(%)	0.21	0.09
Ca^{2+}(cmol/kg)	1.18	0.70
Mg^{2+}(cmol/kg)	2.35	0.17
K^{+}(cmol/kg)	0.32	0.40

From Korea Land Corporation(2001)

areas where it did not disturb the main construction process. Site A contained 39,863m^3 of topsoil, site B contained 40,371m^3, and site C contained 13,139m^3.

After accumulation, the topsoil was covered with mat to prevent damage from rain or wind(Refer to Figure 3). Drainage system was made around the topsoil accumulated sites.

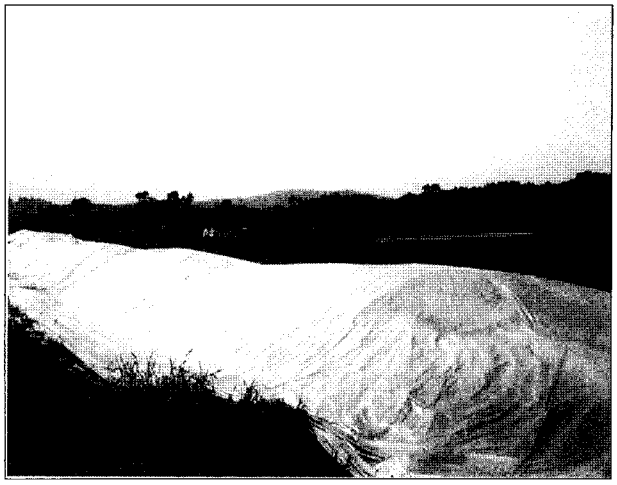

Figure 3. Topsoil accumulation

The shape of the topsoil accumulation sites were trapezoid and the average height of these places were approximately 1.6m. The topsoil was reused about 3years later for landscape planting area to enhance green effect of trees.

From this topsoil reusing plan we could save precious topsoil from huge land development project and also could protect the natural soil resources which can give out good landscape planting effect by reusing organic substances in the topsoil.

3) Difficulties in reusing topsoil

The reusing of topsoil in the Dong-Back Project reveals several problems.

(1) Collecting topsoil was a very hard work because topsoil was sprayed on surface in 30cm thickness, and it was very difficult to distinct topsoil from subsoil. Construction workers had to be careful to collect topsoil only.

(2) Topsoil collection happened at the first stage of construction. After accumulation, the topsoil needed to be preserved from other construction process, wind or rain for a long period. Because the landscape planting areas were prepared after 2-3years of topsoil collection, topsoil's original state should be maintained for recycling in landscape planting.

(3) In reusing topsoil, accurate estimation of topsoil was very important. Extra topsoil means waste of money and labor. To reduce loss of money it was required to estimate exact estimation of topsoil.

(4) Recycling topsoil caused addition of extra construction

cost on the other hand. To reuse topsoil, cost of moving and loading was necessary, because the topsoil needed to be moved first to the accumulation sites, and after the construction, to the landscaping areas by truck. In our project, we spent about 173,500,000won(in 2004.6) in moving and loading of topsoil. If it was not the reuse of topsoil, we did not spend those money.

(5) To reuse the accumulated topsoil, the height of landscape planting sites had to be prepared for 50~100cm lower than the designed height for accommodation of accumulated topsoil, and it was very difficult to make exact height for the topsoil reuse.

4) Solutions to these difficulties.

(1) Many construction workers complained about the difficulties in separation of topsoil in construction fields. The criteria for the topsoil preservation specifies just the standard collection thickness. More specific criteria and instructions for the topsoil collection were necessary. In collecting topsoil, construction workers were required to gather up 50cm of surface soil of the mountain, especially during the first stage of construction process.

(2) To reduce the management efforts it is better to move the collected topsoil from collection place to landscape planting sites directly where the topsoil will be reused in the early stage of construction process. But usually landscape planting sites are prepared 2~3years after the topsoil collection. The long preservation period made the reuse of topsoil more difficult. Therefor preparing the landscape planting sites at the early stage of construction process can make the topsoil preservation easier. In Dong Back Project, most of the parks and greenfield were covered with many obstacles so the scarped topsoil couldn't put up at parks and greenfield. We need specific criteria in reusing topsoil such as exact estimation of topsoil, the real definition of topsoil and rapid preparation of landscaping place. We need to set up our criteria for saving our precious natural resources in detail.

V. Conclusion

Topsoil is the most fertile and valuable portion of soil. According to the United States Department of Agriculture, natural processes can take 500years to form one inch of topsoil (http://www.texascenter.org/almanac/Land/SOILCH5P1.HTML). This means quality topsoil is a limited resource therefor if we can preserve and use topsoil before disturbing topsoil again, we can reduce defect rates caused by the inadequacy between plants and soils.

Soil is the result of gradual weathering of plants, rocks, and minerals. Soil formation is a very slow process that in some estimates takes place at a rate of 25cm per century. Topsoil is rich and fertile. And because of its organic content matters, we have to handle the topsoil very carefully.

Recently the preservation and recycling of topsoil became an important issue in the large land development projects. As introduced in this paper, Korea Land Corporation is trying to collect and reuse topsoil in the land development projects. The criteria for the process of topsoil preservation, however, is not specified, and the effect of topsoil preservation has not been proved. In order to increase the effect of topsoil preservation, research regarding these fields is necessary.

References

1. 한국토지공사(2001) 용인동백지구의 친자연적인 택지개발을 위한 자연생태계 정밀조사 및 생태적 녹지 조성방안 연구보고서. pp.174-176.
2. Cregg, Bert(2003) ABC's tree nutrition. Journal of Landscape, August 2003.
3. Koenig, Rich(1997) Topsoil quality guidelines for landscaping. AG/SO-02. May 1997.
4. Kozlowski, T. T. and S. G. Pallardy(1997) Physiology of Woody Plants. Academic Press.
5. Stell, Elizabeth P.(1998) Secrets to Great Soil. Storey Publishing Pownal.
6. Sullivan, Preston(2004) Sustainable Soil Management. Appropriate Technology Transfer for Rural Areas Publication.
7. http://plaza4.snut.ac.kr/%7Erecycle/soil_pollu/soil_02.htm
8. http://www.co.ozaukee.wi.us/ordinances/ord% 2011_01.htm
9. http://www.ext.colostate.edu/Pubs/Garden/07235.html
10. http://www.texascenter.org/almanac/Land/SOILCH5P1.HTML

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