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Article

Analysis of Landscape According to Land Use at Rural Area in Korea Using GIS Application

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To designate rural landscape spatially, land use and topographic features for 383 of "Ri"s or "Dong", which is a basic administrative unit in Korea, were analyzed using GIS application. We have categorized rural landscape into three types such as agricultural, natural and urban landscape by land use. On the basis of spatial landscape pattern, rural area could be classified into 6 groups of Mountainous area (MA), Mountainous village area (MV), Developing mountainous village area (DM), Plain agricultural area (PA), Developing plain village area (DP) and Urbanized area (UA) according to the ratios of land for agricultural and urban use as the criteria. In MA, the ratio of upland area including orchard was slightly larger than that of paddy, while that of paddy was about 1.5 times larger than upland in other groups. Forested area was distributed more than two-thirds among natural landscape area in MA, MV and DM. In plain types (PA and DP), the ratio of irrigated paddy was extremely larger than partially irrigated paddy and the ratio of water body area among the natural landscape area was two times as large as that of forested area. The ratio of land for industrial and livestock facilities among urban landscape area were 20% or more in MV, DM and DP, and it means that these facilities are mainly distributed in the developing rural area where residents and industry are closely related each other. According to the relative ratio of sloped land of 6 categorized areas, the MA area have lots of land with E and F slopes and MV and DM have all grades of sloped land evenly distributed in relative to other types of rural landscape. It has been showed that PA, DP and UA occupied more than two-thirds of land with A or B slope. In case of the analysis of topological distribution in 6 types of rural landscape, there were overwhelmingly lager highland areas in MA. Conclusively, we have confirmed that 6 types of rural landscape classified by land use pattern in 3 categorized areas such as agricultural, natural and urban landscape area would be useful for the management of rural area. For development of sustainable agriculture and the preservation of rural amenity, proper management ways should be properly applied according to rural landscape patterns.

Key words : Spatial indicator, Landscape pattern, GIS, Land use, Slope, and Topography

Introduction

Landscapes are composed of multiple elements, and a variety of these elements create heterogeneity within an area. The elements of a landscape have a particular spatial configuration, which can be portrayed as a map or a geographical information system (GIS) image (Gutzwiller, 2002). Landscape ecology emphasizes the spatial characteristics and dynamic relationships of patches (Forman and Godron, 1986). By identifying the particular spatial configuration of a landscape, the underlying processes that contribute to the pattern formation can be inferred based on the characteristic composition of the patches in space and time (Urban et al., 1987).

Two broad types of landscape can be identified: first, natural landscape formed by various biophysical forces of nature and second, man-made or cultural landscape resulting from the interaction between human activities and the environment (OECD, 2001). In cultural landscapes, which could be divided into urban and agricultural landscapes, anthropogenic processes are of central importance in analyses of structure, dynamics and functions of patches (Houghton, 1994; Lamarche and Romane, 1982; Oldfield et al., 2000; Reid et al., 2000). Therefore, ecological studies of cultural landscapes have to be linked closely to the levels of human activities and

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the hierarchical structure of administrative bodies.

In recent years, numerous case studies have focused on both ecological and socioeconomic aspects of the transformation of natural landscapes and changes of respective land use (Cousins et al., 2002; McLure and Griffiths, 2002; Petit and Lambin, 2002; Pärtel et al., 1999; Sporrong, 1998; Verheyen et al., 1999). Agroecosystems are communities of plants and animals interacting with their physical and chemical environments that have been modified by people to produce food, fiber, fuel and other products for human consumption and processing (Altieri, 1994). They have functioned as eco-bridges between natural and urban ecosystems, which plant, animal and human being are living together.

Land use patterns include changes in total agricultural land use with other uses, such as forestry and urban development, which affects the total "stock" of agricultural landscape. Also they describe the cropping patterns and systems on agricultural land (OECD, 2001).

For this reasons, we analyzed spatially land use pattern and topographic features using GIS application and set up spatial indicator at landscape unit for rural area in Korea.

Material and Methods

Basic scale of landscape have been set up by "Dong" or "Ri", which is a basic administrative unit in Korea, though landscape unit is various according to researchers. The studied areas are shown in Fig. 1.

Fig. 1. Distribution of the studied area. The large region above is Anseong and the other below is Boeun. The four small regions are part of Hongcheon, Icheon, Gongju and Gimje from the above.

383 of "Ri"s were randomly selected by being focused mainly on "Boeun" and "Anseong" and then surveyed to analyze land use pattern and topographic features by using GIS application (ESRI, ArcView 3.2, USA). The maps used in this study were land use map produced by National Geographic Information Institute (NGII) in 1996 and soil survey map surveyed by National Institute of Agricultural Science and Technology (NIAST) in 1990, on scale of 1:25,000. To characterize classified land use in agricultural regions, we analyzed topographical structures by using land status maps overlaid with soil maps. In this study, forested area was set by coniferous, broad-leaves and mixed forest, grassland area by natural and artificial grass lands, golf areas and parks, water body area by foreshore, salt farm, rivers and reservoirs in natural land use and public facilities were set by commercial areas, electro-power stations, schools, military facilities, public places, mineral springs and so on, treatment facilities having potential of pollution by industrial establishments, disposal sites, landfills, livestock, etc. The grade of slope from A to F was characterized by Institute of Agricultural Sciences(IAS), where A was used for 0-2%, B for 2-7%, C for 7-15%, D for 15-30%, E for 30-60% and F for 60-100% of slope (IAS, 1992).

Results and Discussion

Landscape unit areas surveyed were recorded 372.10 ha in average, with range of 48.95 to 2,792.27 ha. According to land use derived from land use maps, rural landscape was categorized into three main landscapes: natural landscape, agricultural landscape, and urban landscape (OECD, 2001). In natural landscape area, land use was classified into forested area, grassland area and water body area. Agricultural landscape area was divided into paddy, upland and orchard, and urban landscape area was divided into resident area, industrial facilities, and livestock facilities depending on land use.

For categorizing the first-landscape pattern, we have suggested that landscape patterns on the basis of the ratio with agricultural and urban landscape could be grouped by the ratio of agricultural landscape into less than 30%, 30 to 70% and more than 70%, and the ratio of urban landscape into less- and more than 10% with combination. In addition, if the ratio of urban landscape exceeds 50% irrespective of others, we counted it as extra one.

Based on this criteria, rural area in Korea could be classified into 6 groups, i.e. Group 1, the ratio of land for agriculture was less than 30% and that for urban was less than 10%, named Mountainous area (MA) type; Group 2, ratio of land for agriculture was between 30 and 70% and that for urban was also less than 10%, Mountainous Village area (MV) type; Group 3, ratio of land for agriculture was less than 70% and that for urban between 10 and 50%, Developing mountainous Village area (DM) type; Group 4, ratio of land for agriculture was more than 70% and that for urban less than 10%, Plain Agricultural area (PA) type; Group 5, ratio of land for agriculture was more than 70% and that for urban between 10 and 50%, Developing Plain Agricultural area (DP) type; and lastly Group 6, the ratio of land for urban was more than 50%, Urbanized area (UA) type (Table 1).

According to these six groups classified by ratio of land use, all "Ri"s studied were rearranged and analyzed by their properties in detail for characterizing the groups of rural landscapes. Table 2 shows the average and standard deviation of "Ri"s area, and average ratio of land use categorized by agricultural, natural and urban landscape. The average area studied was largest in MA type among six-types, averaged 510.23 ha with 428.03 in standard deviation. The area of UA type was recorded the smallest, however we could not jump to awkward conclusion because only one "Ri" sample belonged to this type. The other types averaged similarly in their area, with a range of 218.62 to 283.20 ha. When the type changed from MA to MV, DM and UA, the average ratio of nature was decreased drastically from 82 to 21%. Similarly, when the type changed from PA to DP and UA, agricultural land use contributed significantly to the urbanization. With these results, we might conclude that urbanization at DM and DP types mainly results from the changes and destruction of land for nature and agriculture to urban landscape. It could be inferred that developments of land should be conducted against agricultural land because over 60% of total land is generally consisted of mountainous topography in Korea.

The ratio of land for agriculture, nature and urban of each site was drawn at triangular plot as shown in Fig. 2. Many dots are distributed in the bottom of diagram, which means most of them have been not urbanized. There was only one "Ri" for UA type, located in center of rural town, because the studied areas were mainly distributed in the rural region. As a whole, it could be called MA, MV, and PA as typical agricultural regions undeveloped, though DM and DP as another agricultural region developing village or town. Of special interest is, as the ratio of land for agriculture increase, the ratio of land for urban increase slightly. It indicates that agricultural regions have more adaptable to live than mountainous regions. In addition, the dots less than 20% in land for nature were distributed in agricultural type, not in urban type. As shown in Fig. 2, most points over 10%

Table 1. The grouping of rural area by types of rural landscape and criteria for classification.

Classification	Description of each rural area	Abbr.	Criteria (%)	
			Agr	Urb.
Group 1	Mountainous Area	MA	< 30	< 10
Group 2	Mountainous Village area	MV	30 ≤ and ≤ 70	< 10
Group 3	Developing Mountainous Village area	DM	≤ 70	10 ≤ and < 50
Group 4	Plain Agricultural area	PA	70 ≤	< 10
Group 5	Developing Plain Agricultural area	DP	70 ≤	10 ≤ and < 50
Group 6	Urbanized Village Area	UA	-	50 ≤

Table 2. The ratio of land use depending on types of landscape in rural area studied.

Types†	Agriculture	Nature	Urban	No. of Ri	Av. Area (ha)	STD
	Av. Ratio (%)					
MA	15.75	81.55	2.70	166	510.23	428.03
MV	46.42	47.56	6.02	107	277.99	142.90
DM	45.78	36.15	18.07	63	283.20	198.79
PA	81.30	12.40	6.30	31	218.62	137.00
DP	79.15	7.76	13.09	15	224.81	116.78
UA	2.90	20.96	76.13	1	80.14	-

† MA - mountainous area; MV - mountainous village area; DM - developing mountainous village area; PA - plain agricultural area; DP - developing plain agricultural area; and UA - urbanized area.

in land for urban recorded below 50% in land for nature. In other words, agricultural elements in land use are more vulnerable than mountainous elements against urban developments. To obtain more detailed proofs, it should be needed to analyze real data with time.

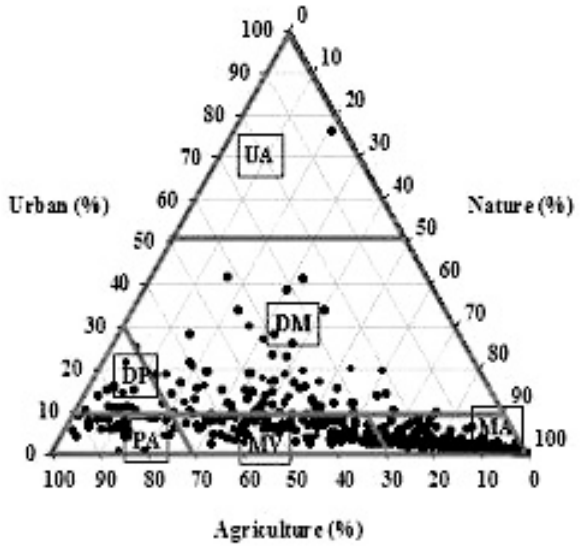

Fig. 2. Triangular distribution of the ratios of nature, agriculture, and urban landscape area in rural areas studied: MA - mountainous area; MV - mountainous village area; DM - developing mountainous village area; PA - plain agricultural area; DP - developing plain agricultural area; and UA - urbanized area. The three capitals (Agriculture, Nature and Urban) represent the relative ratio of each land use.

Figure 3 shows the relative ratios of land uses in agricultural landscape. The ratio of upland area including orchard area was 55%, slightly larger than paddy area summed irrigated and partially irrigated paddy area in MA type, while those of paddy areas were 62 to 78%, about 1.5 to 2 times larger than upland areas in other groups. PA type, where was 78% of irrigated paddy area, showed largest paddy area among agricultural landscape. As the relative ratio of land for agriculture got larger from MA to PA at the bottom in Fig. 2, the proportion of upland area in each type was changed from 50 to 9% and that was changed from 45 to 78% in paddy area, from 5 to 13% in orchard area. Especially, the ratio of irrigated paddy area increased linearly from 11 to 68%. The ratio of irrigated paddy area was extremely larger than partially irrigated paddy area in plain types (58% in PA and 43% in DP). In mountainous types (MA, MV, and DM), the ratios of orchard area were analogous to each other, slightly over 5%. In UA type, however, there was no orchard area. Irrigated paddy area means the typical rearranged land for mechanized agricultural production in Korea. As a result of Fig. 2, we could be found that irrigated paddy area is one of representative landscape elements in rural landscape. So management for conserving rural landscape should be focused on how to make use of irrigated paddy in PA and DP types.

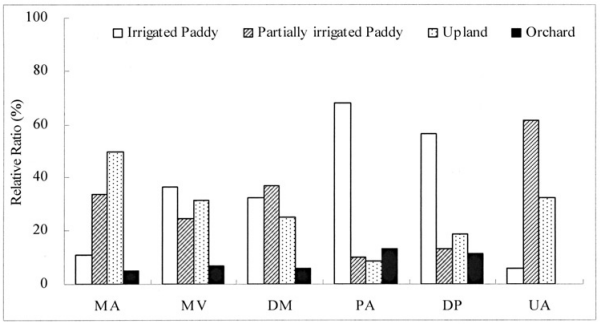

Fig. 3. Relative ratios of land use by each group of rural area in agricultural landscape area. MA - mountainous area; MV - mountainous village area; DM - developing mountainous village area; PA - plain agricultural area; DP - developing plain agricultural area; and UA - urbanized area.

Figure 4 illustrates the relative ratios of land uses in natural landscape. Forested area including coniferous, broad leaves and mixed forests was distributed more than 75% among natural landscape area in mountainous types (MA, MV and DM). While the relative ratio of land for agriculture got larger from MA to PA at the bottom in Fig. 2, the proportion of forested area in each type got smaller from 91 to 32% and that of water body area got larger from 6 to 65%.

The ratios of water body area in plain types (PA and DP) among natural landscape were 65 and 63%, two times as large as those of forested area. It is interesting that there was opposite tendency between forested area and water body area and the point of inflection was located between the mountainous types and plain types.

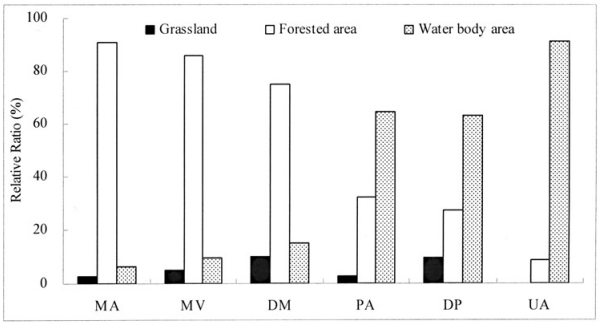

Fig. 4. Relative ratios of land use by each group of rural area in natural landscape area. MA - mountainous area; MV - mountainous village area; DM - developing mountainous village area; PA - plain agricultural area; DP - developing plain agricultural area; and UA - urbanized area.

Among urban landscape in MV, DM and DP, the ratios of land for industrial and livestock facilities, which might recognize to cause pollution problem to its surroundings, were about 20% or more. They got larger from 16 (MA) to 27% (MV). It was 39%, largest in DM type where it has much more bare land than other types. Similarly, it was changed from 13 (PA) to 28% (DP). It indicates that these facilities increased as the type got changed to developing town type (DM and DP). It is interesting that there was no treatment facility in UA type, which reflects as the society is getting more developed, other elements except for residence are moved to suburb or farther (Fig. 5).

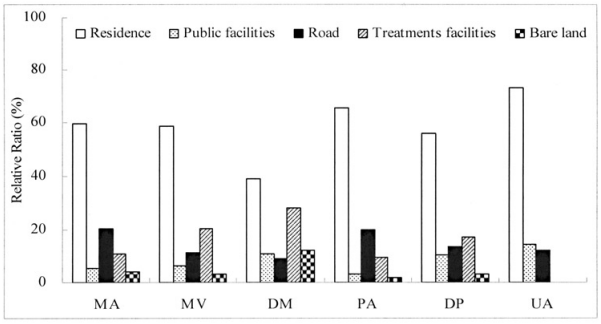

Fig. 5. Relative ratios of land use by each group of rural area in urban landscape area. MA - mountainous area; MV - mountainous village area; DM - developing mountainous village area; PA - plain agricultural area; DP - developing plain agricultural area; and UA - urbanized area.

According to the relative area ratio of sloped land classified into 6 categories, there were 24% of E and 46% of F slopes in MA, while both A and B slope were less than 10%. In case of MV and DM, all grades of sloped land were evenly distributed in relative to other types of rural landscape. Large portion of steep slope in MA, MV and DM types indicate that soil erosion in their types should be focused on for managing landscapes with environmental sound. The distribution of A and B slopes was gradually increased from 9 to 46%, as the types changed from MA to DM, whereas that of E and F slopes stands in sharp contrast to that of A and B slopes. PA, DP, and UA types have more than two-thirds of land with A or B slope (Fig. 6).

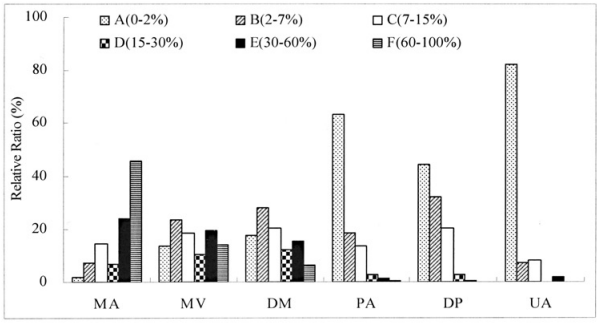

Fig. 6. Distribution of land areas of 6 categorized slopes in each group of rural area. MA - mountainous area; MV - mountainous village area; DM - developing mountainous village area; PA - plain agricultural area; DP - developing plain agricultural area; and UA - urbanized area.

As a result of making an investigation of topographic distribution, there were overwhelmingly larger highland areas including mountain foots, high residuum, and fan and valley in MA. As the types develop from MA to MV and DM, the relative area ratios of highlands got smaller up to 30%. The distribution of alluvial plain was 83%, largest in UA type. With regard to this point, UA type in this study might come topographically from alluvial plain. PA type has naturally the largest plain originated from river or marine with 12 and 19% respectively, might be beneficial for agricultural farming (Fig. 7).

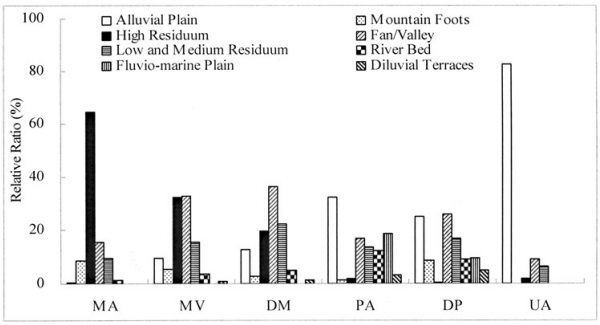

Fig. 7. Distribution of land areas with topographic characteristics in each group of rural area. MA - mountainous area; MV - mountainous village area; DM - developing mountainous village area; PA - plain agricultural area; DP - developing plain agricultural area; and UA - urbanized area.

As a whole view, MA type showed typical properties of mountainous characteristics, i.e. it has overwhelmingly large ratio of land for nature on the basis of its definition, especially more than 90% of forested areas among them, and it might contribute its larger ratio of upland area than paddy area among agricultural landscape. Moreover there were lots of steep slope mainly distributed E and F slope.

MV and DM types have similar properties in land for agriculture and nature but DM type compared to MV has much larger proportion of land for industrial facilities up to 12% which might be exposed to environment more harmfully and has much gentle slope and less highland ratio.

PA and DP types, both have more than 70% of land for agriculture by definition, also showed similar properties

as a whole though DP was more developed at living facilities than PA. Many of sites in DP type were predicted urbanization increasingly. They have outstandingly large ratio of irrigated paddy area in agricultural landscape and relatively large ratio of water body area in natural landscape might make it possible. Compared to DP, PA type has much low plain and gentle slope, which is advantageous for cultivating.

UA type has overwhelmingly large ratio of water body area in natural landscape, low slope and large plain. Land for urbanized village in this type is mainly used for residences, public facilities and roads.

In the view of amenity related with rural landscape, the proposed classification of landscape at rural area is expected helpful. The elements of rural landscape such as paddy levee, bank, natural grasslands, water canal, etc. could be identified as amenity element. It is very useful to apply our proposal about classification of landscape to the rural amenity. This concept is, however, out of scope in this study. Further works on classification of landscape related with rural amenity should be recommendable.

Conclusions

Using GIS application, we analyzed land use pattern and topographic features in terms of spatial unit, and set up spatial indicator for landscape unit in rural area in Korea. As discussed above, we have confirmed that 6 types of rural landscape classified by land use pattern in 3 categorized areas such as agricultural, natural and urban landscape area would be useful for the management of rural area. Much more data should be supplemented for the national representative value to manage rural region by these landscape patterns. And for development of sustainable agriculture and the preservation of rural amenity, proper management ways should be properly applied according to rural landscape patterns.

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GIS기법을 이용한 농촌지역의 토지이용에 따른 경관유형 분석

홍승길 · 서명철* · 정필균 · 손연규 · 박광래 · 강기경

농업과학기술원

우리나라 농촌경관의 공간지표를 설정하기 위해 383 개 “리”와 “동”의 토지이용현황과 지형조건을 GIS기법으로 분석하여, 토지이용 형태에 따라 농촌, 자연, 도시형으로 구분하였고, 이를 다시 공간유형을 기본으로 하여 산악지역(MA), 산촌마을지역(MV), 개발산촌마을지역(DM), 평야지 농업지역(PA), 개발평야지마을지역(DP), 집촌지역(UA)의 6가지 유형으로 분류하였다. 조건불리지역에서는 농업적 토지이용 중에서 논으로 사용하는 비율이 과수원이나 밭으로 사용하는 비율보다 낮았는데, 다른 유형에서는 오히려 1.5배 높았다. 산촌형 지역(MA, MV, DM)에서는 자연적 토지이용 중 산림이 75%이상이었으나, 평야지형 지역(PA, DP)에서는 수계의 비율이 산림보다 2배 이상 높았다. 특히 평야지형 지역에서 경지정리된 논의 비율이 경지정리되지 않은 논의 비율에 비해 월등히 높았다는 것도 특기할 만하다. 도시적 토지이용 중에서 공업시설과 가축사육시설의 비율은 MV, DM, DP에서 약 20%였는데 이러한 시설들이 개발 농촌지역에 주로 분포하고 있음을 말해준다. 6가지 유형에 따른 경사도의 상대적 비율에서는 MA에서 E와 F등급의 급경사가 상당히 많았고, PA, DP, UA에서는 반대로 A와 B등급의 완만한 경사가 75% 이상이었으며, MV와 DM에서는 다른 유형들에 비해 6가지 경사등급이 비교적 균등하게 분포하였다. 지형분포를 살펴보면, MA에서 월등히 많은 고지대가 분포하였다. 이상과 같이 농업, 자연, 도시의 3가지 경관에 대해 토지이용현황을 6가지 유형으로 분류하였고 이 방법이 농촌 지역을 관리하는데 유용함을 보였다. 지속적 농업과 어메니티를 개발하는 방법들을 농촌경관유형에 따라 적절히 적용하여야 할 것이다.

본 실험은 포화수분상태에서 두개의 서로 다른 토양의 흡착가능장소에 대한 흡착능과 경쟁에 따른 Cd, Pb, 그리고 Cr 이온의 이동성을 조사하였다. 이 조사를 위하여 수용성상태로 단일, 이중, 삼중의 중금속 조합을 이용하였다. 두개의 토양시료는 밭토양의 지표면으로부터 20 cm 이내에서 채취한 토양을 사용하였다. 그리고 공극수량에 따른 출현과 용출곡선을 중금속용액과 치환용 K 이온용액을 가하여 각각의 곡선이 최대와 최소치에 이은 시점까지 조사하였다. 조사 결과 출현과 용출곡선은 대칭을 이루지 않았으며 용액상태로 존재하는 중금속이온의 종류가 증가됨에 따라 용출곡선의 미행이 증가되었을 뿐만 아니라 공극수량도 증가하는 경향을 보였다. 그리고 출현과 용출곡선을 기준하여 곡선의 위와 아래의 면적을 비교하여 본 결과 출현 후 K에 의한 용출면적은 상대적으로 작아 K에 의한 중금속 탈착은 작은 것으로 조사되었는데 이는 중금속이온이 가지는 전기음성도 차이에 기인한 것으로 추정되었다. 결론적으로 토양내에서 중금속이온의 이동은 토양내에서 존재하는 중금속이온의 종류가 2개 이상 존재하는 한 토양의 물리적 비평형과 용액상태의 화학적평형이 중금속이온 이동에 영향을 미치는 것으로 추정하였다.