Distribution characteristics of ^{137}Cs in wind-eroded soil profile and its use in estimating wind erosion modulus

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INTRODUCTION

Soil ^{137}Cs originated from fallout of atmospheric nuclear bombs during 1950s~1970s. When ^{137}Cs fallout fell to ground, it would tenaciously bind with fine soil particles and soil organic matter. Because of this tight binding, soil ^{137}Cs is an excellent tracer to study soil particle movement. In the Northern Farming-Grazing Transitional Belt (NFGTB) of China, wind erosion is the dominant erosion type with high annual rates. Land use and land cover are also different from water erosion region such that it has many types of cropland and grassland instead of singular cropland. Therefore, in order to understand the intensity and spatial pattern of wind erosion in the NFGTB of China, distribution characteristics of ^{137}Cs needs to be understood. Based on this understanding, proper assessment model could then be selected to calculate wind erosion modules.

Fig.1 The Northern Farming-Grazing Transitional Belt of China (left) & the distribution of sampling sites in Taipusi County, Inner Mongolia (right).

STUDY AREA AND SAMPLING PROCESS

Soil samples were collected in Taipusi County which lies in the middle part of NFGTB (Fig.1). The area has a mean annual precipitation of 350 mm to 430 mm and belongs to semi-arid highland climate. According to the Year 2000 Chinese Land Use Map, one cropland sampling site and three grassland sampling sites were selected. In each sampling site, soil samples were collected from surface up to 32cm depth in every 2cm increment. Soil ^{137}Cs activities were measured using a γ-ray spectrometry, and obtained from the 662keV peak area with an area error less than 5%.

RESULTS AND ANALYSIS

Distribution pattern of ^{137}Cs activity in soil profile

The low and medium cover grasslands(Fig2a, 2b) had similar ^{137}Cs distribution pattern, represented by a negative exponential curve. Based on the ^{137}Cs distribution pattern and its site inventory data, the two sites could be classified as typical erosion profile.

For high cover grassland area, the data showed a peak at 2-4cm depth, followed by a negative exponential curve (Fig. 2c). The shape parameter t1 in high cover grassland was similar to that for low and medium cover grassland. However, the scale parameter A1 was 3.3 and 1.7 times greater than that for the low & medium cover grassland, respectively.

In the cropland area (Fig. 2d), 137Cs was distributed homogeneously in the plow layer (0 to 18~20 cm). The 137Cs profile in cropland area is fit well for typical human-disrupted distribution type.

Estimation of wind erosion rate

In order to quantify soil loss from 137Cs loss, many erosion models had been developed, and the modified mass balance model is more suitable for assessing soil erosion in cropland. For grassland, the profile distribution model is more appropriate.

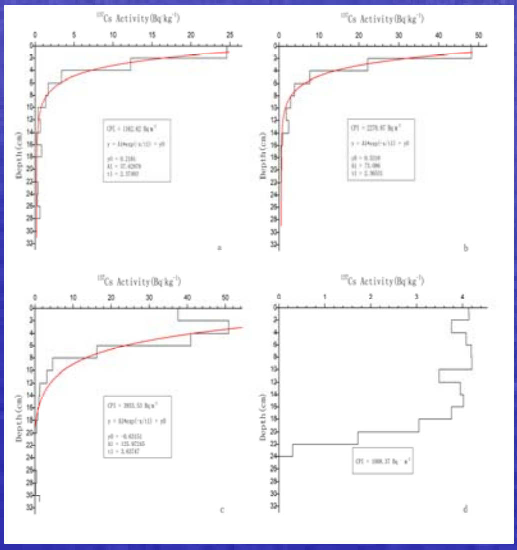

Fig.2 Spatial distributions of ^{137}Cs in soil profile
(a: Low cover sampling site; b: Medium cover sampling site;
c: High cover sampling site; d: Cultivated sampling site)

The simplified mass balance model as $X = X_0 \cdot (1 - \frac{h}{H})^{T-1963}$

The profile distribution model as $X = X_0 \cdot e^{-\lambda \cdot h \cdot (T-1963)}$ $X_0 = CRI \cdot k$

Where X_0 is the effective ^{137}Cs background (Bq·m^{-2}); h is the annual erosion depth (cm·a^{-1}); H is the depth of plow layer (cm); T is the sampling year; λ is the shape parameter describing ^{137}Cs change in soil profile; k is a ^{137}Cs distribution coefficient adjusting for snow-blown and vegetation removal (k= 0.95); and CRI is the ^{137}Cs reference inventory (Bq·m^{-2}).

The high covered grassland site was chosen in this study as background and CRI=3933±214Bq·kg^{-1}.

Table 1 Results of wind erosion assessment for the sampling sites

Land use / Land cover	Annual Erosion Depth (cm·a^{-1})	Bulk Density (g·cm^{-3})	Erosion Modulus (Mg·km^{-2} ·a^{-1})	Erosion Intensity	Applied Model
Cropland	0.579	1.38	7990	Strong	Simplified Mass Balance Model
Low cover grassland	0.314	1.36	4270	Moderate	Profile Distribution Model
Medium cover grassland	0.133	1.36	1808	Light	Profile Distribution Model

Conclusions

1. As the first study to assess wind erosion using ^{137}Cs technique in the Northern Farming-Grazing Transitional Belt of China. The grassland ^{137}Cs distribution obtained from this study could be used as a standard and allowed future comparison study.
2. The ^{137}Cs distribution in vertical soil profile was different for different land use/land cover types. ^{137}Cs was distributed homogeneously over the plow layer for cropland, while it was distributed as a negative exponential curve in low and medium covered grassland. For high cover grassland, ^{137}Cs distribution showed a peak at 2-4cm soil depth followed by a negative exponential curve.
3. Based on the understanding of ^{137}Cs distribution in soil profile, simplified mass balance model and profile distribution model were chosen to calculate wind erosion modulus for cropland and grassland, respectively. Wind erosion modulus was 7990, 4370 and 1808 Mg·km^{-2} ·a^{-1} for cropland, low cover grassland and medium cover grassland, respectively. Wind erosion severity was inversely correlated with the degree of plant cover.