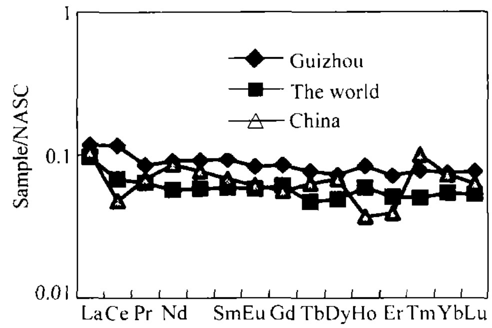

Fig. 1. Shale-normalized REE pattern in soils of Guizhou carbonate region.

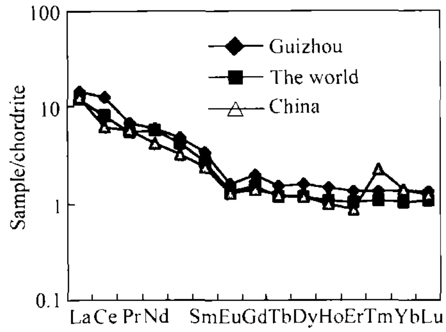

Fig. 2. Chondrite-normalized REE pattern in soils of Guizhou carbonate region.

The order of activate ratio of REE (soluble REE/ΣREE × 100%) is yellow soil (5.07) > red soil (4.64) > paddy soil (4.52) > limy soil (3.07) > yellow brown earth (3.03) > purple soil (2.41). This shows that available REE for plants is absent and potentially absent in soils of Guizhou carbonate region, although the content of REE in soils is higher. Therefore it has great potential for reasonable application of REE to agriculture in Guizhou carbonate region.

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Changes of soil microbial biomass carbon and organic carbon with sea level elevation increasing in soils of mountainous areas, Southwest China

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SOIL organic matter, a major factor affecting agroecosystem stability, is controlled by many parameters. It is well understood that cultivation practive would lead to a decrease in organic matter content of soils. However, small gradual changes in total soil organic matter may be difficult to monitor and detect in the short term because of generally high background carbon levels and natural variability of soils[1]. On a short-term scale the measurement of the living fraction of soil organic matter, i.e. microbial biomass C, can reveal early changes in soil organic matter. Our work is to identify the relationship of soil organic C and changes in microbial biomass C with sea-level elevation increasing.

Twelve terrace fields on the slopes at different altitudes above sea level were chosen as sample localities. The terrace fields, different in size, approximately 10 m^2, were used for growing maize. Those sample localities are in the slope terrains, a transitional zone from low land to hills in the eastern part of the Yunnan-Guizhou Plateau, Southwest China. Microbial biomass C was determined repeatedly using the chloroform fumigation-extraction technique[2]. Organic C in the extracts was measured by means of dichromate oxidation. The standard deviations tested for all samples were below 20 $\mu g \cdot g^{-1}$ soil. Soluble organic C in the nonfumigated extracts was used as an estimate of soluble organic C in soil.

The highest microbial biomass C occurred in winter, reaching 1014 $\mu g \cdot g^{-1}$ soil at site M2; the lowest soil microbial biomass C occurred in summer, being 217 $\mu g \cdot g^{-1}$ soil at site M3. Seasonal changes in microbial biomass C were very significant. It is well understood that plant residues have an obvious influence on the changes of microbial C. In some sites studied, the amount of corn residues incorporated into soils was lower than that of weed's residues, which were weeding at regular intervals and incorporating into soil. Such being the case, the values of microbial biomass C in summer and fall would be higher than those in winter. However, the facts are just opposite, for which other mechanisms would be responsible: the consumption of microbial biomass C was higher than its accumulation in warmer season; the trend was opposite in cooler season.

In each of the 12 sample localities, the microbial biomass C is high in winter, and low in summer. Differences in microbial biomass C between winter and summer are related with soil organic C contents, showing a reciprocal relationship. The significance is relatively high ($r = -0.695$, $p < 0.02$). The contents of soil organic C appeared to be correlated to the sea-level elevation. This correlation between soil organic C and the sea-level elevation is actually related with air temperature. In the ecosystems studied, the sea-level elevation is significantly correlated with the annual average atmospheric temperature ($r = 0.98$, $p < 0.001$). The content of soil organic C decreased with annual average atmospheric temperature increasing.

The microbial biomass C is significantly correlated to both sea-level elevation and annual average atmospheric temperature. Differences in microbial biomass C between winter and summer increased with annual average atmospheric temperature increasing and sea-level elevation decreasing, showing a positive correlation with the annual average atmospheric temperature, but a negative one with sea-level elevation. These results showed that the amounts of conversion of soil organic C (including plant residues) to microbial biomass C at warmer sites were higher than those at cooler sites; and that the amounts of changes in microbial biomass C at warmer sites were also higher than those at cooler sites. It is followed that changes in microbial biomass C may be the major pathway of decreasing of soil organic matter.

In the 12 localities studied, changes in the ratio of microbial biomass C to soil organic C (C_{mic}/C_{org}) were negatively correlated with sea-level elevation , and positively related with annual average atmospheric temperature . The ratios of differences in microbial biomass C between summer and winter to soil organic C contents are also correlated with sea-level elevation and atmospheric temperature, showing that differences in microbial biomass C are governed by atmospheric temperature.

According to the values of variation for microbial biomass C and soluble organic C between winter and summer, and the bulk density values for each sampling site, the total content of lost soil microbial biomass C in an area (1 m^2 and 10 cm in thickness) was calculated. The differences in soluble organic C between summer and winter were significantly correlated with the average annual atmospheric temperature ($r = 0.626$, $p < 0.05$). The lost microbial biomass C was significantly correlated with the total soil organic C ($r = -0.806$, $p < 0.002$). The ratio of lost microbial biomass C to total soil organic C is negatively correlated with the elevation above sea level: below 600 m a.s.l., the mean ratio is $3.9 \pm 0.9\%$; 600—1 500 m, $2.0 \pm 1.4\%$; above 1 500 m, $1.4 \pm 0.5\%$.

The relationships of soil organic C and microbial biomass C and sea-level elevation indicate that the decrease of soil organic C content mainly resulted from changes in microbial biomass C. The extent of change in microbial biomass C at warmer sites is much higher than that at cooler sites. In the ecosystems studied the relationship between soil organic C content and differences in microbial biomass C between winter and summer demonstrate that the atmospheric temperature influences the decomposition of organic C in soils mainly through its effects on microbial biomass C. Therefore, the marked seasonal responses in microbial biomass C are ascribed to annual average atmospheric temperature, which increases with sea-level elevation decreasing.

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