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Sensitivity of soils to acid rain in South China

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Abstract—This paper deals with the sensitivity of soils to acid rain in 5 provinces, South China. Based on field work and literature, and taking soil pH, CEC, and the types of residua into account, the authors classified the sensitivity into 4 categories: highly sensitive, sensitive, slightly sensitive, and non-sensitive. By overlapping the maps of soil pH, CEC, and types of residua, the map of soil sensitivity in South China has finally resulted.

The authors try to summarize the regularity of soil sensitivity to acid rain in this area. The sensitivity of different soil types in the studied area has also discussed.

The seriousness and its prospects of acid rain in this area have been pointed out in order to draw the attention of relevant authorities.

Keywords: acid rain; sensitivity of soils; soil buffer capacity; South China.

Acid rain, as an environmental problem in China, mainly occurrs in the humic subtropical and tropical areas of South China. The aim of this study is to provide information about the sensitivity of soils to acid rain in this area.

The study area includes Yunnan, Guizhou, Sichuan, Hunan provinces and Guangxi Zhuang Autonomous region (Fig.1). Laterites, Lateritic soils, Red earth and Yellow earth are predominant in the subtropical and tropical areas. Most of the original subtropical monsoon forest and tropical rain forest have been turned to agricultural land or secondary forest and bush.

CRITERIA AND METHODOLOGY

Although soil buffer capacity depends mainly on cation exchange capacity (CEC), it is also dependent on soil buffer systems involved, for example, carbonic acid, bicarbonic acid, phosphoric acid, silisic acid, humic acids and their salts. There is also a neutralization effect from alkaline materials and the above mentioned acids. Amphoteric materials such as protein and amino acid also provide soil buffering power.

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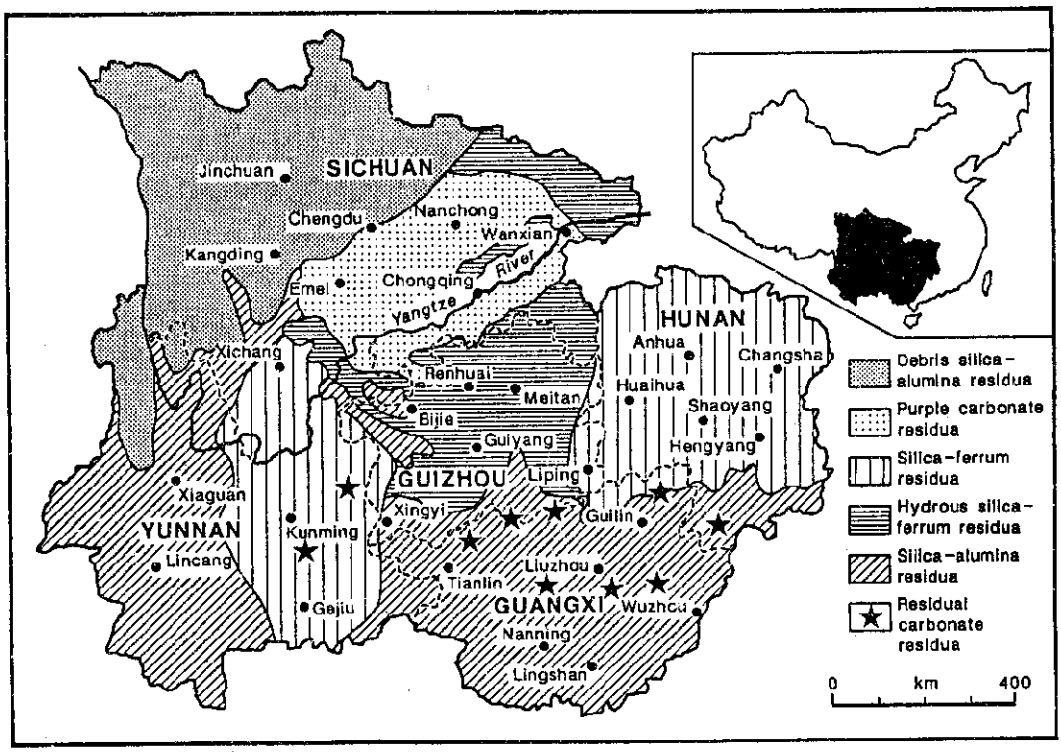

Fig. 1 Residua types in South China

Scientists in China and elsewhere graded sensitivity of soils to acid precipitation in different ways. Kramer (1978) graded sensitivity into 5 classes based mainly on soil pH value, calcium content and soil types, emphasizing the neutralization of $CaCO_3$ to acid and pH value. McFee (1980) stressed the important role of soil CEC, pointing out that the lower the soil CEC, the greater its sensitivity to acid rain. He divided the sensitivity of soils into 3 categories. More recently McFee (1983) also considered relief, soil type, pH value and soil $CaCO_3$ as important factors. Liu Huaiquan and Zhao Dianwu (1984) classified the sensitivity of soils into 4 categories, principally according to soil base exchange capacity (BEC). They also took into account the carbonate content of residua and buffering limit pH, which means the difference between soil pH and limit pH (lim $\triangle$ pH=pH-lim pH).

The authors of this paper classified the sensitivity of soils in the study area using two parameters (i. e. soil CEC and pH) which strongly influence soil buffering power. At the same time, residua were also taken into account. CEC 16 meq/100g is considered as an important criterion by some researchers. McFee (1983) pointed out that different levels of sensitivity will be shown in soils with CEC values lower than 15.2 meq/100g. In South China, soils with CEC $<$ 10 meq/100g more or less coincide with the distribution of Red earth and Laterite. Thus, in this paper, these two values are used to identify sensitive and highly sensitive areas. Calcareous soils developed on locally distributed carbonate regolith have fairly high CEC, normally higher

than 25 meq/100g. This figure is used to distinguish slightly sensitive and non-sensitive soils. The major difference between carbonate and silicic-aluminium or silicic-ferrum residua is used to divide sensitive and non-sensitive soils. The percentage area of these residua are used for further divisions. All of the criteria mentioned above are listed in Table 1.

Table 1 Sensitivity of soils to acid rain in South China

Sensitivity class	Soil CEC (meq/100g)	Soil pH	Type of residuum
Highly sensitive	<10	< 6.0	Silica-ferrum residuum or Silica-aluminium residuum > 80 %*
Sensitive	10–16	5.0–7.0	Silica-ferrum residuum or Silica-alumimium residuum > 60%
Slightly sensitive	16–25	6.0–7.0	Carbonate residuum >60 %
Non-sensitive	>25	>7.5	Carbonate residuum >80%

* Figures represent the percentage of the area of residuum to the whole researched area.

Using these criteria, 3 maps have been compiled, based on field samples and literature data. They are maps of residua types, soil pH values and soil CEC (Fig. 1,2 and 3 respectively). A first attempt at mapping the sensitivity can be achieved by superimposing these maps on each other. After some minor adjustment, achieved by comparing this map with soil and vegetation maps, the soil sensitivity map was finally completed, as shown in Fig. 4.

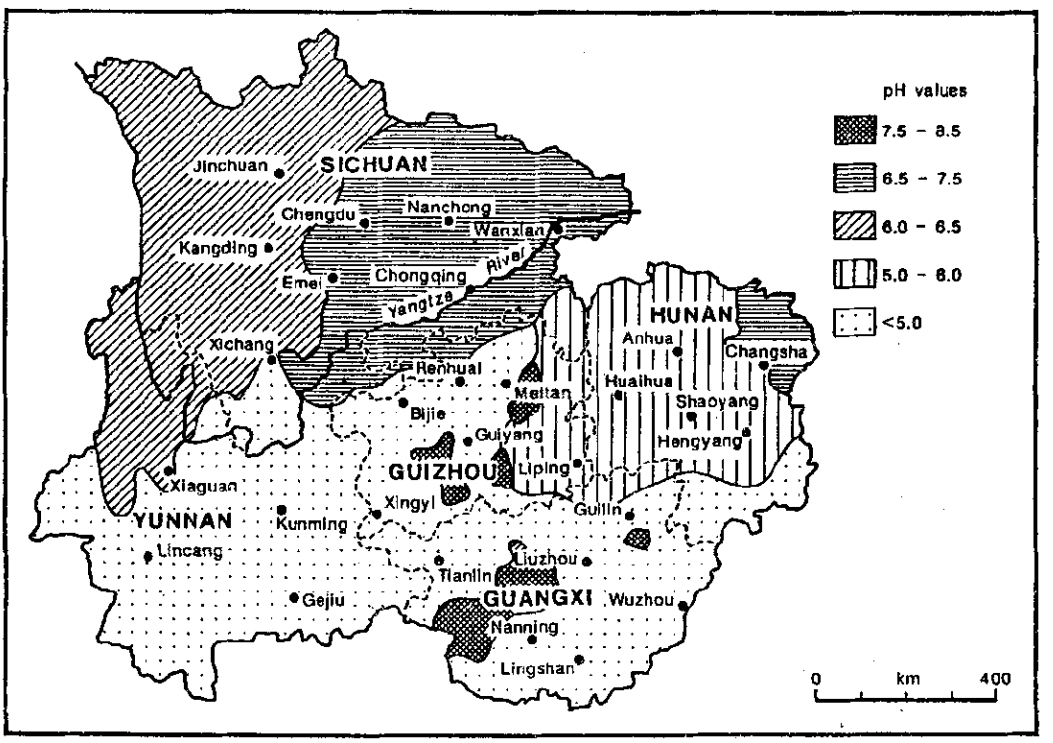

Fig. 2 Soil acidity in South China

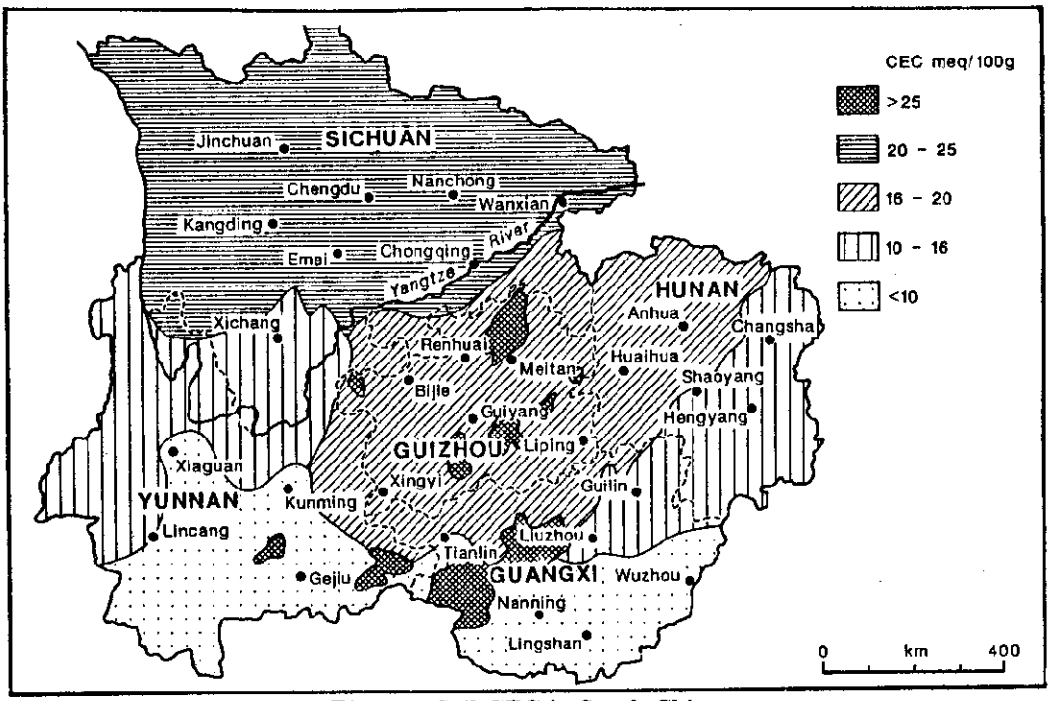

Fig. 3 Soil CEC in South China

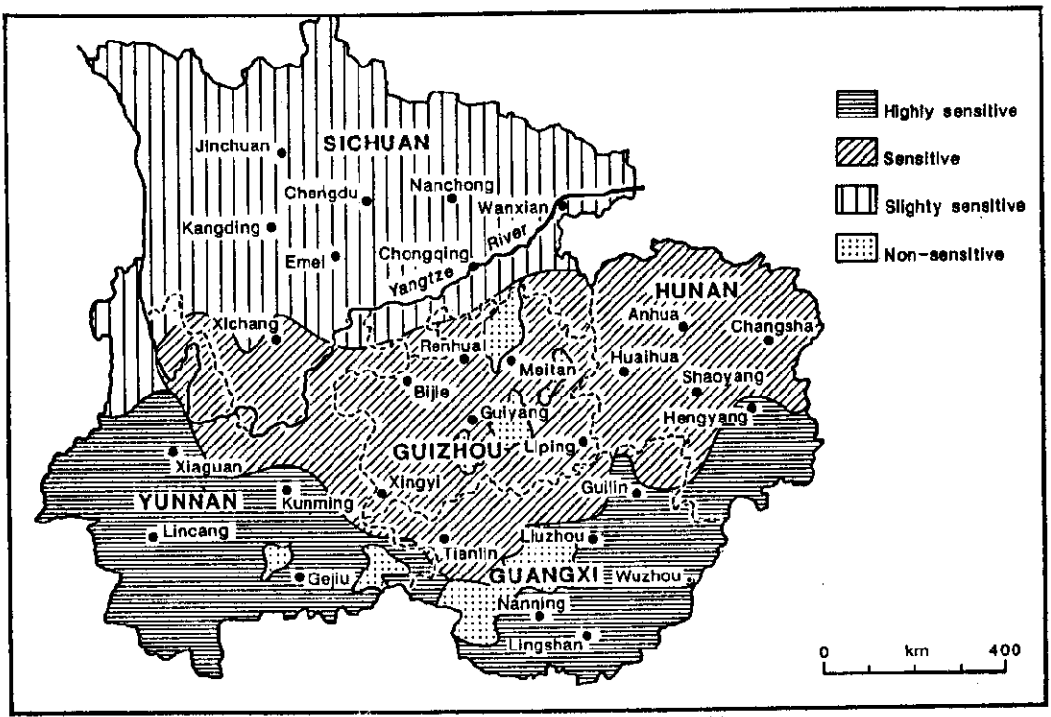

Fig. 4 Sensitivity of soils in South China

RESULTS AND DISCUSSION

The diversity of physical and social characteristics of the study area creates the complex

distribution pattern of soil sensitivity. Yet the regularity of soil distribution in South China leads to the regularity of such soil characteristics as CEC and pH value, which gradually increase northward. This means that the buffer capacity is also increasing in the same direction.

The highly sensitive and sensitive areas are mainly distributed in weak acidic to acidic Laterites, Lateritic soils, Red earths and Yellow earths, are located mainly in the southern part of the research area, and are underlain by silica-alumina and silica-ferrum residua. Under tropical wet and hot weather conditions, soils have been strongly leached and have low pH values (4.5–6.5) and low CEC (usually <16 meq/100g).

The slightly sensitive area is mainly located in Sichuan Basin and the mountain area of its western margin. The unique Purple soils have developed from the carbonate residua of the purple sandstone and shale rocks that dominate this area. The CEC values of Purple soils are fairly high, usually higher than 16 meq/100g. Soil pH is generally above 7.0 with some acid varieties in some regions. In contrast, Yellow earths, Yellow-brown earths and Brown earths are located mainly in the western mountain margins. Vegetation in this area is more or less intact, resulting in high organic matter content and high CEC values (the latter are usually higher than 16 meq/100g). These features provide moderate buffer capacity to soils.

Scattered limestone soils are non-sensitive. Soil CEC is very high (i. e. in excess of 25 meq/100g) and buffering power is also high to acid rain.

Acid rain has been recorded in many sites in South China, e. g. Chengdu, Chongqing, Guiyang, Kunming, Guilin, Hengyang and Changsha. In some areas the frequency of acid rain is as high as 70–80%. In some sites, the rain with very low pH has also occurred. To make the situation even more severe, more than 60% of the entire study area belongs to sensitive and highly sensitive groups. Poor soil management will possibly accelerate acidification, impoverish soils and lead finally to the collapse of the whole ecosystem. Therefore, in the economic development of this area, care must be taken by the decision makers of the local authorities to prevent environmental acidification.

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