Journal of Environmental Sciences Vol. 8, No. 2, pp. 249—254, 1996 ISSN 1001-0742

Soil carbon pool in China and its global significance*

Fang Jingyun, Liu Guohua, Xu Songling

Research Center for Eco-Environmental Science, Chinese Academy of Sciences, Beijing 100085, China

Abstract——Soil organic carbon density and its related characteristics of 41 soil types all over China were analyzed by using data of 745 soil profiles, and size of soil carbon pool was estimated. As a result, area-weighted averages of these 41 soil types for bulk density, profile depth, organic carbon content and profile carbon were 1.24 tC/m^3, 86.2 cm, 3.04% and 19.7 kg C/m^2 respectively. Total size of soil carbon pool was 185.68×10^9 tC, which is 29 times of that in terrestrial biomass of China and 12.6% of global soil carbon pools. Because of its huge carbon pool, soil of China plays an important role in global carbon cycle.

Keywords: China; global climate change; soil carbon content; soil carbon pool; soil type.

1 Introduction

Elucidating CO_2 source/sink function of in the global terrestrial ecosystem is one of the most important aspects in the research of global climate change. As the biggest carbon pool in terrestrial biosphere, soil plays a very important role in maintaining global carbon balance. Its importance lies in following three aspects. First, soil constitutes about 2/3 — 3/4 of global carbon pools, and is larger than summation of that of atmosphere and land biomass (Takeuchi, 1982; Woodwell, 1984). Second, soil is one of the most important basic elements in the global carbon cycle. Third, a less change in soil carbon pool can make atmospheric CO_2 concentration a marked change, and therefore causes a sharp effect on the global climate (Raich, 1992).

Estimating size of soil carbon pool of China is a fundamental and essential work in Chinese climate change research program. The authors' purpose in the present paper is to estimate size of soil carbon pool of China by utilizing soil profile data collected throughout China, and to evaluate contribution China's soil to global carbon pool.

2 Methods and procedures

* This study is supported by the National Natural Science Foundation of China, and is a part of the Eighth 5-Year National Science and Technology Key Project (No. 85-913-01-02)

Soil area was gotten for each soil type from a soil map with a scale of 1:10000000 (Editorial Committee for National Maps, 1989), 745 soil profiles and their physical and chemical properties (such as bulk density, profile depth, organic matter or organic carbon content) were obtained from books of "Soil of China" (Nanjing Institute of Pedology, 1982), "Forest soil of China" (Zhang, 1986) and related literature. For soil profiles that organic carbon content was not recorded, it was gotten from organic matter content multiplying by Bemmelen factor (0.58). A global mean carbon density of peatland, 72.3 kg C/m^2 (Schlesinger, 1984), was used to calculate the organic carbon amount of boggy soil (peatland) because of its less data in China. Total carbon amount of a soil type was estimated by Equation (1) and Fig. 1.

Total soil carbon amount = Total soil area × soil mean depth
× mean bulk density × mean organic carbon content (1)

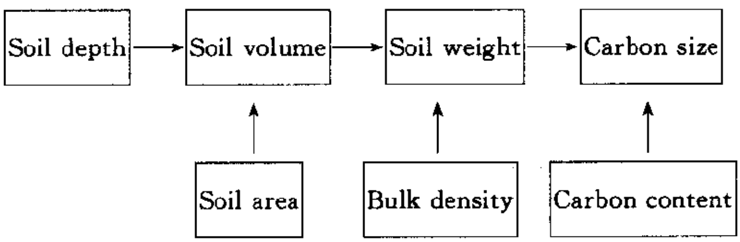

Fig. 1 Calculating procedure of soil organic carbon

3 Results and discussion

3.1 Carbon pool and its distribution

Table 1 lists organic carbon amount of each soil type and related characteristics. Area-weighted means for bulk density, profile depth, organic matter content and soil profile carbon of 41 soil types were calculated, being 1.24 t/m^2, 86.2 cm, 3.04% and 19.7 kg C/m^2, respectively. Total size of carbon pool in Chinese soil is 185.7 × 10^9 tC (Table 1).

Table 1 The physical properties and organic carbon content of soils in China

Soil type	Area, 10^5ha	No. of profile	Mean depth, cm	Mean bulk density, t/m^3	Mean organic content, %	Carbon content per m^2 kg C/m^2	Total carbon content, 10^9tC
Latosol	59.03	8	125.6	1.18	2.08	17.9	1.06
Lateritic red earth + red earth	1022.2	28	106.8	1.25	1.99	15.4	15.78
Yellow earth	355.65	59	113.1	1.04	4.29	29.2	10.40
Torrid red earth	5.28	7	111.3	1.20	2.46	19.0	0.10
Yellow brown earth	340.98	52	107.0	1.03	4.65	29.7	10.14
Brown earth	379.87	72	92.7	1.02	6.48	35.7	13.54
Dark brown earth	406.63	128	89.7	0.84	8.42	36.9	15.01

Table 1 (continued)

Soil type	Area, 10^5ha	No. of profile	Mean depth, cm	Mean bulk density, t/m^3	Mean organic content, %	Carbon content per m^2 kg C/m^2	Total carbon content, 10^9tC
Podzolic soil	104.25	14	91.8	0.80	11.54	49.3	5.14
Cinnamon soil	406.48	56	115.5	1.41	3.91	37.1	15.08
Cumulic cinnamom soil	37.23	12	115.0	1.35	5.50	49.5	1.84
Gray-cinnamom soil	61.58	15	118.2	1.30	7.44	66.2	4.08
Dark loessial soil	38.36	4	120.0	1.28	5.00	44.5	1.71
Chernozem	227.56	8	129.8	1.25	3.14	32.1	7.31
Castenozem	488.92	9	114.3	1.24	2.91	23.9	11.66
Brown pedocal	298.31	3	107.3	1.25	1.05	8.1	2.43
Sierozem	80.62	3	180.0	1.25	0.71	9.3	0.75
Gray desert soil	64.33	4	74.0	1.25	0.84	4.5	0.29
Gray-brown desert soil	413.30	4	36.8	1.25	0.27	0.7	0.30
Brown desert soil	308.33	4	68.0	1.25	0.27	1.3	0.41
Black soil	81.41	11	111.0	1.25	4.17	33.6	2.73
Albic soil	42.32	9	108.2	1.28	4.49	36.0	1.52
Fluvo-aquic soil	246.24	14	84.6	1.33	2.05	13.4	3.31
Lime concretion fluvo-aquic soil	36.11	4	37.0	1.39	0.83	2.5	0.09
Meadow soil	273.11	16	76.1	1.21	2.56	13.7	3.73
Anthropogentic-calluvial soil	49.58	3	47.0	1.25	1.23	4.2	0.21
Oasis soil	30.08	2	66.1	1.60	1.20	7.3	0.22
Boggy soil	109.65	/	/	/	/	72.3a	7.78
Paddy soil	313.72	9	80.1	1.27	1.71	10.1	3.16
Alkali-saline soil	166.76	11	43.8	1.39	1.15	4.1	0.68
Purple soil	102.23	15	76.6	1.39	1.38	8.6	0.88
Limestone soil	71.85	21	84.4	1.24	3.53	21.3	1.53
Yellow soft soil	131.58	2	100.2	1.30	1.50	11.3	1.49
Wind-blown soil	554.82	9	66.6	1.62	1.20	7.6	4.19
Subalpine meadow soil	350.88	51	84.5	1.20	7.76	45.9	16.11
Alpine meadow soil	378.87	27	82.9	1.20	6.30	36.5	13.81
Subalpine steppe soil	186.73	10	86.7	1.25	1.26	7.9	1.48
Alpine steppe soil	733.78	11	48.7	1.25	1.52	5.4	3.96
Subalpine desert soil	24.78	1	85.0	1.30	0.70	4.5	0.11
Alpine desert soil	173.91	18	51.9	1.30	0.97	3.8	0.66
Alpine frozen soil	291.28	11	43.5	1.25	1.08	3.4	1.00
Total	9448.6	745	/	/	/	/	185.69

a Schlesinger, 1984

The authors (Fang, 1993a) have reported that total carbon pool of 6.4×10^9tC stored in Chinese terrestrial biomass. This means that the total carbon pool of Chinese soil is 29 times as that of vegetation biomass. Globally, soil carbon pool is 2—4 times as that of terrestrial biomass (Moore, 1989; Schlesinger, 1977; Woodwell, 1984). Why is so great difference between carbon pools stored in soil and vegetation biomass in China? Three main reasons may be considered.

(a) In China, forest covering rate is far lower than average value of the world, and the forest quality also is lower. Tropical rain forest, a vegetation type with a high productivity, for example, is only 0.37% of total forest area. Accordingly, as the biggest vegetation carbon pool, forest carbon pool is far smaller in China than the world average level.

(b) Compared with less forest, the proportion of grassland and other dry vegetation types is relatively high in China, but their contribution to carbon pool is less than that of forest.

(c) In China, there exists a wide area of temperate grassland and alpine meadow. In these soils, organic carbon is very rich because of long time accumulation of dead roots. Many studies have shown that carbon density of these soils is just less than that of biomass of tropical rain forest, being almost equal to that of subarctive (subalpine) coniferous forest which has a very high biomass production (Schlesinger, 1984; 1991; Prentice, 1990). Especially, soil of the Qinghai-Xizang (Tibetan) Plateau is a huge carbon pool because a slow decomposition of organic matter. Size of soil carbon pool in the Plateau was estimated to be 38.4×10^9tC, which held in the layer of 0—72 cm (a mean depth of different soils; Fang, 1993b). The size constituted about 21% of total carbon pool in China, and was 183 times as that of biomass (biomass of the Plateau was estimated as 2.1×10^8 tC; Fang, 1993b). This indicates that soil of the Qinghai-Xizang Plateau plays an important role in Chinese soil carbon pool.

As shown in Table 1, soil carbon density increases as increasing latitudes. For instance, the carbon density increases from 15.4—17.9 kg C/m^2 of red soil and laterite to 36.9 kg C/m^2 of dark brown earth. Such a change is closely related to environmental factors which affect the decomposition rate of soil organic matter (Raich, 1992; Schlesinger, 1984).

3.2 Contribution of Chinese soil to the global carbon pools

We discuss briefly the estimated value of the global soil carbon pool to evaluate the contribution of soils in China to the global soil carbon pools. The estimated values by different authors are listed in Table 2.

Carbon amount stored in the surface soil of China was 185.7×10^9 tC (Table 1). This is to say, 12.6% of the global soil carbon pools is held in Chinese soils, while Chinese land area is only 6.4% of the world land. Namely, the average carbon content of Chinese soils is about two times as the global average level. This indicates that Chinese soil has an extreme important role in maintaining the global carbon balance, and that protecting Chinese soil is of significance globally.

Table 2 Estimates of soil carbon pool in the world

Author	Carbon pool, 10^9tC	Author	Carbon pool, 10^9tC
Bolin (1970, 1977)	700	Bazilevich (1974)	1404
Kovda (1974)	1392	Bohn (1976,1978)	3000
Baes *et al.* (1977)	1080	Schlesinger (1977,1991)	1456
Bolin *et al.* (1979)	1672	Ajtay *et al.* (1979)	2206,1636
Meentemeyer *et al.* (1981)	1457	Post *et al.* (1982)	1395
Buringh (1984)	1477	Schlesinger(1984)	1515
Prentice & Fung (1990)	1143,1313		
Average	1472[a]		

Value averaged by different authors' estimates but not including Bolin's (1970, 1977) and Bohn's (1976, 1978) estimates.

Finally, it is necessary to note that soil in Qinghai-Xizang Plateau is a huge carbon pool, and it possesses about 2.6% of the global soil carbon.

References

Ajtay GL, Ketner P, Duvigneau P. Terrestrial primary production and phystomass (Eds by Bolin B, Degens ET, Kemps S, Ketner P). New York: John Wiley & Sons, 1979:129

Baes CF, Goeller HE, Olson JS, Rotty RM. Amer Scient, 1977; 65:310

Bazilevich NI. Trans the X ICSS, 1977; 6:17

Bohn HL. Soil Sci Soc Amer J, 1976; 40:468

Bohn HL. Tellus, 1978; 30:472

Bolin B. Scient Amer, 1970; 223:124

Bolin B. Science, 1977; 196:613

Bolin B, Degens ET, Duvigneaud P, Kempe S. The global biogeochemical carbon cycle (Eds by Bolin B, Degens ET, Kempe S, Ketner P). New York, John Wiley & Sons, 1979

Buringh P. Organic carbon in soil of the world (Ed by Woodwell GM), New York:John Wiley & Sons, 1984:91

Editorial Committee for National Maps. Album of China agricultural maps. Beijing: China Map Publishing House. 1989

Fang JY, Xu SL, Liu GH. Carbon pools in Chinese terrestrial ecosystems. in: The First IGAC-Scientific Conference (Eilat, Israel), 1993a

Fang JY, Liu GH, Xu SL. Biogenic carbon pools in China and their contribution to global carbon pools. In: Preceedings of the XV IBC (Tokyo, Japan). 1993b

Kovda VA. Biosphere, soils and their utilization. In : The 10th International Congress Soil Science (Moscow). 1974

Meentemeyer V, Box EO, Thompson R. Abstr Ecol Soc Amer Bull, 1981; 62(2):104

Moore B, Gildea MP, Vorosmarty CT, Skole DL, Melillo JM. Biogeochemical cycles. In: Global Ecology (Eds by Mitchell BR, Margulis L, Fester R). New York: Academic Press, 1989:113

Nanjing Institute of Pedology. Soil of China. Beijing: Science Press. 1982

Post WM, Emanuel WR, Zinke PL, Stragenberger AG. Nature, 1982; 298:156

Pretice KC, Fung TY. Nature, 1990; 346:48

Raich JW, Schlesinger WH. Tellus, 1992; 44B:81

Schlesinger WH. Biogeochemistry: An analysis of global change. San Diego: Academic Press, 1991

Schlesinger WH. Ann Rev Ecol Syst, 1977; 8:51

Schlesinger WH. Soil organic matter: a source of atmospheric CO_2 (Ed by Woodwell GM). New York: John Wiley & Sons, 1984:111

Siegenthaler U, Sarmiento JL. Nature, 1993; 365:119

Takeuchi K, Hasegawa I. Global Ecology. Tokyo: Diamond Sha, 1982

Wada H. The global carbon cycle. Tokyo: National Institute of Environmental Science, 1987

Wolf-Gladrow D. Environ Sci & Pollut Res, 1994; 1:99

Woodwell GM. The carbon dioxide problem (Ed by Woodwell GM). New York: John Wiley & Sons, 1984:3

Zhang WY (Ed). Forest soil of China. Beijing: Science Press, 1986

(Received September 12, 1995)