# CARBON SEQUESTRATION BY GRASSLAND AND WOODLAND SOILS OF DIFFERENT CLIMATE ZONES AS REVEALED BY (THIN)LAYER WISE CARBON-14 DATING

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## ABSTRACT

Estimates are, that grassland sequesters on ca 3.2 bil ha about 50 Pg C in the biomass, 300-350 Pg C in SOM (soil organic matter).,woodland analog on some 4.2 bil ha 360 Pg in the biomass ,785 Pg in the SOM. The SOM-C in grassland is comparable in quantity of C.m-2 with C in tropical rain forests´ living biomass (Whittaker & Likens,1973). C14-dating of soils reveals a tendency of higher C-residence time in grassland and former grassland-cropland soils, compared with adjacent woodland soils of about same climate and geomorphology. In (sub)tropical soils C-residence time proved higher in upland soils than in well aerated (puddled) lowland rice soils. 129 (thin)layer wise C14 dated soil profiles of Alfisols,Inceptisols, Mollisols, Spodosols and Vertisols show in the mostly grassland derived soils (-alf, -oll, -ert) the highest C14 dates, i.e. C-residence times, consequently the steepest regression curves for age versus depth and the highest correlation factors. In grassland and cropland soils,among the soil texture fractions, highest C14 age / C-residence time was obtained from SOM attached to fine silt as well as to clay domains.



## KEYWORDS

C in biomass & SOM, grassland high C-residence time, C14 dating


## INTRODUCTION

Efforts for an assessment of C sink potentials in different ecozones show a comparable economy for sequestration of atmospheric CO2 into SOM with cost estimates of developing substitutes for fossil C sources with their greenhouse forcing trace gas emissions (CO2, CH4, N2O). Besides of reforestation, where Bouwman (1990) estimates about 465 mil ha additional forests to be adequate, easier manageable grassland and cropland could contribute. Besides of biomass - C production rate also the C residence time in grassland, woodland, cropland in comparison to the C residence time in woodland would matter.

## METHODS

Further to Carbon analysis C14 dating of SOM-C in (thin)layer wise sampled adjacent soil profiles of grassland, former grassland-cropland and woodland is required. C14 dating was carried out based on benzene synthesis of SOM-C and measurement in a liquid scintillation spectrometer.

## RESULTS AND DISCUSSION

Table 1 compares the maximum C14-dates (C mean residence time) of horizon- or layerwise C14-dated soil profiles under forest or under grassland or cropland derived from grassland, all from Germany. Evidently, the C residence time in the SOM is superior in the grassland and cropland from grassland derived soil profiles. Figure 1 carries on this trend with regard to four soil profiles from Australia. The Vertisol under grassland (Paget) exceeds the Vertisol under Acacia (Chinchilla) as well as the two Krasnozems in C-residence time, where again the profile Beechmond under subtropical rainforest has a lower range of C residence time than the profile Gabbinbar under wooded grassland. Table 2 shows, based on soil profiles from India, Philippines, Thailand, Taiwan and Israel,that the C-residence time in upland soils is superior to that of (submerged) paddy soils. The puddling process of soil preparation with its extraordinary aeration and homogeneisation produces a fast turnover of all SOM fractions, also the older ones, so that the average mean residence time becomes low despite a slight SOM enrichment in paddy below a temperature of ca 28°C. In Table 3 carbon residence time mean values from regression lines, derived from 129 layer- and horizonwise C14-dated soil profiles are accumulated. The ascent of the regression lines for all the depth related C14-dates, reflecting C-residence time in 13 Alfisol-, 16 Inceptisol-, 47 Mollisol-, 9 Spodosol- and 44 Vertisol soil profiles of these five important soil orders as well as the correlation factors of dates within each soil order are indicated. Again the typical grassland products, the Mollisols, Alfisols and also Vertisols reflect highest C14-ages (C-residence times), as well as logically ascent of the regression line and also highest correlation factors. In case of the Alfisols with illuvial argillic horizon much of the stability of the SOM is associated with the complexation between SOM and clay domains in the argillic horizon, whose samples show the highest C14-age of the many dated profile depth layers.According to studies mainly in Mollisols (Scharpenseel et al,1986) highest C14-ages within texture fractions were associated with fine silt fractions as well as SOM complexes with mainly coarse and middle clay fractions. In Fig 2a-e another set of internationally strayed layer-wise C14-dated soil profiles ,again Alfisols, Inceptisols, Mollisols,

Spodosols, Vertisols, precipitates the trend of Table 3 with highest C residence times in the preferably grassland derived Mollisols, Alfisols and Vertisols. (There is an overlapping of profiles, some constribute to Table 3 as well as to Fig.2.).


## REFERENCES

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**Table 1**

Maximum C14 age of layerwise / horizonwise sampled udolls, argidudolls, udalfs as forest soils or former steppe, later cereal or pasture soils in NW Germany

| SOIL SITE, HORIZON, DEPTH, REFERENCE | MAXIMUM C14 AGE<br>FOREST SOIL | ORIGINALLY GRASSLAND NOW ALSO CROPLAND (few trees or bushes) |
|---|---|---|
| ASEL FOREST, BtAh2, 60 - 80 cm | 2950 | |
| SOLLINGEN patch of trees, BtAhC, 85-110 cm | 3880 | |
| OHLENDORF, Beech wood, SwBt2, 70 cm | 3400 | |
| OHLENDORF, Beech wood, BtSd3, 110 cm | 2700 | |
| WOHLDORF, Beech wood, IISdBt4, 80 cm | 2350 | |
| TIMMENDORF, Beech wood, SwBt, 70 cm | 2800 | |
| SOLLINGEN-windmill, cropland, BtAh, 80 cm | | 4800 |
| SOLLINGEN, creek, crops, grass, BtAh, 80 cm | | 4320 |
| COLLINGEN S-end crops, grass, BtAC, 90 cm | | 5300 |
| JERXHEIM, high C, crops, grass, AC, 90 cm | | 5500 |
| ADLUM, cropland, BtAC, 80 cm | | 3130 |
| ADLUM, near main drain, BtAhC, 90 cm | | 4000 |
| KLEINALTENDORF, cropland, AhBt, 75 cm | | 4400 |

**Table 2**
(sub) tropical soil profiles, upland and lowland

| SOIL PROFILE | | | MAXIMUM C14 AGE IN 2 cm or 5 cm THIN LAYER-WISE DATED SOIL PROFILES (YEARS) UPLAND | LOWLAND RICELAND |
|---|---|---|---|---|
| INDIA | PATENCHERU | Rhodustalf crops, fallow | 5,200 | |
| | | Chromustert crops, fallow | 13,900 | |
| PHILIPPINES | LOS BANOS | Tropaquept riceland | | Bomb c, Modern age |
| | PANGIL | Tropaquept riceland, fallow | | 2,900 |
| | PAO | Tropaquept riceland | | |
| | BUGALLON | Hydraquent rice (ac.sulf.) | | 3,600 |
| | TIAONG | Hydraquent fallow, grass, rice | | 1,100 |
| | TIAONG | Haplaquoll banana, coco, rice | | 300 |
| | SAN DIONISIO | Paleudult (Fe-Tox.), rice | | 3,700 |
| THAILAND | KHON KAEN | Paleaquult (Low biomass) | | 1,500 |
| | KLONG LUANG | Tropaquept (Ac. sulf. soil) | | 3,400 |
| TAIWAN | TAICHUNG | Fluvaquent riceland | | 2,850 |
| | PINGTUNG | Fluvaquent riceland,beans | | 4,100 |
| ISRAEL | AKKO | Pelloxerert poor vegetation | 7,900 | |
| | QEDMA | Pelloxerert fallow | 14,300 | |

**Table 3**
Average regression: correlation factor and corresponding C14-age (AMRT = apparent mean residence time) for different depth levels of layerwise dated soil profiles (13 alfisols, 16 inceptisols, 47 mollisols, 9 spodosols, 44 vertisols). Paleosols were not included: soild profiles sampled in different W-, E-, S- Europe countries, in Argentinia, Australia, Israel, Sudan and Tunisia.

| SOIL ORDER | ASCEND REGRL.L | CORR.F. | AMRT OF REGRESSION LINE, (YEARS B.P.) 10 cm | 20cm | 50cm | 100cm | 150cm | 200cm |
|---|---|---|---|---|---|---|---|---|
| ALFISOLS | 0.4651 | 0.739 | 480 | 960 | 2400 | 4800 | 7200 | 9600 |
| INCEPTISOLS (PLAGGEPTS) | 0.0225 | 0.209 | 870 | 920 | 1000 | 1160 | 1350 | 1490 |
| MOLLISOLS | 0.4695 | 0.888 | 750 | 1240 | 2700 | 5150 | 8050 | 10000 |
| SPODOSOLS | 0.0747 | 0.332 | 1350 | 1430 | 1680 | 2100 | 2520 | 2930 |
| VERTISOLS | 0.4014 | 0.772 | 0 | 410 | 1620 | 3650 | 5670 | 7700 |
| ALL SOILS ALF+EPT+OD +OLL+ERT | 0.4415 | 0.755 | 460 | 920 | 2300 | 4600 | 6900 | 9200 |

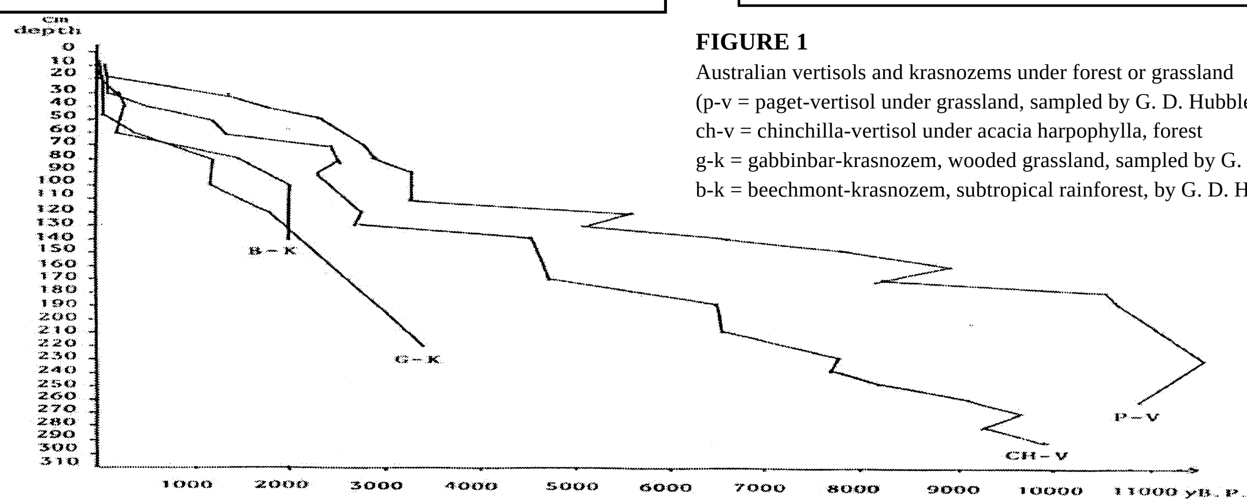


**FIGURE 1**
Australian vertisols and krasnozems under forest or grassland
(p-v = paget-vertisol under grassland, sampled by G. D. Hubble, csiro, Queensland
ch-v = chinchilla-vertisol under acacia harpophylla, forest
g-k = gabbinbar-krasnozem, wooded grassland, sampled by G. D. Hubble
b-k = beechmont-krasnozem, subtropical rainforest, by G. D. Hubble

**Figure 2**
Age Versus Depth Measurem, Nts (Diverse Countries) Inceptisols, Spodosols, Vertisols, Alfisols, Ollisols