QUANTITATIVE AND QUALITATIVE CHARACTERISTICS OF SOIL ORGANIC MATTER UNDER CERRADOS

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SUMMARY - In the Cerrados, the amount of soil organic matter decreases, and the changes in its composition are considerable during cultivation. Therefore, the factors affecting the accumulation of soil organic matter should be taken into account for soil management.

Objectives

In order to achieve suitable soil management, the properties of the Cerrado soils were analysed in relation to the dynamic of organic matter in soil.

Working hypotheses

1. The amount of soil organic matter decreases wilk soil cultivation.
2. Composition of soil organic matter changes, namely the amount of easily decomposable organic matter decreases while the resistant one increases.

Method

Comparisons were carried out between virgin soil and cultivated soil, and between Cerrado soil (LE = dark red latosol) and Terra Roxa and Latosol Roxo from Paraná state. Total carbon content was determined by the wet combution method and humus composition was analysed by the methods used in the temperate zone (Kumada et al. 1976. Tatsukawa, 1966. Tsutsuki & Kuwatsuka, 1989).

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Results and Discussion

I. Changes in the amount of soil organic matter during cultivation.

Carbon content was high in the surface horizons and low in the subsurface horizons (Figure 1).

Carbon content tended to decrease during cultivation, both in the surface and subsurface horizons (Figure 2).

Degradation of soil organic matter and plant is considered to follow the first order kinetics (Jenny et al. 1949, 1950. Greenland & Nye 1959. Olson 1963. Stanford & Smith, 1972).

We can consider a case where a certain amount of plant material is added annually (Figure 3).

During this process, the carbon content is expressed by the dotted line.

MO total = MOsoil(s) + MOplant(p),

MOs = Co exp(-kn),

MOp = P x {exp(-k)-exp(-nk)}/{l-exp(-k)}, where

Co = original soil organic C content,

P = amount of plant carbon added annually,

k = degradation rate constant,

n = number of years.

When n is sufficiently large,

MOs $\rightarrow$ 0,

MOP/P $\rightarrow$ exp(-k)/{1-exp(-k)} (Figure 4).

when MOp/P = 1, the soil carbon content is equivalent to the amount of plant carbon added each year. The expression for calculation of plant carbon added to the soil is shown in Apendix 1.

MOp is high, if k is low. When k = 0.7, MOp/P = 1.

Under these conditions the following factors should be considered for the accumulation of soil organic matter;

1. Amount of plant material added each year (P), especially roots.
2. Degradation rate (k),

(i) lignin content (especially of roots),

(ii) protection effect by soil components (difference among soil types),

(iii) degradation acceleration by nutrients from fertilizers,

(iv) soil temperature and moisture,

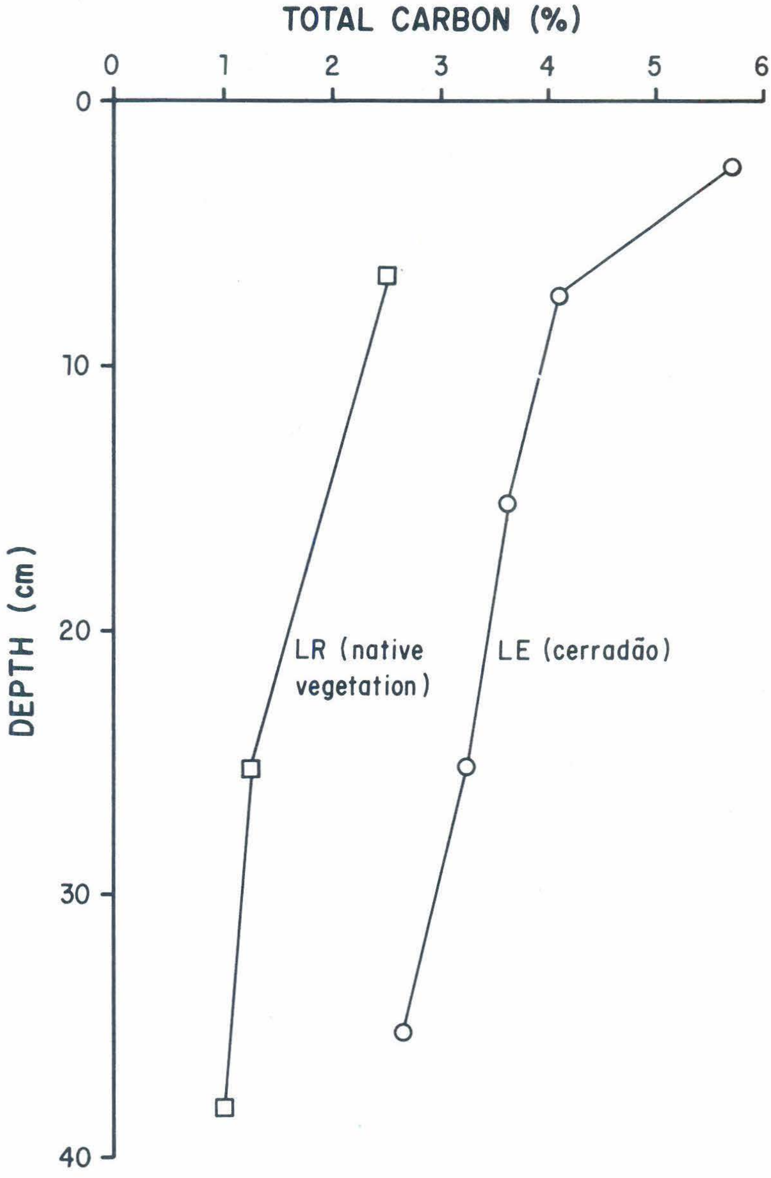

FIG. 1 - Distribuition of total carbon content in virgin soils.

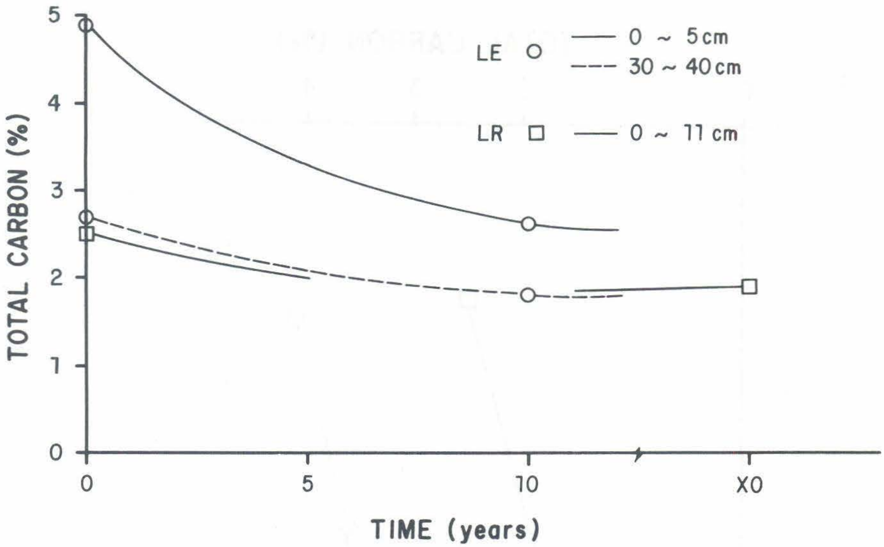

FIG. 2 - Carbon content changes in soils after clearing.

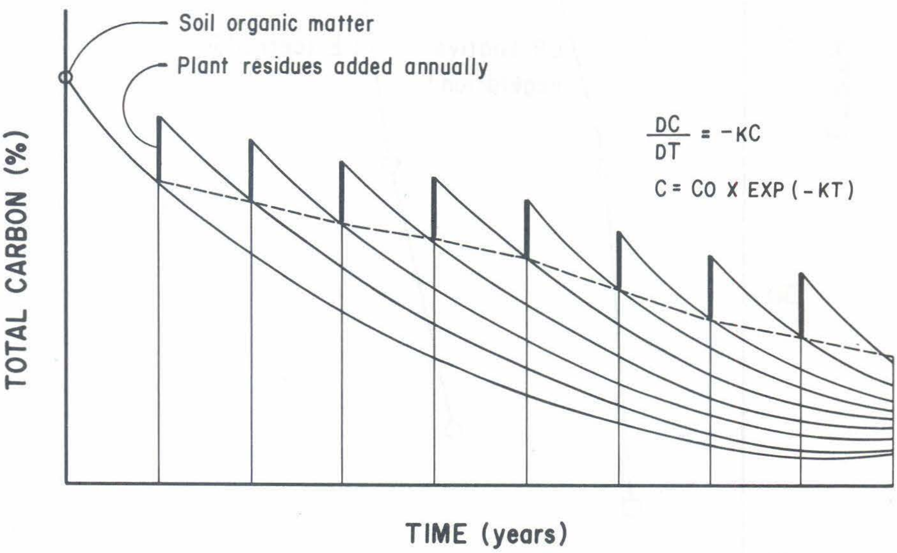

FIG. 3 - Acumulationa of soil organic matter after addiction of plant residues each year.

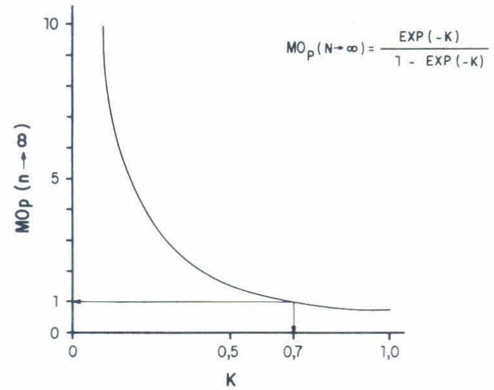

FIG. 4 - Effect of degradation rate of plant materials on carbon accumulation.

3. Number of years of organic matter application (n).

II. Changes in the composition of soil organic matter during cultivation.

After fractionating organic matter based upon its solubility characteristics (Figure 5) the following phenomena were recognized:

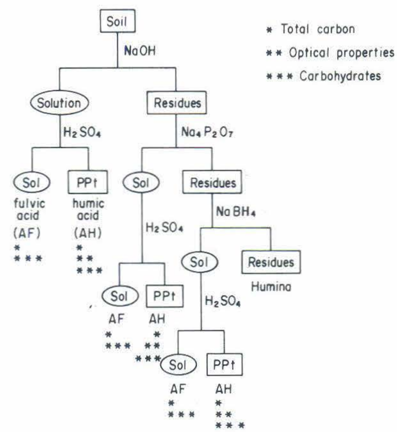

FIG. 5 - Flow chart of soil organic matter analysis.

(i) the amount of undissolved components (humin) increased (Figure 6),
(ii) the fulvic acid content decreased,

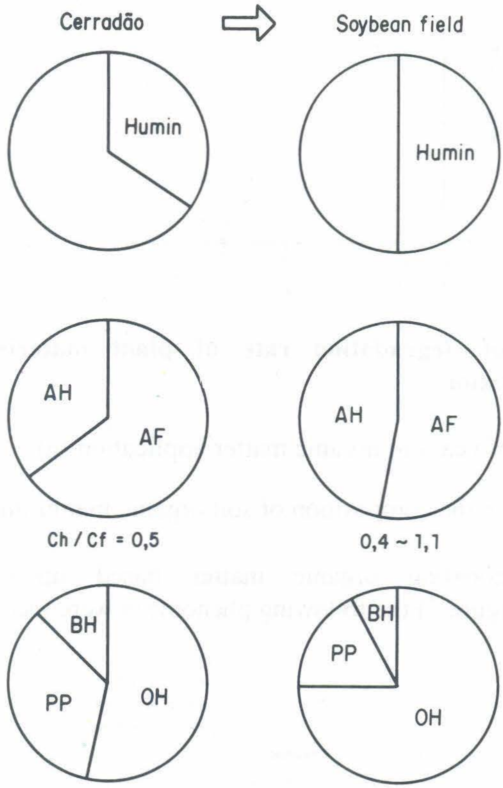

FIG. 6 - Changes in soil organic matter composition during cultivation.

(iii) It is possilble that the extractability changed due to the presence of bound-type materials (Fe, etc. bound to Al?), and

(iv) denaturation of humic acid.

Denaturation of humic acid was reflected in its optical properties (relative color intensity K600/C and color index). K600 and C mean optical density at 600nm of na HA solution and ml of 0,1N Kmn04 consumed by 30 ml of the HA solution, respectively. According to these properties, humic acid was classified into Rp, B, P and A types (Figure 7).

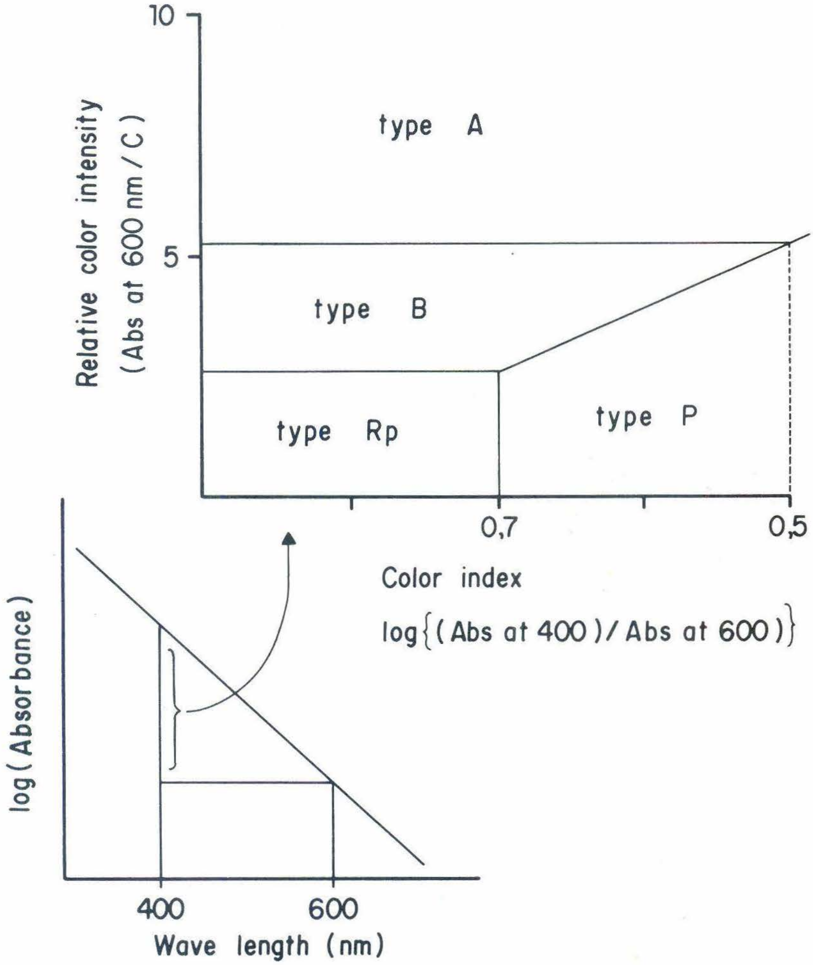

FIG. 7 - Classification of humic acid types.

During the humification process of the plant materials, the color intensity increased and the value of the color index decreased. Some examples of spectra of humic acid are shown in Figure 8.

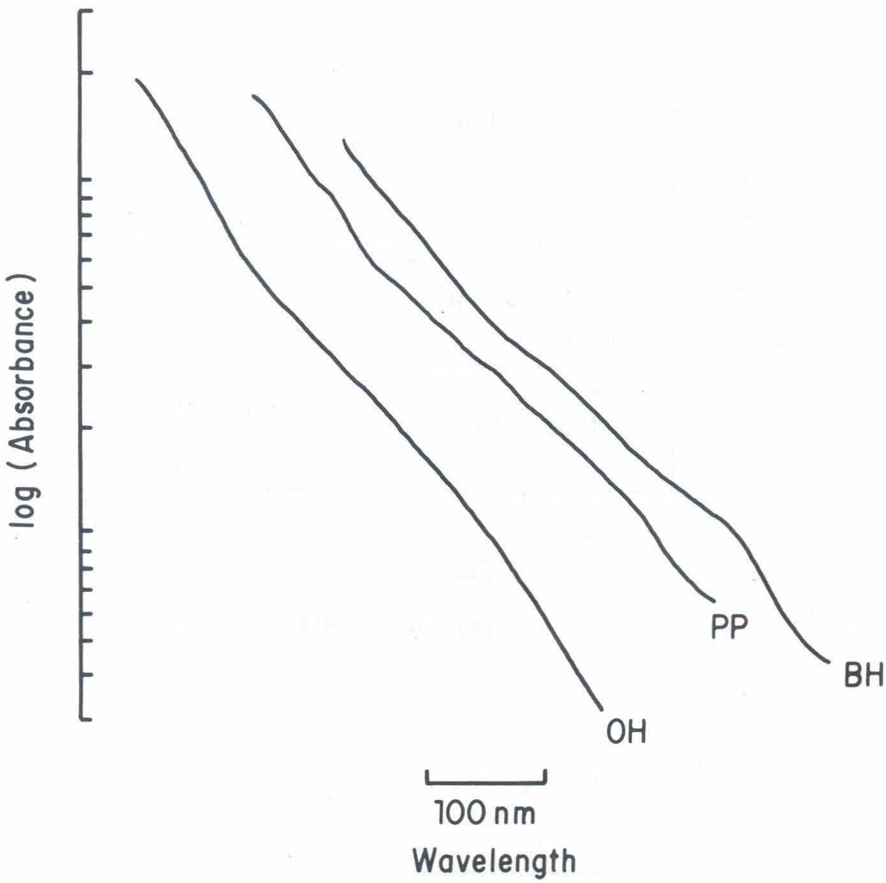

FIG. 8 - Examples of spectra of humic acid from samples taken at 0-5 cm depth of a soybean field tillaged by disk plow.

Chemical changes accompanying the humification can be determined using 13C NMR spectra, namely, the amount of aliphatic-, or carbohydrate carbon decreased, and that of aromatic-, and carbonyl carbon increased (Figure 9).

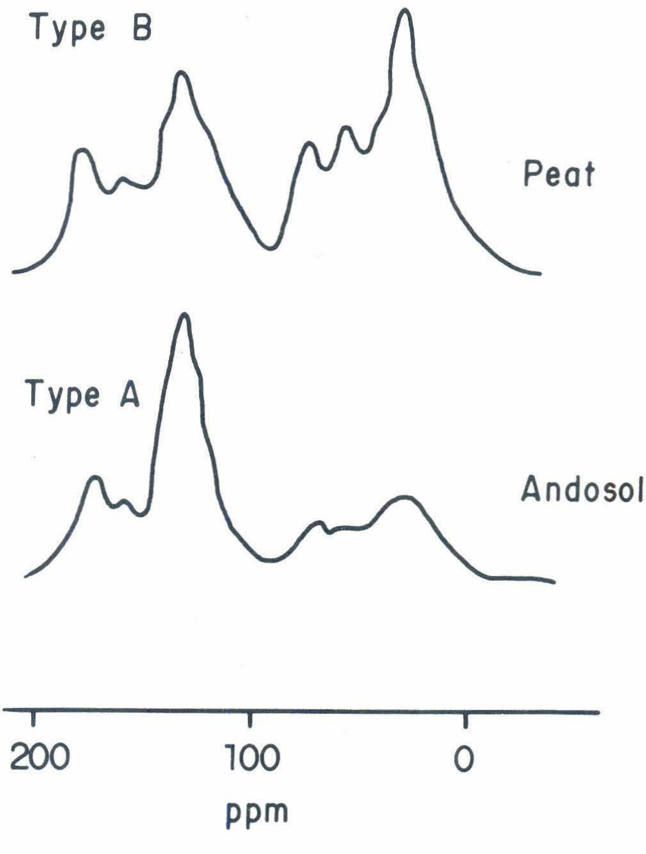

FIG. 9 - Chemical changes of humic acid following changes in optical properties. 13C - NMR Spectra (ARAI et al., unpublished data)

When the data obtained from Cerrado soils were plotted on the diagram, almost all of humic acid of LE belonged to type A or B. In contrast the humic acid of Terra Roxa and Latosol Roxo showed lower relactive color intensity, suggesting a certain degree of immaturity (Figure10).

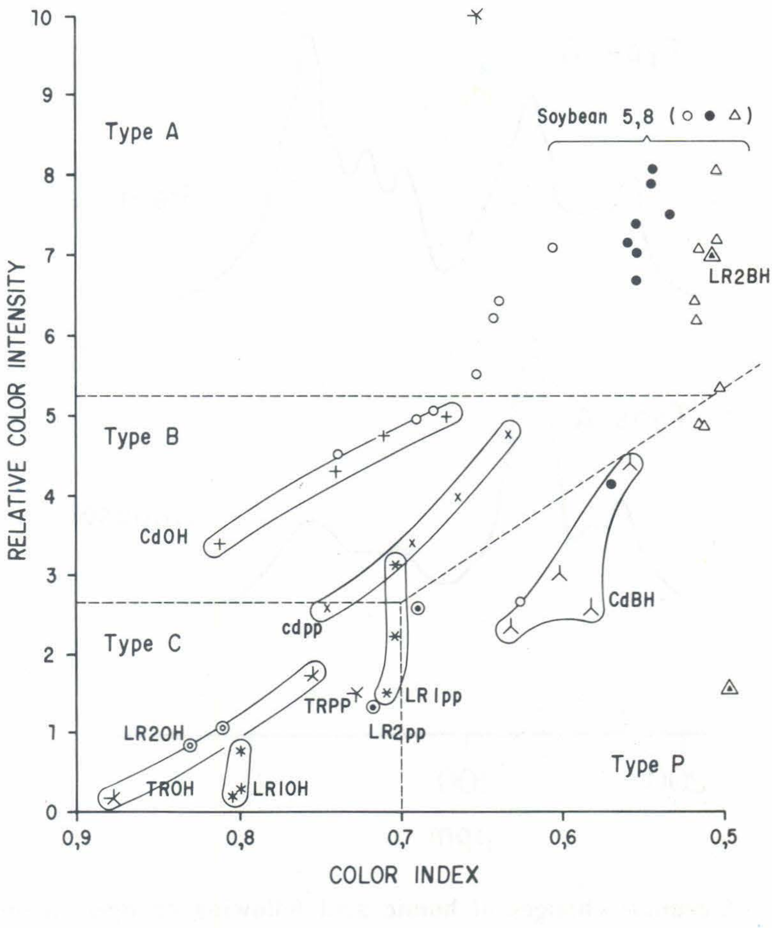

FIG. 10 - Optical properties of humic acid of Cerrado soils, compared with TR, LR.

In Japan, type A humic acid occurs in humic volcanic soils, and it is protected by aluminum. In the Cerrados region it is possible that aluminum has also some protective effect over humic acid which in the LE soil is derived from lignin.

References

KUMADA et al. Humus composition of mountain soils in central Japan with special reference to the distribution of P type humic acid. **Soil Sci. Pl**. v. 13, n. 5, p.151-158 (E), 1967.

TATSUKAWA. Method of rapid determination of organic matter in soil and liquid samples, with a few methods determining sugars. **Journal of Soil Science Plant Nutrition**. TSUTSUKI, v. 37, n. 1, p.28-33 , 1966.

KUWATSUKA. Degradation and stabilization of humus in buried volcanic ash soils. I. Humus composition, molecular size distribution of humic acids and sugar composition of soils. . **Journal of Soil Science Plant Nutrition**. v. 35, n. 2, p.207-216 (E), 1989.

JENNY et al. Comparative study of decomposition rates of organic matter in temperature and tropical regions. Soil Science, v. 68, p. 419-432, 1949.

JENNY. Causes of the high nitrogen and organic matter contents of certain tropical forest soils. **Soil Science**, v. 69, p. 63-69, 1950.

GREENLAND & NYE. Increase in the carbon and nitrogen contents of tropical soils under natural fallows. Journal Soil Science, v. 10, p.284-299, 1959. OLSON. Energy storage and the balance of producers and decomposers in the ecological systems. **Ecology**, v. 44, p.322-331, 1963.

STANFORD & SMITH. Nitrogen mineralization potential of soil. SSSAP, v. 36, p.465-472 (E), 1972.

Appendix

1. Calculation of the amount of C accumulated soil was perfomed as follows: Organic matter in soil MOs = Q.exp(-μt), plant residues MOp = P.exp(-kt)

O year	Q				
1 year	Q exp(-μ)	P			
2 year	Q exp(-2μ)	P exp(-k)	P		
3 year	Q exp(-3μ)	P exp(-2k)	P exp(-k)	P	
4 year	Q exp(-4μ)	P exp(-3k)	P exp(-2k)	P exp(-k)	
(n-1) year	exp(-(n-1)μ)	P exp(-(n-2)k)	P exp(-(n-3)k)	P exp(-(n-4)k)... P	
n year	exp(-nμ)	P exp(-(n-1)k)	P exp(-(n-2)k)	P exp(-(n-3)k)...	P exp(-k) V

At n.th year,

$$MOp = P\{\exp(-(n-1)k) + \exp(-(n-2)k) + \exp(-(n-3)k) + \ldots + \exp(-2k) + \exp(-k)\}$$

$$\exp(-k)\,MOp = P\{\exp(-nk) + \exp(-(n-1)k) + \exp(-(n-2)k) + \ldots + \exp(-k) + \exp(-2k)\}$$

$$\{1-\exp(-k)\}\,MOp = P\{\exp(-k) - \exp(-nk)\}$$

$$\therefore MOp = P\,\frac{\exp(-k) - \exp(-nk)}{1-\exp(-k)}$$