Factors controlling the rate of OM decay

1 Placement

2 Size and Surface Area

3 C:N Ratio

4 Litter Quality

4. Litter Quality

C/N > 20 (% N < 2.5) → N immobilized

C/N < 20 (% N > 2.5) → N release

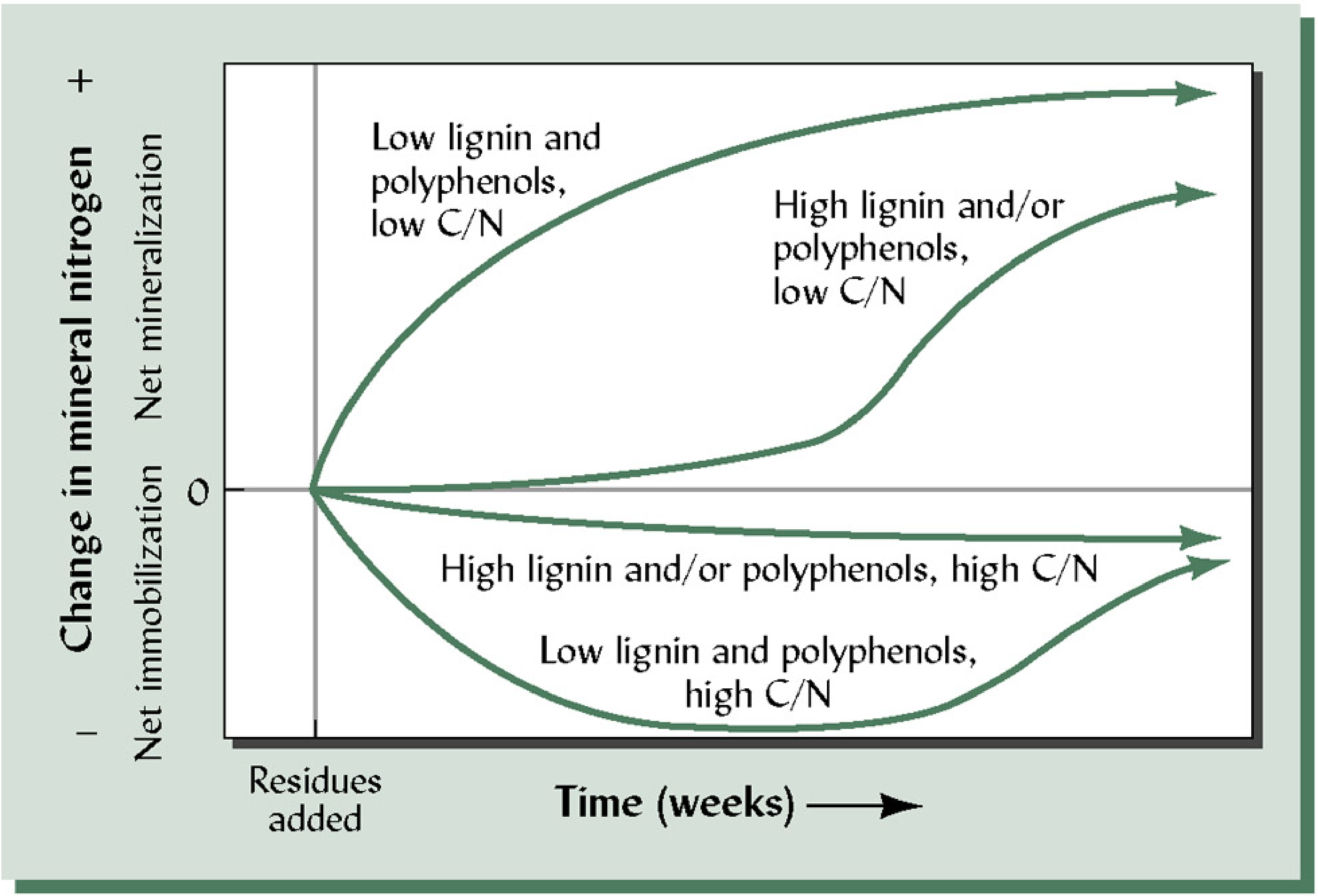


TABLE 12.3 Litter Quality in Relation to the Lignin Content, Polyphenol Content and C/N Ratio of Several Types of Plant Residues

Prunings (leaves and small twigs) of three common agroforestry tree species and afterharvest residues of two cereal crops were applied at a rate of 5 Mg/ha to an Oxic Paleudult in a humid tropical region of Nigeria. Low values of C/N, lignin, and polyphenols all contribute to high litter quality and high speed of decomposition. The inhibitory effect of polyphenol content can be seen by comparing Gliricidia *to* Leucaena.

Plant species	*Plant parts*	*Lignin, %*	*Polyphenols, %*	*C/N*	*Decomposition constant,*[a] *k/week*	*Litter quality*
Gliricidia sepium	Prunings	12	1.6	13	0.255	High
Leucaena leucocephala	Prunings	13	5.0	13	0.166	Medium–high
Oryza sativa	Straw	5	0.6	42	0.124	Medium
Zea mays	Stover	7	0.6	43	0.118	Medium
Dactyladenia barteri	Prunings	47	4.1	28	0.011	Low

[a] As each type of residue decomposed during a 14-week season, researchers periodically determined the proportion Y of the original residue dry matter remaining. The decomposition rate k was determined from the equation $Y = e^{-kt}$, in which e is the base of natural logarithms, and t is time in weeks. Therefore, the larger the decomposition constant k, the faster the decomposition.

Data selected from Tian, et al. (1992 and 1995).

Rate of Plant Tissue Decay

Rate of organic matter decay depends on:

1. **Properties of the organic matter**

Physical - eg. chopped straw vs. whole straw
Chemical - high lignin & cellulose slows decay
(eg. wood vs. grasses)

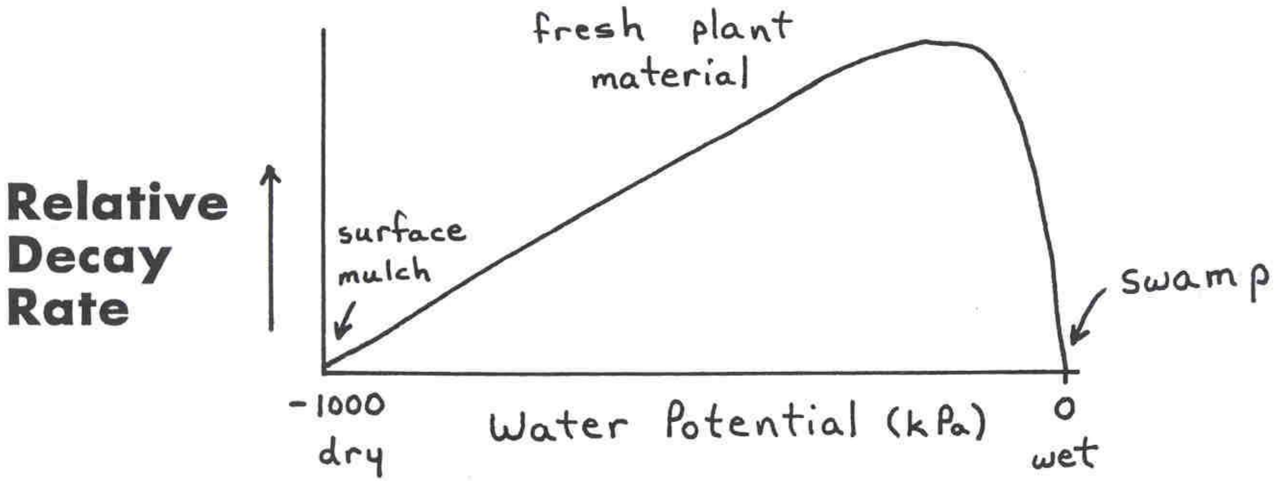
(A) C:N ratio (this could be consider chemical),

(B) high surface area (size) and

(C) resistance to decay

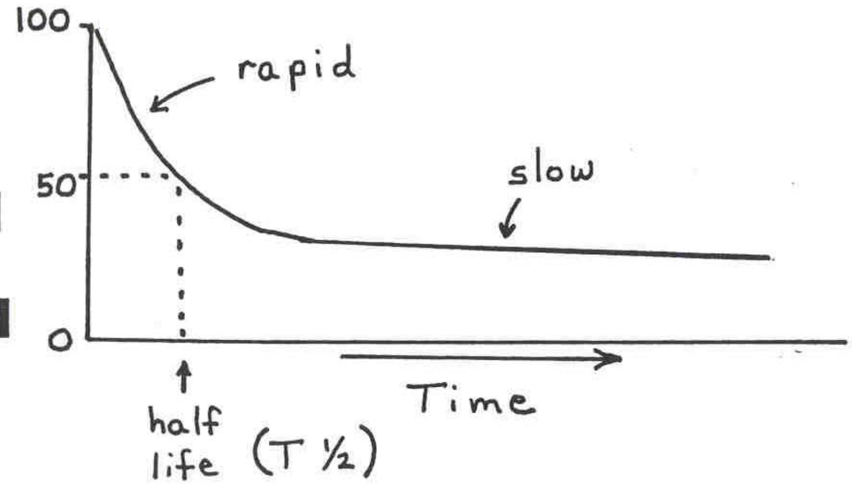
2. Water

Decay fastest in moist soil
Slow in dry <u>or</u> waterlogged soil



3. Stage of Decay

Amt. of Original Organic Material Left



Decay Rates - Fresh Material - up to 50%/week
- humus - 3%/year

Table 3. Values T 1/2 for a variety of experiments in different regions of the world

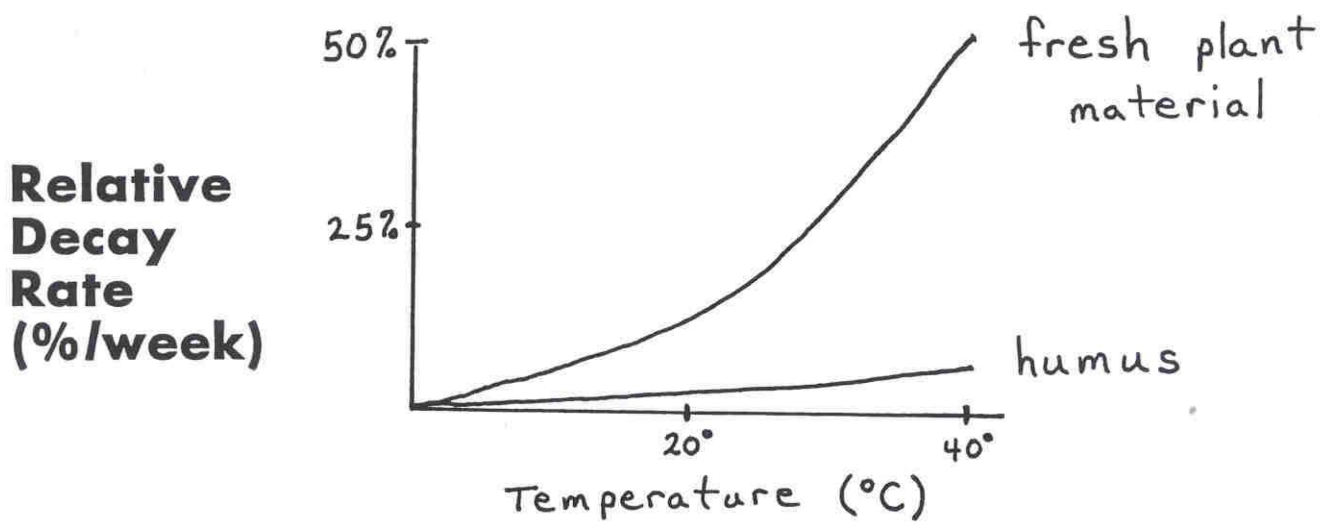
Location	Cropping System	T 1/2, years
Illinois, USA	Continuous corn	29
Kansas, USA	Wheat-fallow	11
Assam, India	Unshaded Tea	7
Congo, Africa	Food crops	2
Rothamsted, England	Grass	25[1]
Puerto Rico	Grass-legume	3[1]

[1]Organic matter accumulation, all others organic matter decline.

4. Temperature

Overall soil respiration declines at low temp.

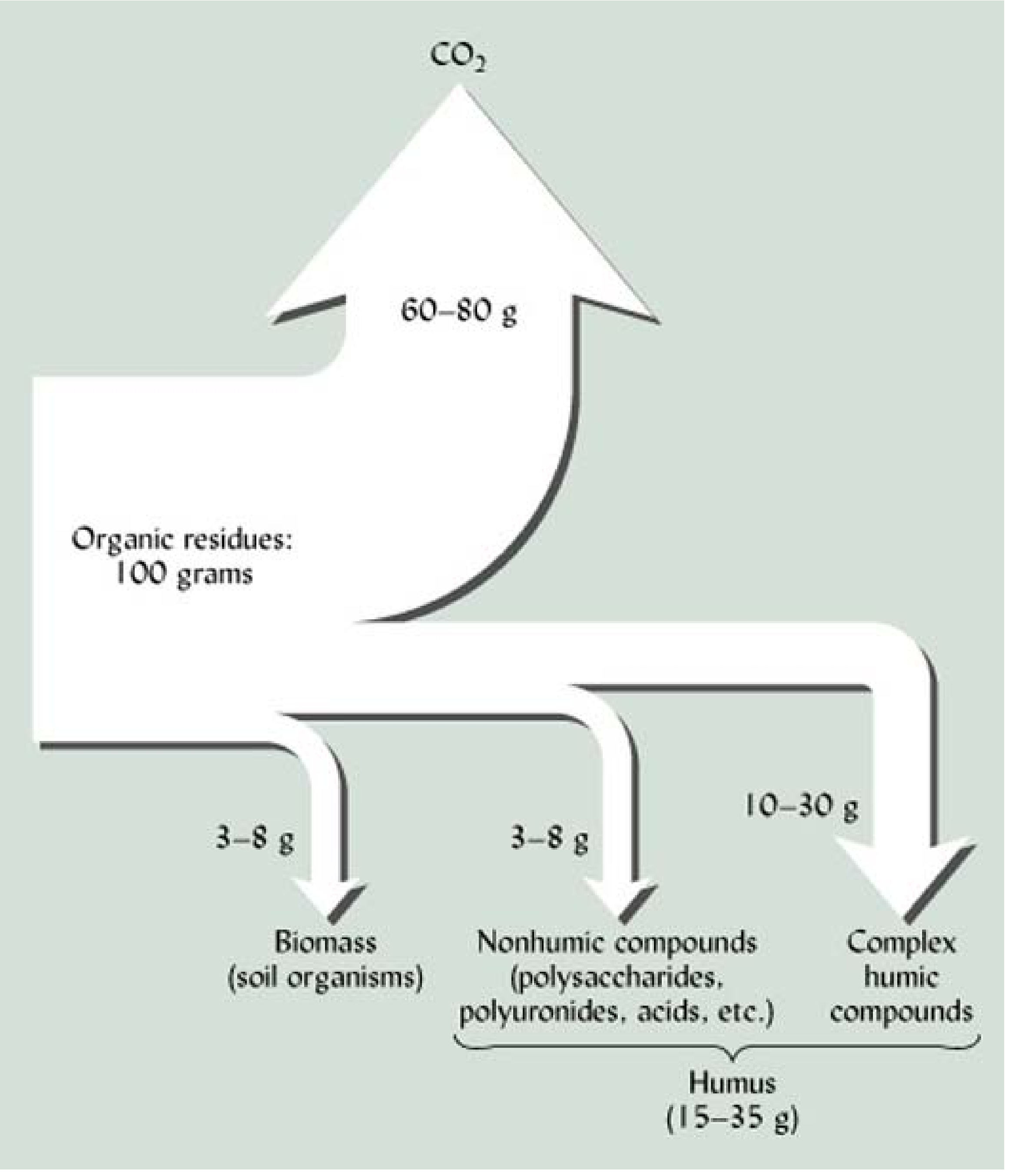
Result: cool climates produce soils with high organic matter



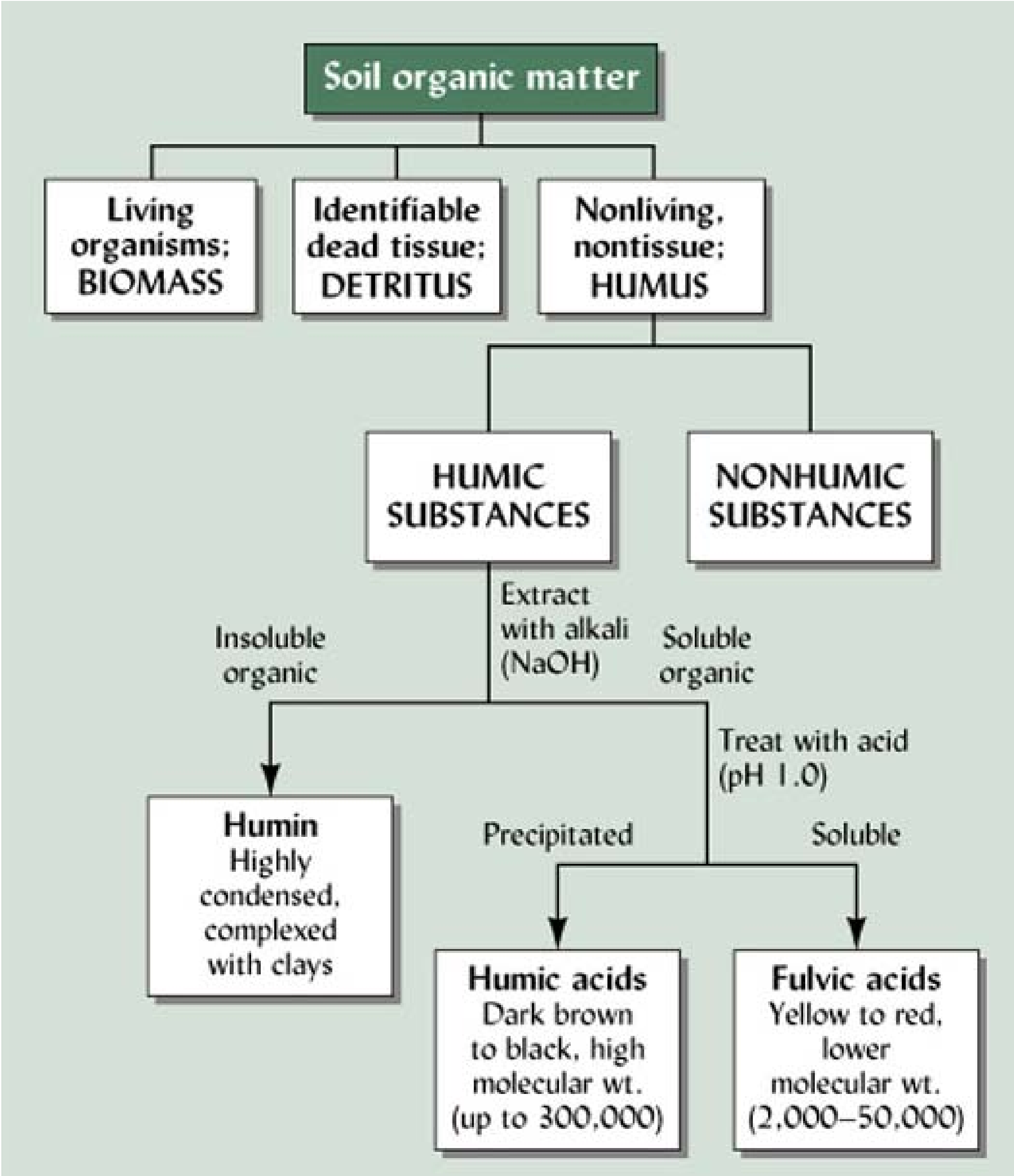
5. Chemical Factors ~ factors which might inhibit microbes

- extremes of pH (<4.5, >9) inhibit decay
- very high salinity inhibits decay
- nutrient deficiencies (usually N) inhibit decay.
- C:N ratio (this could be consider physical),

Humus



CO_2
60–80 g
Organic residues:
100 grams
3–8 g
3–8 g
10–30 g
Biomass
(soil organisms)
Nonhumic compounds
(polysaccharides,
polyuronides, acids, etc.)
Complex
humic
compounds
Humus
(15–35 g)



Nonhumic group consists primarily of polysaccharides

HUMUS - colloidal soil organic matter that decomposes slowly and colors soils brown or black.

- organic "glue" holding mineral particles together as aggregates.

- two important properties like clay:

  1. highly charged (negative), adsorbing exchangeable cations.

  2. large surface area per unit mass.

- very reactive in soil (despite low content).

3 chemical groupings: fulvic acids
humic acids
humin

HUMUS FORMATION

HUMUS - A mixture of colloidal organic decay products that resists further decay.

PROPERTIES OF HUMUS -

1. **Contains Phenolic Polymers -**
   - confers dark color
   - produces resistance to decay
   - buffers pH (in part)

2. **Contains Carboxyl (-COOH) Groups**
   - buffers pH between 4-6.5
   - $COOH \rightleftharpoons -COO^- + H^+$
   - generates pH-dependent CEC
   - chelates certain cations (eg. Cu, Zn)

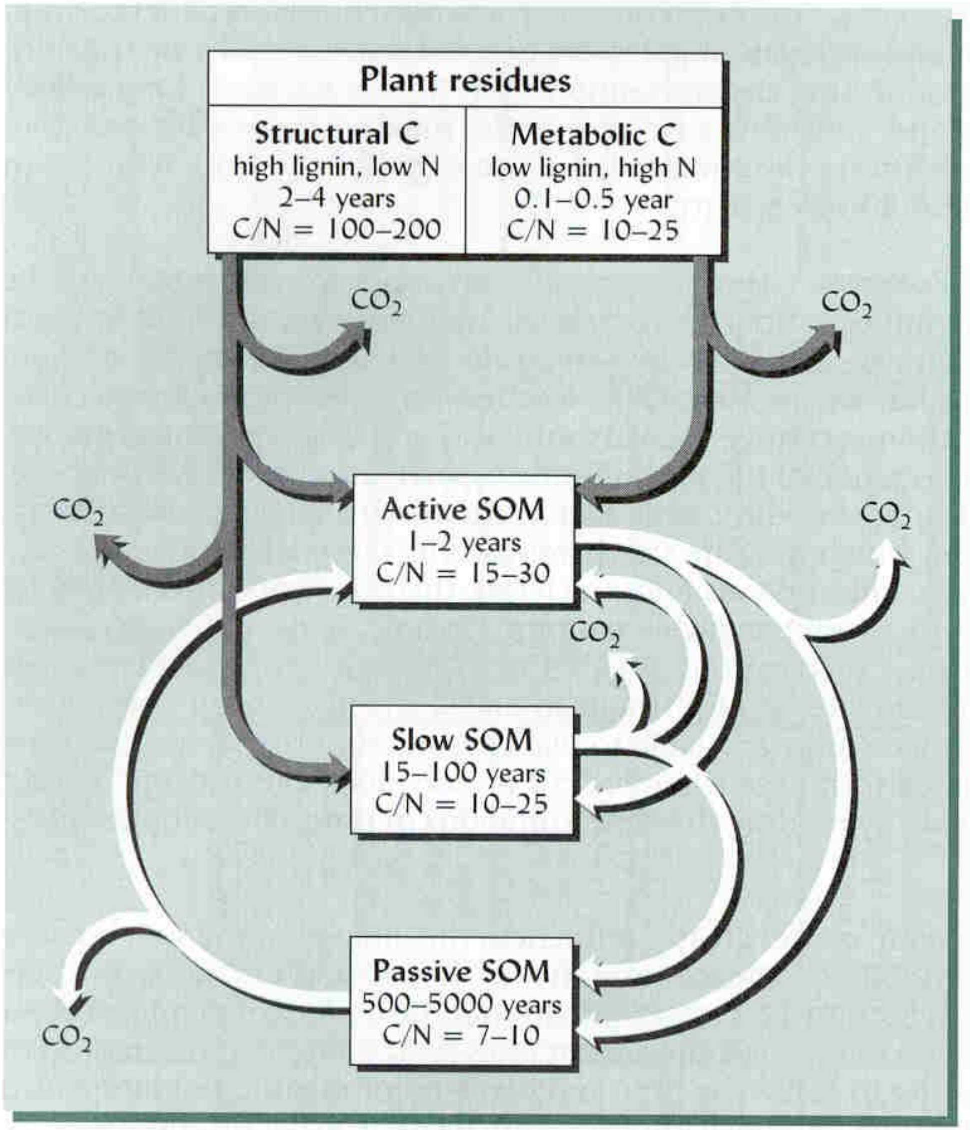
3. **Accumulates N and S as it Decays**
   - main source of these in unfertilized soils
   - tied up in fairly unavailable form
   - C/N, C/S ratios decrease during decay.

TABLE 12.4 Some Direct Effects of Humic Substances on Plant Growth

Effect on plant growth	*Humic substance*	*Concentration range, mg/L*
Accelerated water uptake and enhanced germination of seeds	Humic acid	1–100
Stimulated root initiation and elongation	Humic and fulvic acids	50–300
Enhanced root cell elongation	Humic acid	5–25
Enhanced growth of plant shoots and roots	Humic and fulvic acids	50–300

From Chen and Aviad (1990).

Soil Organic Matter Management



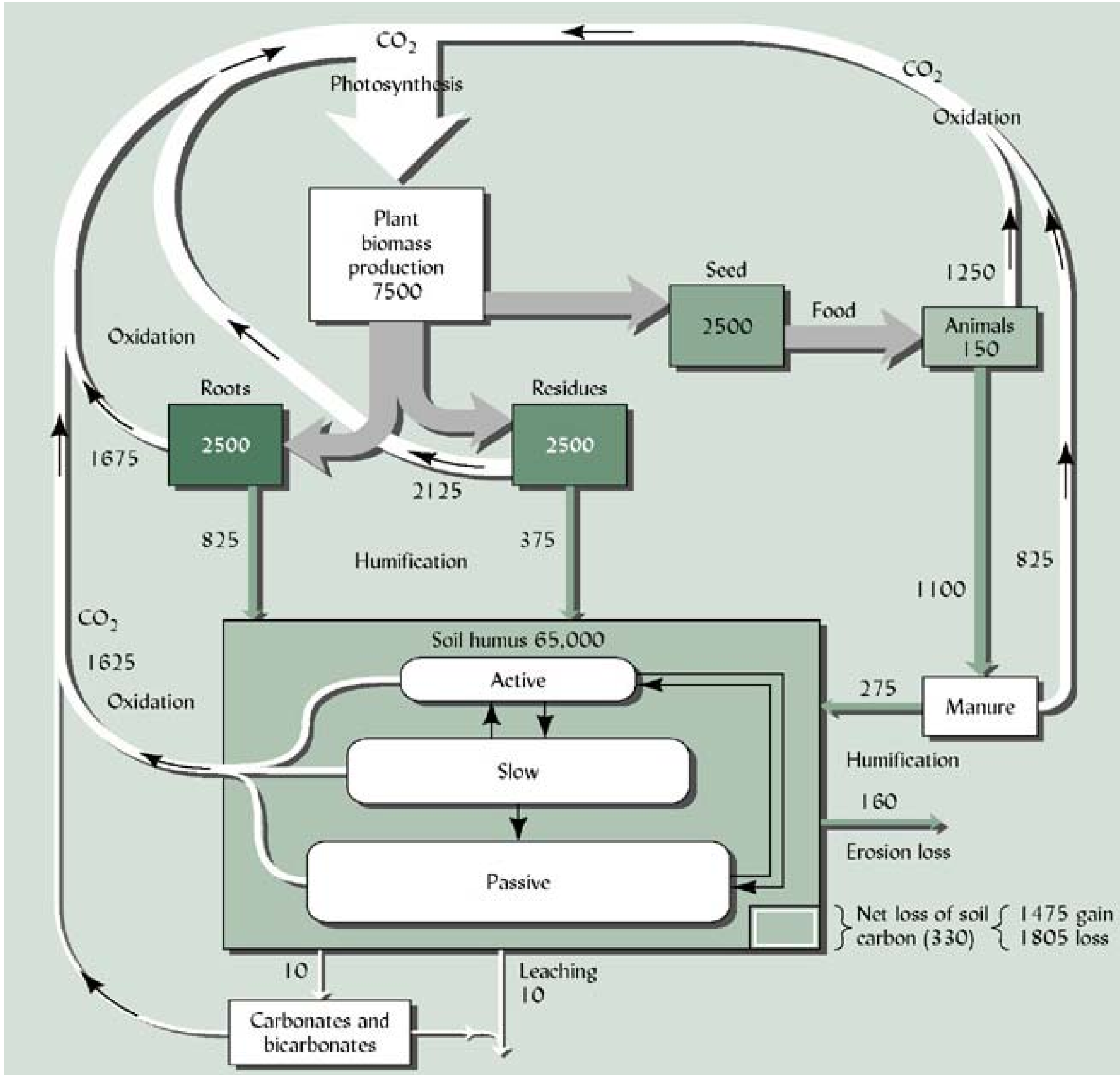
<u>3 Pools of SOM</u>

Active

Slow

Passive

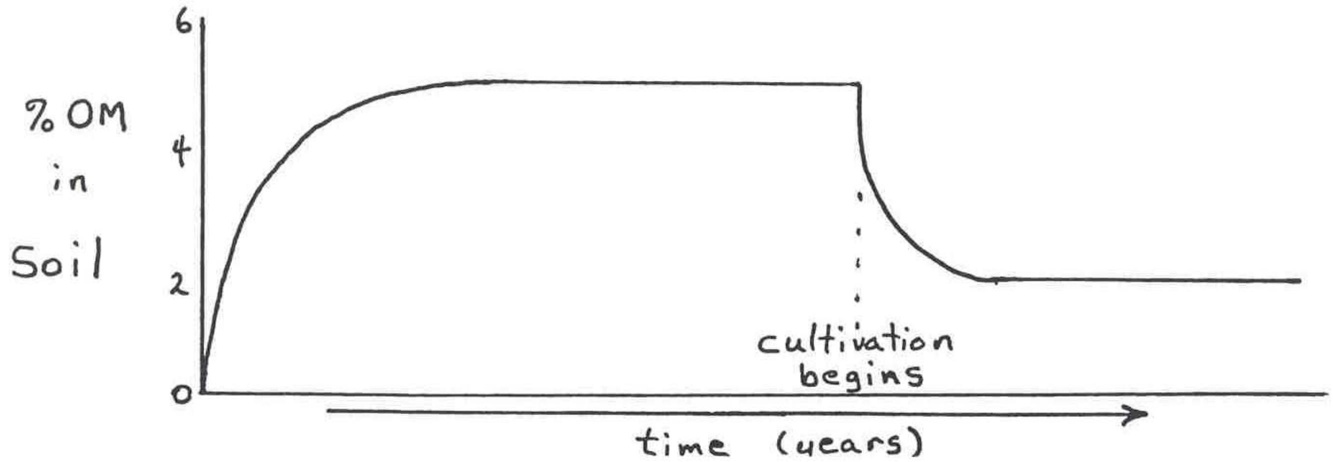
Agronomic System

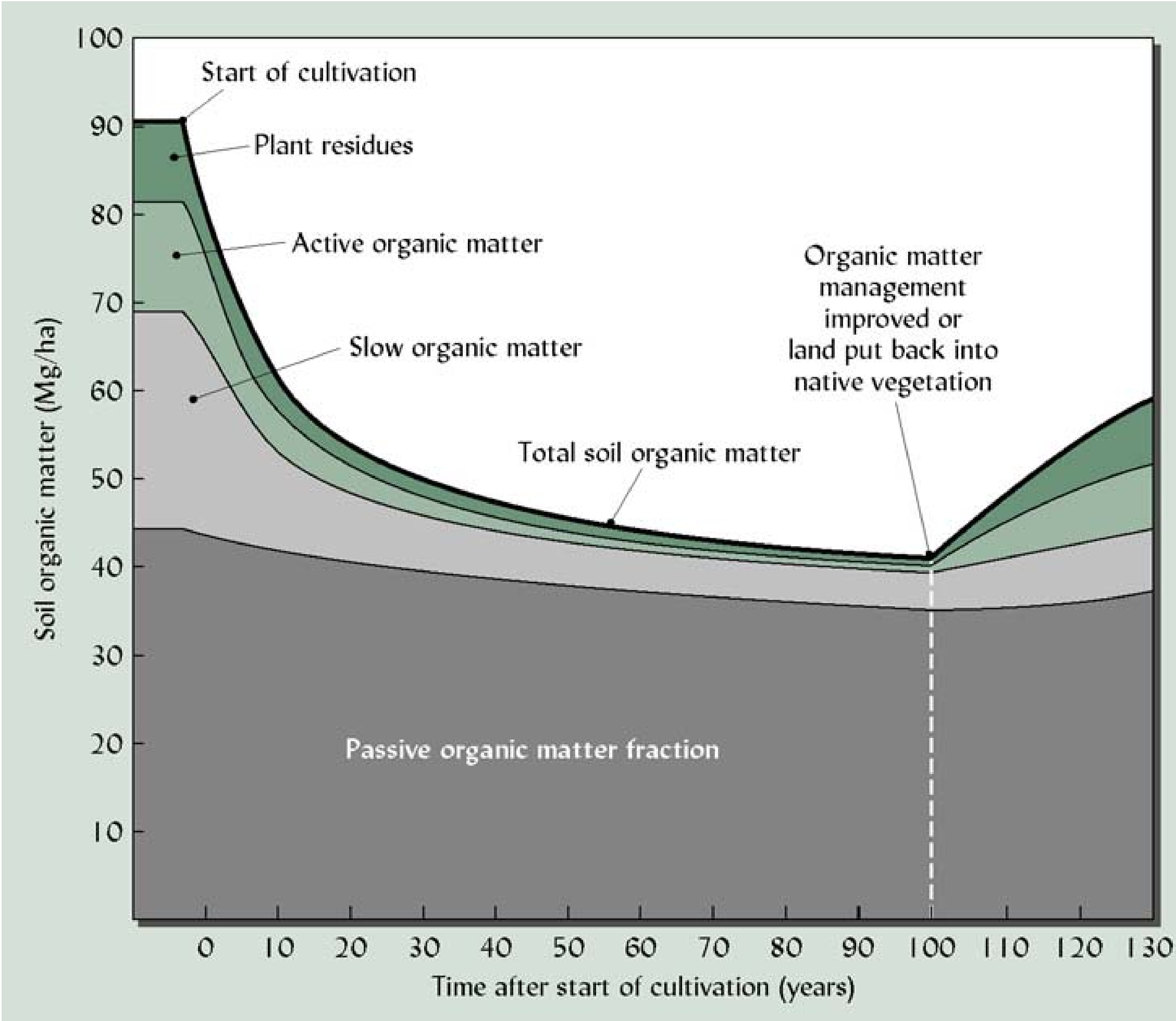


kg/ha

TABLE 12.5 Factors Affecting the Balance between Gains and Losses of Organic Matter in Soils

Factors promoting gains	*Factors promoting losses*
Green manures or cover crops	Erosion
Conservation tillage	Intensive tillage
Return of plant residues	Whole plant removal
Low temperatures and shading	High temperatures and exposure to sun
Controlled grazing	Overgrazing
High soil moisture	Low soil moisture
Surface mulches	Fire
Application of compost and manures	Application of only inorganic materials
Appropriate nitrogen levels	Excessive mineral nitrogen
High plant productivity	Low plant productivity
High plant root:shoot ratio	Low plant root:shoot ratio


% OM
in
Soil
6
4
2
0
cultivation
begins
time (years)


100
90
80
70
60
50
40
30
20
10
Soil organic matter (Mg/ha)
Start of cultivation
Plant residues
Active organic matter
Slow organic matter
Organic matter management improved or land put back into native vegetation
Total soil organic matter
Passive organic matter fraction
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Time after start of cultivation (years)

Managing Soil Organic Matter

Purposes:

1. To dispose of organic material (e.g. sewage waste, crop residue)

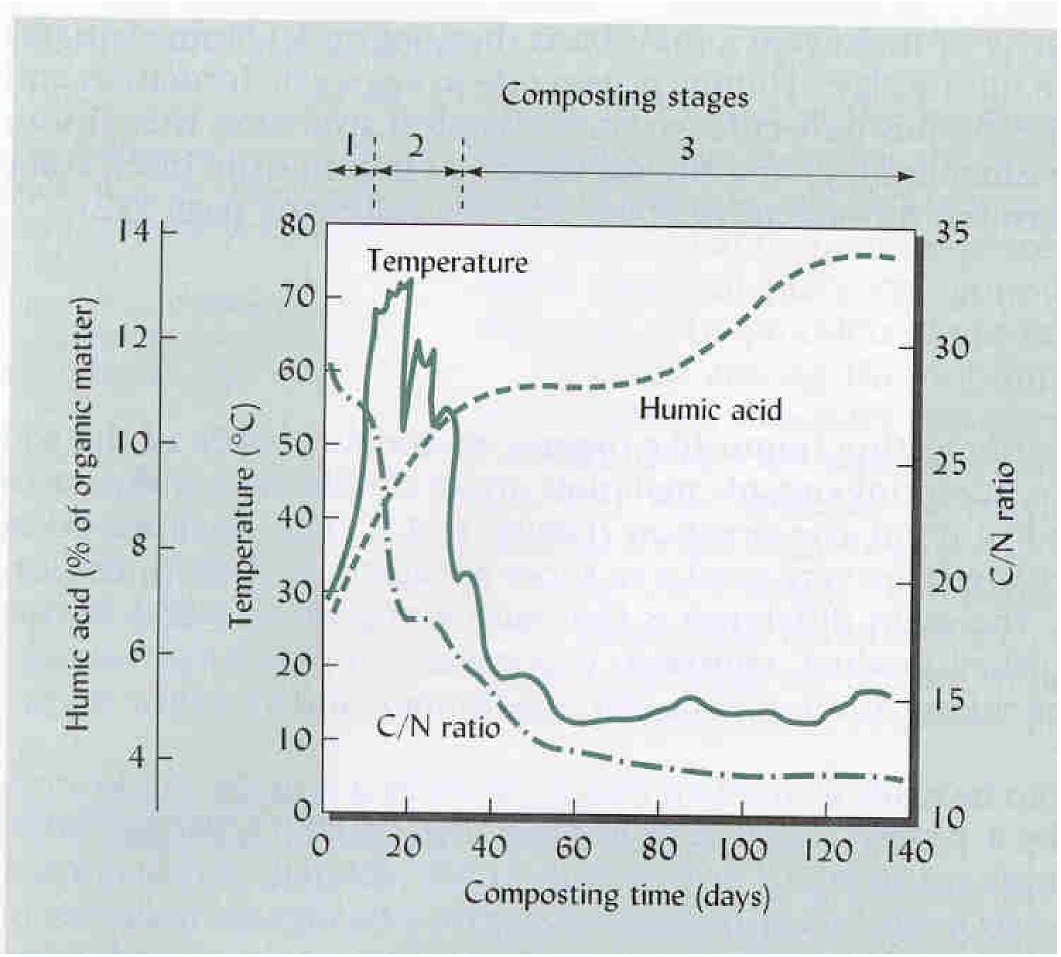
2. To build up or maintain humus for
   - structure
   - water retention
   - N & S supply
   - cation retention
   - pH buffering

3. Improve water infiltration & aeration (structure-related)

4. Provide a mulch to prevent soil
   - crusting
   - erosion
   - overheating

Managing Soil Organic Matter

1. To dispose of OM waste
   – composting, vermicomposting, etc…



Composting – 3 stage process

1. Mesophilic Stage 1

   Simple sugars & other readily digestible food sources are metabolized raising the temp > 40^{O}C

2. Thermophilic Stage

   Cellulose & other less digestible materials are metabolized raising the temp to 50 to 75^{O}C

3. Mesophilic Stage 2

   "Curing", during which mesophilic organism recolonize, ↑ in plant stimulating hormones & ↑ hormones detrimental to plant pathogen fungi as well as ↓ in the compost temperature

Benefits of Composting

1. Safe Storage
2. Easier Handling
3. N competition avoidance
4. N stabilization
5. Partial Sterilization
6. Detoxification
7. Disease Suppression

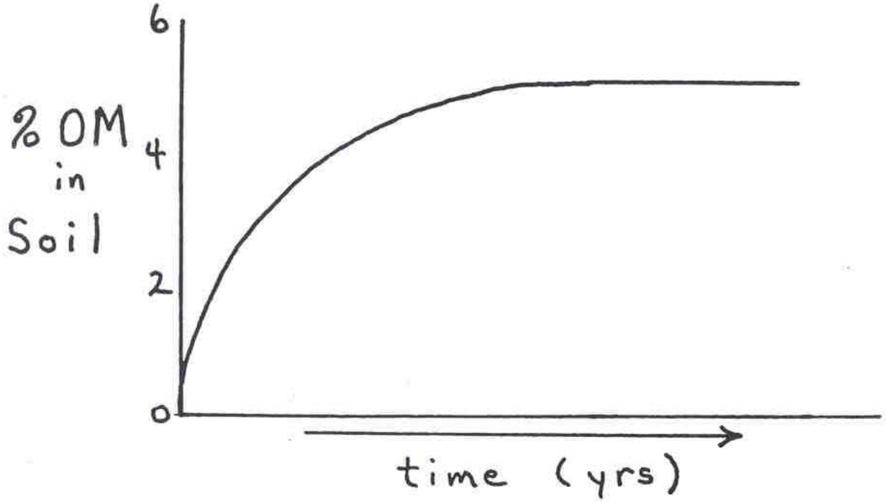
Ways to Increase Organic Matter Levels:

1. **Reduce Losses -**
   - control erosion
   - select slowly-decaying organics
   - modify soil enviornment (aeration, etc.)

2. **Increase Inputs -**
   - add organic wastes-manures, composts
   - incorporate crop residues-green manures, straw, etc.
   - increase crop yield (fertilizer, etc.)

Amount of organic matter in soil is constant if:

RATE of ADDITION of RESIDUES to SOIL = RATE of LOSS by DECOMPOSITION



Soil Formation

organic matter accumulation

Reduce loss by modifying litter quality

Plant species	*Plant parts*	*Lignin, %*	*Polyphenols, %*	*C/N*	*Decomposition constant,*[a] k/week	*Litter quality*
Gliricidia sepium	Prunings	12	1.6	13	0.255	High
Leucaena leucocephala	Prunings	13	5.0	13	0.166	Medium–high
Oryza sativa	Straw	5	0.6	42	0.124	Medium
Zea mays	Stover	7	0.6	43	0.118	Medium
Dactyladenia barteri	Prunings	47	4.1	28	0.011	Low

Reduce loss by Soil Environment Modification