An introduction to
SOIL ORGANIC MATTER

W.M.C.J. Wijekoon – SS2101

May 2015 V.1, March 2016 V.2,
June 2019 V.3

Dr. Chamila Wijekoon's screen

Soil Organic Matter

- Sources:
  - Plants origin – roots, vegetative parts *etc*
  - Animal Origin – Dead bodies, Faeces

- Forms:
  - Living biomass
  - Recognizable plant residues
  - Substances no longer identifiable as plant/animal material – amorphous and colloidal mixture

    Humus

Dr. Chamila Wijekoon's screen

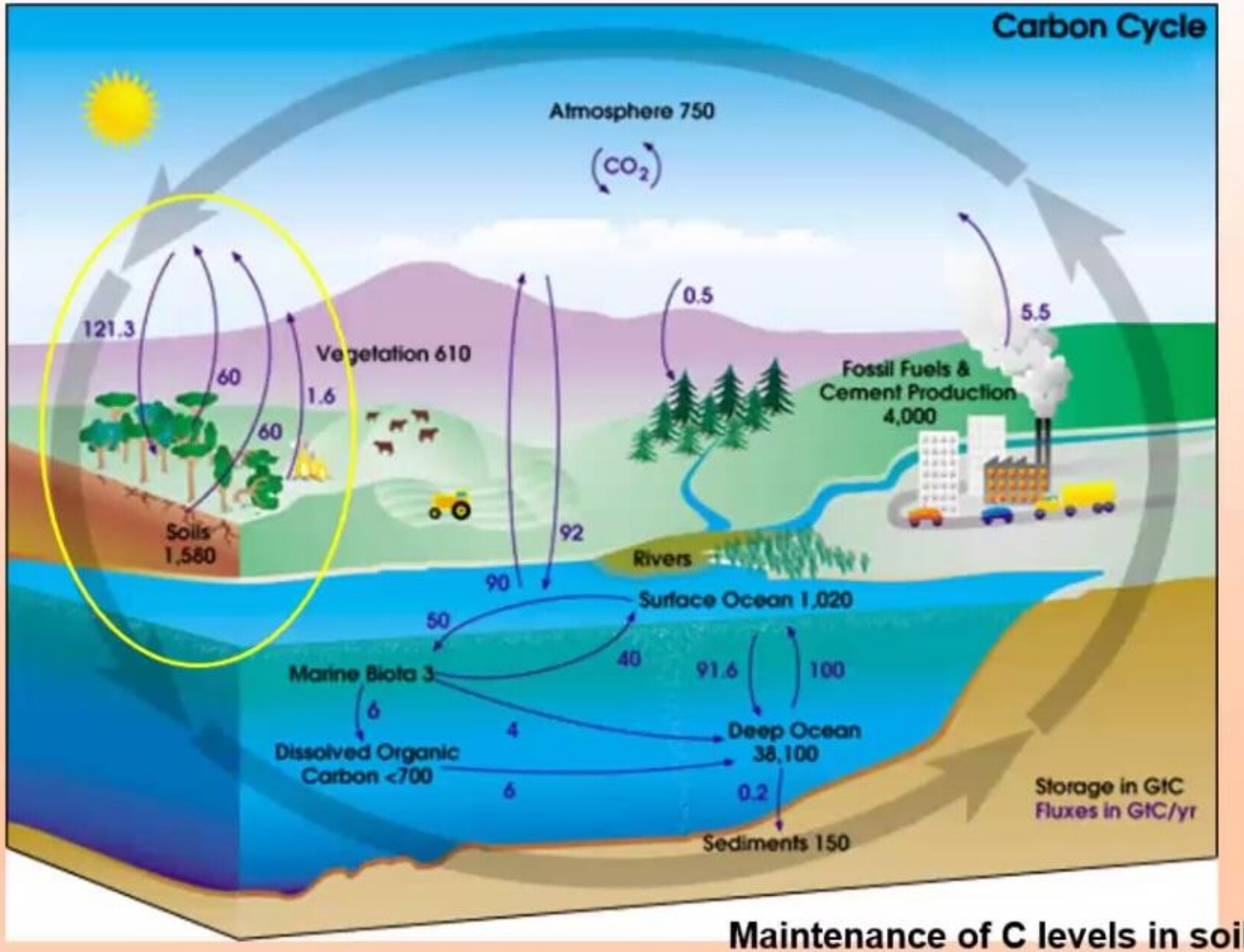
- Humus:
  - Not just material with plant origin
  - Result of synthesis and decomposition

- Humic substances
  - 60 – 80 % of SOM
  - Complex structures (aromatic rings like phenols *etc*)
  - Highly resistant
  - Dark in colour
  - Amorphous

- Non humic:
  - 20 – 30 % of SOM
  - Less complex
  - Less resistant to MO attacks
  - Have bio-molecules with definite physical and chemical properties
  - Synthesized or modified

- Functions of humus
  - Maintain OM content even over thousands of years
  - Protecting nutrients
  - Ion exchange sites
  - Give colour to soil
  - Maintain soil physical/chemical properties
  - Formation of chelates
  - Help in mineral weathering

Recording



Maintenance of C levels in soil

NASA 2008

Recording

How the OM is balanced?

- Compromise between addition and removal

Importance of OM balance

Recording

Dr. Chamila Wijekoon's screen

Outline

- Plant residue decomposition and C:N ratio
- Mineralization and immobilization of nutrients
- Influence of organic matter on soil properties
- Managing soil organic matter towards sustainable agriculture.

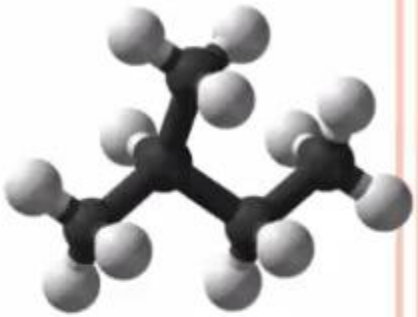
Recording

ILOs

- Briefly explain the term “Soil Organic Matter”
- Explain the fate of freshly added OM in the soil in varying environments
- Explain the importance of C:N ratio in soil organic matter decomposition
- Explain the effect of OM on soil chemical and physical properties
- Relate the management of SOM to the sustainability of agriculture

Recording

Composition of SOM



- Complex and varied mixture of organic substances
- Ranges from simple substances such as sugars to complex substances like lignin, humic substances *etc*
- Other than C, rest of the nutrients are also included Eg. N, P, K, Mg *etc*

* *40% of the SOM is contained in histosols and inceptisols*

Recording

Composition of SOM

- **Water 75%**
- **Dry matter 25%**

- **Dry matter -**
  - **Cellulose 45%**
  - **Hemicellulose 20%**
  - **Lignin 20%**
  - **Protein 8%**
  - **Sugars & Starch 5%**
  - **Fat and waxes 2%**

Recording

How the balance is maintained

- Addition
  - Plant litter fall
  - Death of plant
  - Dead animals

  } Humification

- Removal
  - Decomposition
  - Erosion ?
  - Deforestation

  } Accelerated Oxidation

Recording

Organic matter decomposition

Driving factors

- A biological process
  - Large spatial scale – Climate (T and RF)
  - Local scale – Litter quality
    - C:N ratio
    - Fiber content
    - Lignin: N ratio etc

Recording

WHAT HAPPENS DURING THE DECOMPOSITION

- **Simple carbon compounds oxidized to CO_2**
- **Elements released/ immobilized by a series of reactions N, P, K, Mg *etc***
- **Resistant material is formed by microbial action or compound modification (Humus)**

Recording

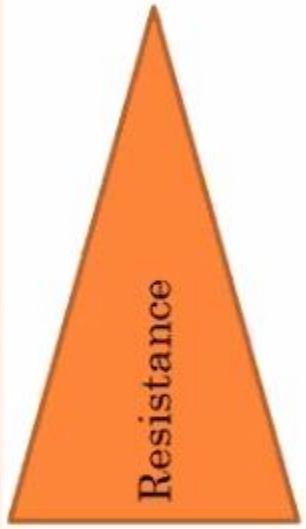
Reactions generalized

- **Under aerobic conditions**
  - **R-(C, 4H) + $2O_2$ -> CO_2 + $2H_2O$ + Energy**
  - **Proteins which contain N and S may yield NH_4^+, NO_3^- and SO_4^{2-} *etc***
- **Under anaerobic conditions (Bacteria mediates)**
  - **$4C_2H_5COOH + 2H_2O \rightarrow 4CH_3COOH + CO_2 + 3\ CH_4$**
  - **$CH_3COOH \rightarrow CO_2 + CH_4$**
  - **$CO_2 + 4H_2 \rightarrow 2H_2O + CH_4$**

    Slow and releases little energy

Recording

Resistance to decomposition



Component	Approximate composition
Sugars & Starch	5%
Protein	8%
Hemicellulose	20%
Cellulose	45%
Fat and waxes	2%
Lignins	20%

Recording

Mineralization

- **Overall process that releases elements from organic compounds to produce inorganic forms (Minerals)**
  - **Released ions are readily available for plants**
  - **Prone to be removed from the soil**

Recording

IMMOBILIZATION

- **Simply the opposite of mineralization**
- **Microbial utilization or demand for particular mineral makes the mineral unavailable for plant use. This condition is termed as immobilization.**
- **Generally, N immobilization is considered as one of the main events in organic matter decomposition in the soil**

Recording

C:N Ratio

- **C:N Ratio of plants (Eg. Legumes 10:1 to 30:1**
  Saw dust 600:1)

- **C:N Ratio of soil micro organisms (Eg. 5:1 to 10:1) Avg 8:1**

- **C:N Ratio of soil**
  - **Surface 8:1 to 15:1 Avg 12:1**
  - **Subsoil – comparatively lower**

Recording

C:N Ratio of SOM

- **40% C (Range 45- 58%)**
- **N content 1 – 6% (varies)**

- **Importance**
  - **If the C:N ratio of added material is high there will be an intense competition for soil N**
  - **Determine the availability of N**
  - **Soil C:N is relatively constant. Therefore the C maintenance is constrained by the soil N level**

Recording

Dr. Chamila Wijekoon's screen

- **If you add organic matter with high C:N ratio (More carbon) what will happen?**
  - **MO has a source of energy**
  - **Need N to utilize the energy to reproduce (Need N in various ways, DNA, Proteins, Enzymes ...)**
  - **Get N from the soil**
  - **Higher plants show N deficiency symptoms**

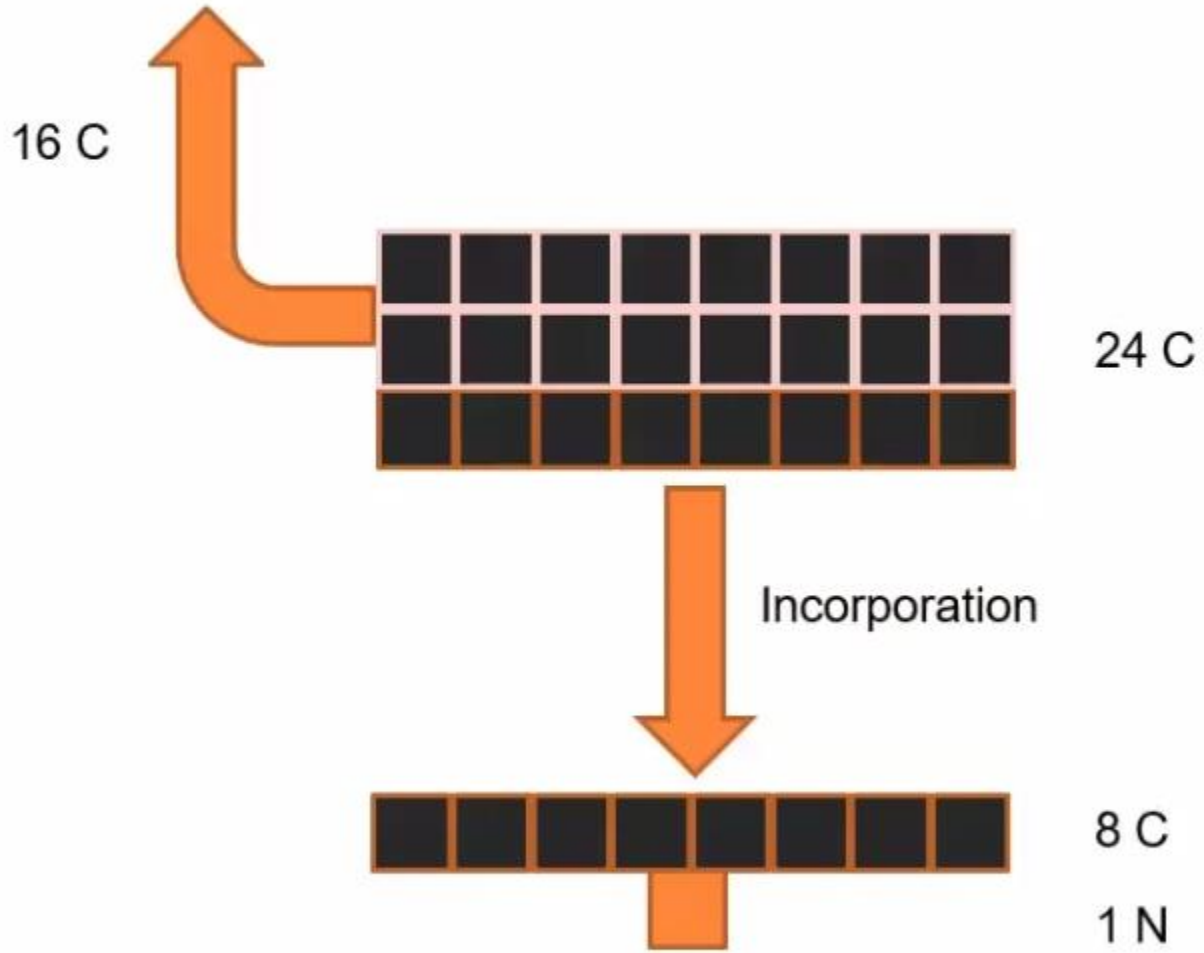
Recording

Simple illustration of C:N ratio and its importance

- **MO need 8 pats of C for every part of N they incorporate into their body (as their C:N ratio is 8:1)**

- **MOs can metabolize only 1/3 of the total carbon they consume**

Recording



Recording

Dr. Chamila Wijekoon's screen

- **There fore for every 1 g of N they incorporate they need**

  3 x 8 = 24 g of C

  Therefore when you add organic matter their C:N ratio should not exceed

  25:1

  to prevent micro organism scavenging for soil N

Recording

- **Example**

- **8000 kg of dry leaf litter was added to the soil**
- **Composition**
  - **42 % carbon**
  - **0.65 % N**

  - **Therefore C:N ratio 42:0.65 = 65:1**

Recording

- **Amount of C in plant residue**
  - **8000 x 42/100 = 3360 kg**
- **Only 1/3 is incorporated**
  - **3360 x 1/3 = 1120 kg**
- **C:N ratio of MOs 8:1**
  - **Amount of N need to incorporate 1120 kg C =**
  - **1120 / 8 = 140 kg**

Recording

- N coming from the leaf litter =
  - 8000 x 0.65/100 = 52 kg
- Micro organism need 140 kg
- Residue supply only 52 kg
- Deficit = 140 – 52 kg = 88 kg
- If the process goes like this MOs may take this 88 kg N from the soil N pool

Influence of organic matter on soil properties

- SOM can reduce soil erosion (acting as a cover)
- Increase the soil moisture content.(WHC)(Drainage)
- Support the reproduction of MO
- Increase soil nutrient level.
- Can help to stop leaching of nutrients.
- Improve soil aeration.
- Improve the availability nutrients.
- Influence the soil temperature.
- Can improve the soil structure.
- Can improve the CEC.
- Buffering of soil reactions.
- Increase the diversity and the activity of SMO.
- Provide special bio-molecules.

- Reduce N availability.

MANAGING SOIL ORGANIC MATTER TOWARDS SUSTAINABLE AGRICULTURE

- What is sustainability?

- Maintain the Carbon pool.
- Recycling of materials in the environment.
- Reduce utilization of chemical fertilizers.
- Maintain good soil structure.
- Improve biotic and abiotic relationships in a soil system.
- Reduce ground water contamination.
- Increase the vigor of the plants

EXAMPLE CALCULATION ON C:N RATIO

- A farmer has 15 tons of fresh crop residue
- He also has 1 ton of compost
- He wishes to add these to the field in a good way

- Composition of the material is as follows

	% moisture	% Carbon	% N
Crop residue	50	40 (Dry basis)	1 (Dry basis)
Compost	40	40 (Dry basis)	10 (Dry basis)

- Farmer has urea in his stock as an inorganic fertilizer

Recommend a suitable combination of above items to be applied to his field

Example calculation on C:N ratio

Scenario of application of crop residue (CR) only

Weight of crop residue (CR)	= 15,000 kg
Dry weight of the CR	= 15,000 kg x (100-50)/100
	= 7,500 kg
C:N ratio	= 40:1
Amount of carbon in CR	= 7500 x 40/100
	= 3,000 kg
Amount of N in CR	= 7500 x 1/100
	= 75 kg
Amount of N required to utilize the carbon in crop residue	
	= 3000 x (1/3) x (1/8)
	=125 kg

EXAMPLE CALCULATION ON C:N RATIO

Deficit of N = 125 – 75 kg

= 50 kg

Alternatives the farmer has

Add compost or

Add urea or

Add both

Compost is preferred – (economically and environmentally)

C:N ratio = 4 : 1 (More nitrogen)

Dry weight of compost = 1,000 x (100 – 40)/ 100

= 600 kg

Carbon in compost = 600 x 40/100

= 240 kg

Example calculation on C:N ratio

N in compost = 600 x 10/100

= 60 kg

If apply CR and compost in combination

Total amount of carbon = 3000 + 240 kg

= 3240 kg

Required amount of N = 3240 x 1/24

= 135 kg

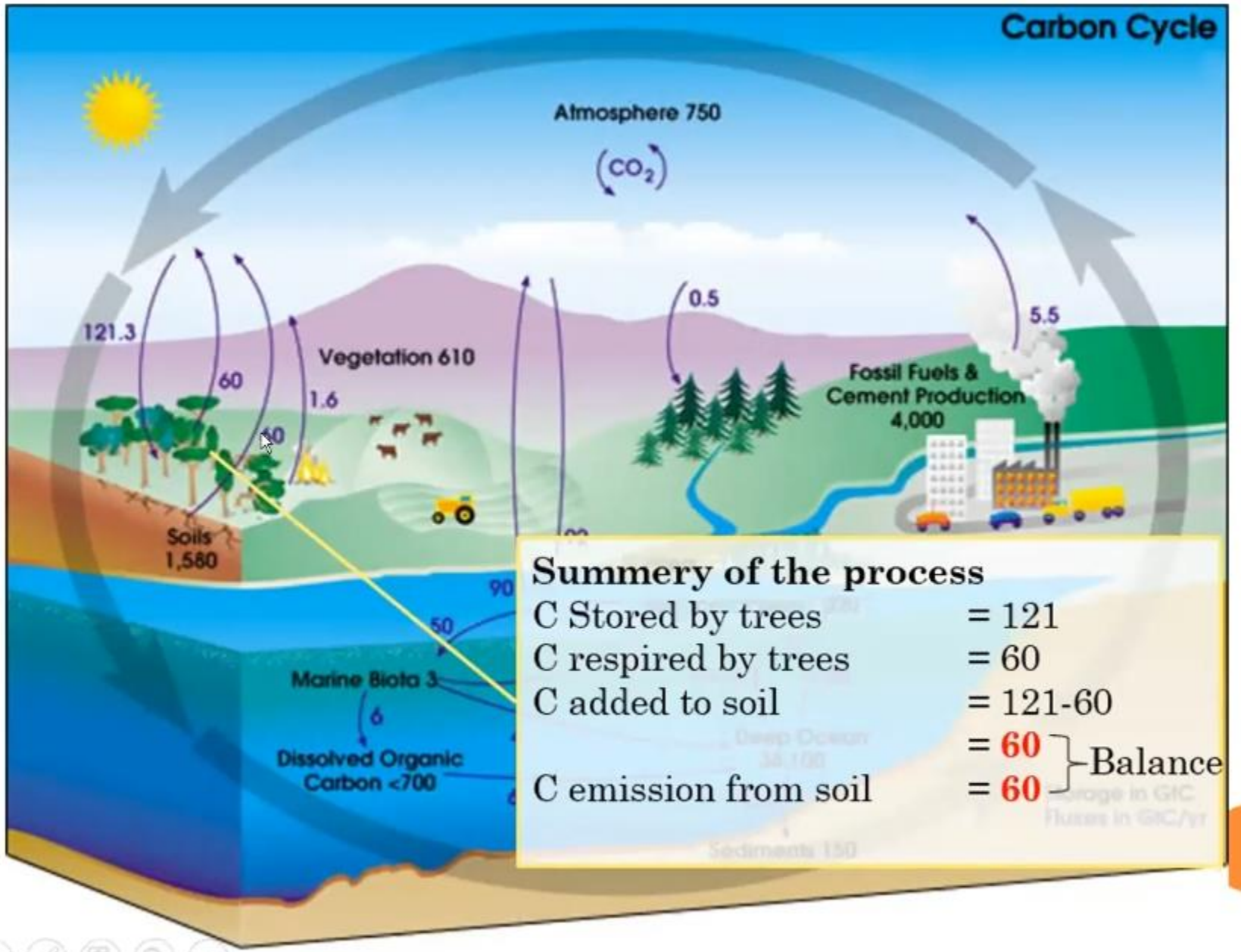
Total N supplied by CR and compost

= 60 + 75 kg

= 135 kg

- A perfect combination !

GLOBAL CARBON CYCLE AND SOM



Soil and the greenhouse effect

- Explain how?
- What are the greenhouse gases emitted from soil?
- What are the consequences of global warming?