The Carbon Cycle

Carbon recycling is one of several recycling processes, but it may be the most important cycle affects all life on earth, since is known to the basic building block of life. Cycling is the process in which the carbon atoms are recycled over and over, take place within Earth's biosphere and between living things and nonliving environment. Carbon occur in nature into two main states; complex carbonated organic compounds (**C** reduced form), and inorganic carbon, most of inorganic carbon is in form of **CO2** (**C** more oxidized state). So **CO2** is the source of all carbonated compounds, both in living organism and fossil deposits.

Carbon dioxide constitutes about 0.0 45% of atmosphere gases, in this rate is more less than the requirements of photosynthetic organisms, so **CO2** release continuously from respiration and decomposition to maintain carbon balance in nature.

Biology plays an important roles in the all aspects of the carbon cycle through three types of participation:

***Producers**

They represent the beginning of all food chains in nature, the producers fix atmospheric **CO2** and its subsequent assimilation into organic molecules through photosynthesis process

***Consumers**

Carbon is transferred from organism to other when plants are eaten by herbivores, which are in turn eaten by carnivores along the food chain. Primary→ Secondary→ Tertiary… , consumers get their required C either directly by eating plants or indirectly by eating animal that have eaten plants, to become their cellular materials or to release to atmosphere through respiration, in which a considerable portion of carbohydrates is oxidized to yield **CO2, H2O**, and **energy** as follows:

C6H12O6 + 6O2------- Respiration **----------→ 6CO2 + 6H2O + energy**

***Decomposers**

Decomposers are m.o. that lives mostly in soil, but also in water, they contribute substantially to carbon pool by their feeding and processing of rotting remains of other organisms. It is their job to consume both waste products and dead organic matter of land or ocean. Decomposers not only play key role in carbon cycle, but also break down, remove, and recycle what might be called nature's garbage.

Microorganisms play a key role in carbon recycling, they contribute to the carbon cycle by:

•Fixation of CO2 (Photosynthesis) ; An important step in carbon cycle is the fixation of atmospheric **CO2** and its subsequent assimilation into organic molecule. Autotrophic organisms are able to covert **CO2** into organic molecules via photosynthesis process, include plants, algae, some bacteria, and some archaea. The cyanobacteria and specific soil bacteria have the ability to conduct photosynthesis , **H2S** and other reduced compounds serve as **e-** donor to reduce **CO2**

Bacterial photosynthesis:

$$CO_2 + 2\,H_2A \xrightarrow[\text{bactochlorophyll}]{\text{Light}} (CH_2O)_x + H_2O + 2A$$

•Decomposition.

Decomposition is a biological process that includes physical breakdown and biochemical transformation of complex organic molecules of dead materials into simpler organic and inorganic molecules. The major function of soil m.o. in the

Carbon Cycle is as decomposers – degrader of complex organic matter that would otherwise permanently sequester carbon, keeping it from being useful to organisms. Each organic compound is utilize in a slightly different manner, and each yield different products when degrade, but many of these decomposers also release **CO**2, contributing to the rising concentration in the atmosphere. Bacteria and fungi are particularly effective in breaking down of organic matter, while actinomycetes are responsible in degradation of tough remains, like lignin and chitin. Some management activities, particularly those that change nutrient level in soil can shift the dominance of decomposers from bacteria to fungi, when one group become dominant where it shouldn't be there is also shift the rest of system.

The rate of decomposition is affected by; soil temperature, moisture, aeration and food availability, mainly decomposition is either aerobic or anaerobic:

Aerobic decomposition, Most of heterotrophic microbes easily utilize aerobically soil organic compounds for both energy metabolism and as a carbon source:

Complete oxidation

Aerobic decomposition ----------→ CO2 + H 2O + energy

(Mineralization) (assimilation) (respiration)

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Temporarily immobilized in form of Living matter **again recycled to atmosphere**

Mineralization: This is the process by which organic matter is decomposed to release simpler, inorganic compound (e.g. **CO2**, **NH4+**, **CH4**, **H2**).

Immobilization: The nutrients that are converted into biomass become temporarily "tied up" from nutrient recycling, until the organism dies, at which time the **C** released back into the environment via decomposition.

Anaerobic decomposition, The anaerobic degradation of carbonaceous matters is a collaborative effort involving numerous bacteria , these bacteria are responsible for the bulk of Co2 and methane that released to the atmosphere.

Anaerobic decomposition ----------→ H2 + CH4 + alcohol + organic acid

Decomposition of organic matter under anoxic conditions such as deep compacted mud, differs considerably from oxygen availability, in that reduced end products accumulated including **organic acids,** and **CH4**. Accomplished by certain soil bacteria known as **Methanogenic bacteria,** are biologically very primitive, strict anaerobic, and sensitive to pH.

Methanogenic bacteria are a part of carbon cycle, anaerobically, they either combine the acetic acid made by acetogenic bacteria (anaerobic decomposer bacteria degrades amino acids to acetic acids) to **CH4**, **CO2**,and **water .**

Methanogens

$HC_2H_3O_2 + 4H_2 \longrightarrow CO_2 + H_2O + CH_4$

Or derived CH4 from oxidation of hydrogen and reduction CO2 (both produced from organic carbon)

$CO_2 + H_2 \longrightarrow CH_4 + 2\ H_2O$

In both routs of conversion requires hydrogen, and yield energy for the methanogens.

Main soil methanogens are :

Methanococcus, Methanobacteria, Methanosarcina .

To complete the recycling pattern another group of methane bacteria called **Methanotrophes** (literally methane eaters) are able to reoxidize released **CH4** again to **CO2**, like ***Pseudamonas*** *and* ***Methylomonas*****.** This conversion also yields water and energy.

Other soil autotrophic bacteria are able to participate in the cycling of carbon by oxidizing carbon monoxide **CO.** This gas is relatively rare under ordinary condition, released from some activities, commonly from partial combustion. Exceedingly poisonous for most aerobic organisms, including man, its relished as a source of energy and carbon by at least one bacterial species ***Carboxydomonas*** that oxidize **CO** to **CO2**

CO + 1\2 **O2 ----------→ CO2**

The carbon cycle has come under intense scrutiny in the last decade or so. Because of there is an increase of **Co2** in atmosphere about one – third, and its continue to rise. Like to **Co2** methane concentration is likewise increasing about 1% per year, from 0.7 to 1.7 ppm. These two gases in combination with **H2O** (water vapor), **O3** (ozone), and **N2O** (nitrous oxide), represents the **greenhouse gases**, the term describes the ability of these gases to trap heat within Earth's atmosphere, in that correlated with global temperature change, a phenomenon known as global warming. Soil microorganisms play a role in the generation of each of these gases.

Cellulose decomposition

Cellulose is the most abundant chemical constituent of plant cells, its polysaccharides contain glucose units linked by β -1-4 linkage, total number of glucose units in cellulose molecule vary from 2 × 103 to 1 × 104. Total amount of cellulose in plants tissues varies from 15 t0 60 % .

Cellulose are not tough for decomposition, variety microbes presents in millions per 1 millimeter of soil are capable to breakdown cellulose under different circumstances, oxic and anoxic , in availability of oxygen cellulose decomposes into **CO2,** while in anoxic condition cellulose incompletely decomposes with release of many intermediates like organic acids and alcohols.

Three different enzymes involve in cellulose breakage, they collectively termed **cellulases** , each enzyme participate in certain stage of cellulose decomposition and produced by different microorganisms, m.o. that are able to biosynthesize all three enzymes called true cellulytic microorganism. Initial stages of cellulose decomposition take place by cleavage of cellulose by extracellular enzymes then the cleaved pieces are transported into the decomposers cell for energy generation (catabolism) or production of biomass (anabolism) and manipulated by the two rest intacellular lytic enzymes.