ESTIMATING THE INTERCONVERSION BETWEEN CO_2 AND ORGANIC MATTER IN THE ENVIRONMENT USING MATHEMATICAL MODELS AND SOME CONSIDERATIONS

Tomás de Aquino Portes

Federal University of Goiás, Institute of Biological Sciences, Department of Botany,
Campus Samambaia, 74690-900, Goiânia, Goiás, Brazil, portes@ufg.br

Abstract: The aims in this work were to use mathematical models to analyze the interconversion between the amount of organic matter produced and the consequent variation in the concentration of CO_2 in the atmosphere and to discuss, supported by the data presented and the literature, possible changes in the Earth's environment. Scientific findings and evidence indicate that the concentrations of CO_2 and O_2 varied throughout the existence of the Earth. These variations were a consequence of the existing environment in different ages, resulting in changes in all other processes that depended on these gases. Chemical reactions occurred and organic products such as petroleum arose abiotically. These products gave origin to organic chemistry and drastically reduced the concentration of CO_2 and elevated O_2 in the atmosphere. In the current plants, for each O_2 produced in the photochemical step of photosynthesis, one CO_2 is assimilated in the biochemical step. Supported by this relationship and by the results presented in this work, it can be inferred that the first photosynthetic organisms originated on Earth when the concentration of CO_2 was possibly at a concentration below 1000 ppm, the biochemistry activity started with these organisms. The results suggest that the reduction in CO_2 concentration was linear in relation to the age of the Earth, before the origin of photosynthetic organisms. This relationship changed with origin of these organisms, due to the major changes that occurred in the environment. There is evidence that in certain periods, CO_2 concentrations have been reduced below the CO_2 compensation point for certain plants resulting in the extinction of these plants and the organisms that depended on them.

Keywords: atmosphere volume, climatic change, mathematical models, organic matter of the Earth, plant extinction.

ESTIMANDO A INTERCONVERSÃO ENTRE CO_2 E A MATÉRIA ORGÂNICA NO AMBIENTE USANDO MODELOS MATEMÁTICOS E ALGUMAS CONSIDERAÇÕES

Resumo: Os objetivos neste trabalho foram usar modelos matemáticos para analisar a interconversão entre a quantidade de matéria orgânica produzida e a consequente variação na concentração de CO_2 na atmosfera e discutir, amparado nos dados apresentados e da literatura, prováveis mudanças no ambiente da Terra ao longo da sua idade. Constatações científicas e evidências indicam que as concentrações dos gases CO_2 e O_2 variaram ao longo da existência da Terra e as variações foram em consequência do ambiente existente ao longo da evolução do planeta, resultando em mudanças em todos os outros processos que dependiam dos referidos gases. Reações químicas ocorreram e, como consequência surgiram, abióticamente, produtos orgânicos como o petróleo e outros, dando origem à química orgânica e, redução drástica da concentração de CO_2 e elevação do O_2 na atmosfera. Nas plantas atuais para cada O_2 produzido na etapa fotoquímica da fotossíntese um CO_2 é assimilado na etapa bioquímica. Amparado por esta relação e pelos resultados apresentados neste trabalho pode-se inferir que os primeiros organismos fotossintetizantes se originaram na Terra numa Era em que a concentração do gás CO_2 já se encontrava possivelmente numa concentração abaixo de 1000 ppm e com estes organismos iniciaram as atividades bioquímicas. Os resultados sugerem que a redução na concentração do CO_2 tenha sido linear em relação a idade da Terra, antes da origem dos organismos fotossintetizantes. Esta relação não existiu a partir da origem destes organismos, em função das grandes alterações que ocorreram no ambiente. Há indícios de que em certos períodos as concentrações de CO_2 reduziram-se abaixo do ponto de compensação para certas plantas resultando na sua extinção e de organismos que dependiam delas.

Palavras-chave: volume da atmosfera, mudanças climáticas, modelos matemáticos, matéria orgânica na Terra, extinção de plantas.

INTRODUCTION

Carbon dioxide (CO_2) and oxygen (O_2) gases varied their concentrations throughout the age of the Earth resulting in drastic changes in the formation, extinction and organization of life on the planet (Bellefroid, et al., 2018; Ehleringher et al., 2005; Ehleringher et al., 1997; Farkuhar et al., 2011; Franck et al., 1999; Sage, 1995). Both CO_2 and O_2 have their concentrations altered as a function of the processes to which they are involved, being the main the assimilation of CO_2 and O_2 production in photosynthesis in plants and the loss of CO_2 through biochemical processes such as respiration in plants and animals besides the oxidation of organic substances through chemical processes such as fire. There is evidence that before the origin of the photosynthetic organisms, in a abiotic environment, chemical and physical processes triggered systems that caused changes in the concentrations of said gases (Negron-Mendoza & Ramos-Bernal, 2000; Schopf, 1983; Walker, 1990).

The process of carbon assimilation via photosynthesis involves two steps, a photochemistry and a biochemistry, both inside the chloroplasts. The photochemical stage occurs in the membranes of the thylakoids where the pigments involved in the capture of light are found and the biochemistry occurs in the stroma (Blankenship, 2014; Heldt & Pichulla, 2011) and keeping these processes in mind are necessary for the understanding of the present article.

In the photochemical stage the energy from photons of light captured by the pigments is transferred to the production of ATP and NADPH. In the biochemical stage, ATP and NADPH, coming from the photochemical stage, will enter the process of reducing CO_2, a molecule poor in energy from the atmosphere, generating molecules rich in energy, made up of many carbons. The bond between carbon atoms is driven by the energy of light, the greater the amount of carbon in the molecule the greater the amount of energy stored (Blankenship, 2014; Heldt & Piechulla, 2011; Taiz et al., 2014).

For each O_2 molecule produced in the photochemical stage of photosynthesis, from the water, a CO_2 molecule is assimilated into the chloroplast stroma at the biochemical stage (Graham & Chapman, 1979; Taiz et al., 2014).

Photorespiration, which occurs in C3 plants, in the organelles: chloroplast, peroxisomes and mitochondria, contributes to significant CO_2 loss, even under suitable environmental conditions for plant growth. For each molecule of CO_2 lost in photorespiration, three oxygen molecules are consumed (Farquhar & Caemmerer, 1982; Taiz et al., 2014, Tolbert, 1979). In C4 plants this loss is negligible due to its CO_2 concentrating mechanism, this mechanism allows C4 plants to survive in environments whose CO_2 concentration are lower than the minimum required by C3 plants (Hatch & Slack 1966; Sage, 2005).

The oxidation of the compounds rich in carbon and energy produced in photosynthesis occurs in the cytoplasm (glycolysis) and mitochondria (Krebs cycle or tricarboxylic acid cycle, and Oxidative phosphorylation), so without photosynthesis there would be no respiration. Respiration, in the mitochondria, occurs with loss of part of the CO_2 assimilated in the photosynthesis. Most of the assimilated CO_2 will make up the dry mass of the plants. In the same way as in photosynthesis, in respiration for each O_2 consumed a CO_2 is produced (Taiz et al., 2014).

In general balance, under normal ambient conditions (in particular light, water and CO_2 in the atmosphere), the daily amount of CO_2 assimilated in the photosynthesis minus the amount lost in respiration and photorespiration is positive, resulting in mass gain by plants that is organic mass found on the Earth's surface. This is because during the day the amount of CO_2 assimilated by photosynthesis is normally around 20 times the amount lost by respiration and photorespiration (Kerbauy 2008; Sikolia et al., 2009; Taiz et al., 2014), and the resulting net quantity is accumulated in the form of a reserve, usually starch, which is used in various metabolic routes of plants, even in the absence of photosynthesis as in the night.

In the biochemical stage of photosynthesis are formed several substances, but not enough to supply all the demands of plants, for this reason to respiration, which is the oxidation of substances produced in photosynthesis, is attributed to the function of producing the other substances (Heldt & Piechulla, 2011).

The result of the oxidation is the release of energy in the form of ATP, the NADH and FADH reducers and carbon skeletons that will serve as precursors in the synthesis of the other substances necessary to the plant. A small part of the oxidized substances is lost as CO_2 (Taiz et al., 2014).

When the amount of CO_2 assimilated in the photosynthesis is identical to the amount lost in respiration the plant does not gain or lose mass and this condition is known as the point of compensation, which may be by light or by CO_2 (Kerbauy, 2008).

Light compensation point is defined as the luminous intensity supplied to the plant in which the amount of CO_2 assimilated in the photosynthesis is identical to the amount lost in the respiration and CO_2 compensation point, is the amount of this gas available to plants in which the amount assimilated in the photosynthesis is identical to the lost in respiration (Kerbauy 2008; Sikolia et al., 2009, Taiz et al., 2014; Tolbert et al., 1995). Below the point of compensation, the plant loses mass and dies, and above, the plant gains mass and develops.

The objectives in this work were: a) to estimate the amount of CO_2 retained in the vegetable and animal organic matter produced, as a function of the photosynthetic reduction of the CO_2 concentration in the atmosphere b) estimate the amount of CO_2 released into the atmosphere from the burning of all plant and animal organic matter on the Earth's surface c) to question the biological origin of petroleum and suggest that its origin is not biological, but abiotic and d) to explain that, in some time in the past, the extinction of species of plants, and animals that fed on them, may have been due to the drastic reduction in the concentration of CO_2 in the atmosphere.

MATERIALS AND METHODS

The data presented in this article were estimated from mathematical models developed by Portes (2020). Firstly, was estimated the amount of organic matter produced from the amount of CO_2 present in the atmosphere, secondly, was estimate the amount of CO_2 produced from all organic matter of plant and animal origin on the Earth's surface.

1. The quantities of organic matter produced (*Qom* in $Mg.ha^{-1}$) as a function of the concentrations of CO_2 available in the atmosphere were estimated using the following model:

$$Qom\left(Mg/ha\right)=ppm\,CO_2\times Vatm\times 5.357142857\times 10^{-11}/C\%\times Earthsurf \quad (Eq.\ 1)$$

2. The quantities of CO_2 produced (ppm (CO_2)) as a function of the quantities of organic matter incinerated were estimated using this other model:

$$ppm\left(CO_2\right)=OM_{Mg/ha}\times C\%\times Earthsurf\times 1.8666666667\times 10^{10}\,\mu L\,of\,CO_2/Vatm\left(L\right)=\mu L/L \quad (Eq.\ 2)$$

3. The volume of the atmospheric layer that is assumed to contain CO_2 and which will receive the amount of CO_2 released by burning organic matter were estimated using this model:

$$Vatm=\left(4.1888\times h^3+80173.632\times h^2+511507772.17\times h\right)\times 10^{12}=Litres \quad (Eq.\ 3)$$

Where: *Qom* ($Mg.ha^{-1}$) amount of organic matter in $Mg.ha^{-1}$; *ppm* (CO_2) = amount of CO_2 in ppm; *Vatm* = volume of the atmospheric layer in liters; C% = proportion of carbon in dry matter by percentage. The proportion of 45% was considered according to Walker (1992). *Earthsurf* = surface of the Earth in ha where organic matter is presumed to exist; *h* = height of the atmospheric layer where CO_2 is presumed to exist. The models used in this work are detailed in Portes (2020).

It is more appropriate to express the organic matter in Mg per hectare of the Earth's surface, so the amount of organic matter produced from all the CO_2 contained in the atmosphere must be divided by the desired area or surface. In this case, it would be the surface of the Earth (*Earthsurf*) considering the aboveground and underground organic matter from vegetable and animal origin. This equation takes a proportion (X/100) of the emerged surface of the earth (*emergedsurf*) corresponding to approximately 1.48 10^8 km^2 or 1.48 10^{10} ha, plus a proportion (Y/100) of the submerged surface (*submergedsurf*) corresponding to 3.622 10^8 km^2 or 3.622 10^{10} ha. X corresponds to the percentage of the *emergedsurf* where it is possible to find organic matter and Y corresponds to the percentage of the surface with water bellow which organic matter can be found and is considered here as *submergedsurf*. In this way, the resulting equation becomes (Portes 2020):

$$Earthsurf=\frac{X}{100}\times emergedsurf+\frac{Y}{100}\times submergedsurf\ \left(Eq\,4\right)$$

In this paper X was considered equal 90% and Y equal 30%, then the *Earthsurf* calculated was equal 2.42 x 10^{10} ha.

In both cases (Eq. 1 and 2) it was considered that in the atmosphere the CO_2 is found up to a height of 30 km (*h* = 30 km). The profile of CO_2 concentration in the atmosphere is very controversial due to its variation depending on the latitude, time of the year, altitude (Foucher et al., 2011). In the present work, an average altitude (*h*) of 30 km from the surface of the Earth was considered as having a constant amount of 390 ppm of CO_2, based on the work of the aforementioned authors. The amount of CO_2 dissolved in water (rivers, lakes and seas) was not considered.

Accumulated organic dry matter (*Δom*) is the result of the difference between the amount of organic dry matter produced by the CO_2 taken as reference (*omREf*) and the organic dry matter produced by the CO_2 under consideration (*omC*).

$$\Delta om = omREf - omC$$

RESULTS

QUANTITY OF ORGANIC MATTER PRODUCED (*QOM*) AS A FUNCTION OF CO_2 CONSUMPTION OF THE ATMOSPHERE VIA PHOTOSYNTHETIC ASSIMILATION

Following the model (Eq. 1) and assuming the concentration of CO_2 in the atmosphere equal to 400 ppm (*omRef*), if fully assimilated via photosynthesis, it would result in 302.1 $Mg.ha^{-1}$ or 30.2 $kg.m^{-2}$ (*Δom*), of dry organic matter (Fig. 1). If the reduction was from 400 (*omRef*), to 50 ppm (*omC*), where the CO_2 compensation point occurs for most C3 plants, the amount of dry organic matter produced would be 264.4 $Mg.ha^{-1}$ or 26.4 kg m^{-2} (*Δom*). That is 350 ppm of CO_2 in the atmosphere if fully transformed into organic matter, it would produce 264.61 Mg ha^{-1}. For forests, higher values are found, considering an average for the different forest biomes (Chave et al., 2003). Considering pastures and agriculture as brachiaria grass, maize, soybean, the production of dry organic matter, usually does not exceed 50 $Mg.ha^{-1}$ or 5 $kg.m^{-2}$ for tropical conditions (Portes et al., 2000; Portes & Carvalho, 2009).

Assuming the concentration of CO_2 in the atmosphere equal to 1000 ppm, if fully assimilated via photosynthesis, it would be sufficient to produce 758.87 $Mg.ha^{-1}$ of organic matter or 75.88 $kg.m^{-2}$ (Fig. 2), a value very high even for forest areas, considering as average for the entire surface of the Earth where it is possible to find organic matter.

Following the model (Eq. 1) and hypothetically considering the CO_2 concentration in the atmosphere equal to 21% or 210000 ppm and taking into account that for each CO_2 assimilated via photosynthesis one O_2 is released, such concentration would be sufficient to produce 159,363.9 $Mg.ha^{-1}$ of OM or 15.936 $Mg.m^{-2}$ (Fig. 3), an extremely exaggerated and impossible value due to the absence or very low concentration of O_2, in an Era when there was no Earth life. This organic matter would form a large layer involving the Earth, which is unlikely, so what happened was the abiotic fixation of CO_2 possibly as petroleum, carbonated rocks, among others until reduced to a value favorable to life.

In the hypothesis that there was, in some way, a gradual reduction in CO_2 in the atmosphere from 210000 ppm to 1000 ppm, the resulting difference, assimilated photosynthetically would be enough to produce 158,605.04 $Mg.ha^{-1}$ of dry organic matter or 15.860 $Mg.m^{-2}$, an extremely high value.

ESTIMATED AMOUNT OF CO_2 PRODUCED AS A FUNCTION OF A CERTAIN AMOUNT OF INCINERATED ORGANIC MATTER

This model (Eq. 2), deduced from the previous one (Eq. 1), was developed to facilitate estimating the amount of CO_2 produced as a function of the amount of organic matter incinerated:

$$ppm(CO_2) = OM_{Mg/ha} \times C\% \times Earthsurf \times 1.8666666667 \times 10^{10} \mu L\, of\, CO_2 / Vatm(L) = \mu L/L$$

By this model, assuming that the Earth currently has an average of 100 $Mg.ha^{-1}$ of vegetal and animal organic matter, a very high value compared to that reported by Abelson (1978), incinerated would result in 129.13 ppm

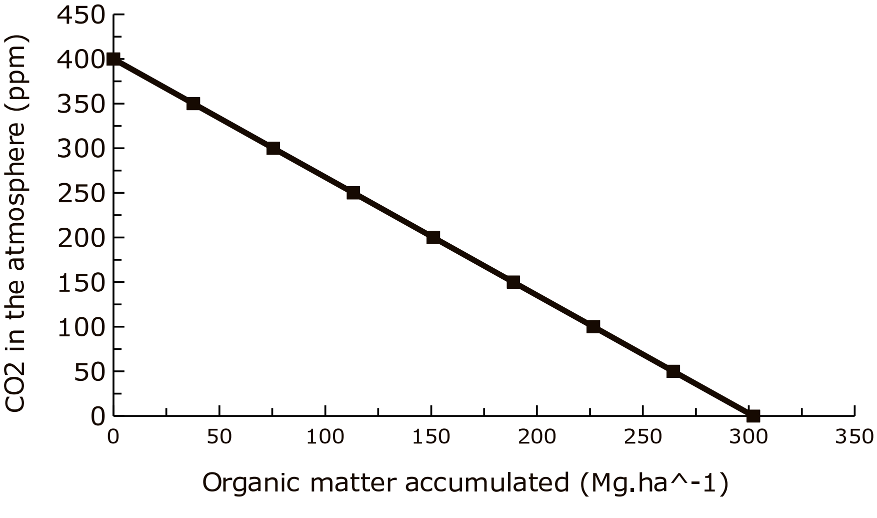


Fig. 1. Reduction of the concentration of CO_2 in the atmosphere in function of the quantity of organic matter produced. Considering the initial concentration of CO_2 equal to 400 ppm

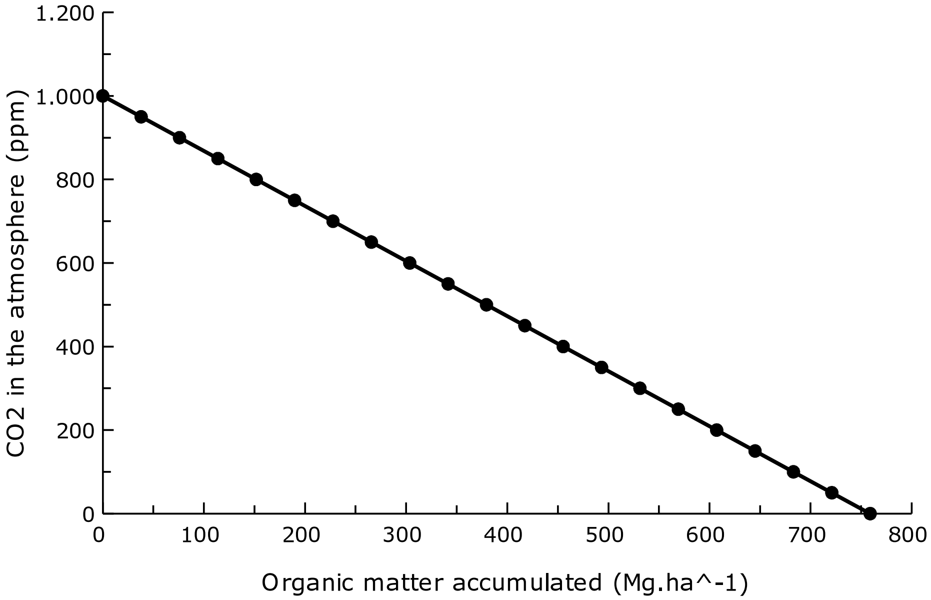


Fig. 2. Reduction of the CO_2 concentration in the atmosphere in function of the quantity of organic matter produced. Considering the initial concentration of CO_2 equal to 1000 ppm.

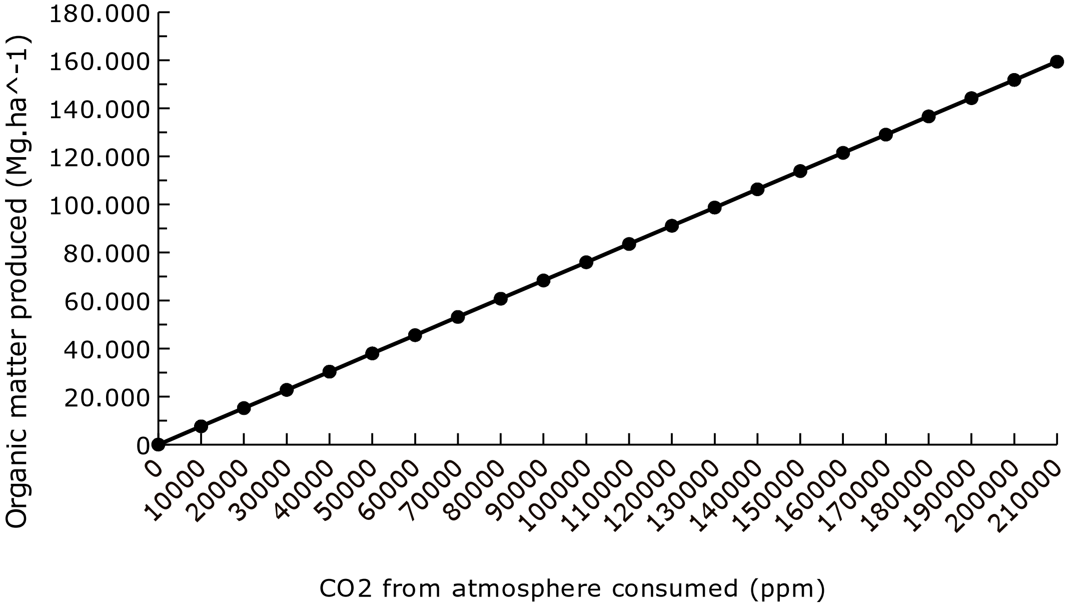


Fig. 3. Amount of organic matter produced ($Mg.ha^{-1}$) as a function of the concentration of CO_2 available in the atmosphere (ppm), according to the model developed.

of CO_2 (Fig. 4). By incinerating 300 $Mg.ha^{-1}$, a highly exaggerated value would result in 387.38 ppm. But, imagining that this value was real, added to the 390 ppm, currently existing in the Earth's atmosphere, would result in approximately 777 ppm of the gas, thus not even reaching 1000 ppm.

The lower the amount of CO_2 in the atmosphere the greater the amount of organic matter available and vice versa. That is, the amount of organic matter in the Earth is inversely proportional to the amount of CO_2 available in the atmosphere.

Assuming an amount of organic matter in the Earth equal to 1000 $Mg.ha^{-1}$, an absurdly high value, if fully incinerated would result in 1320 ppm CO_2, a relatively small value considering that the gas concentration at the earliest stages of the Earth was extremely high (Fig. 5).

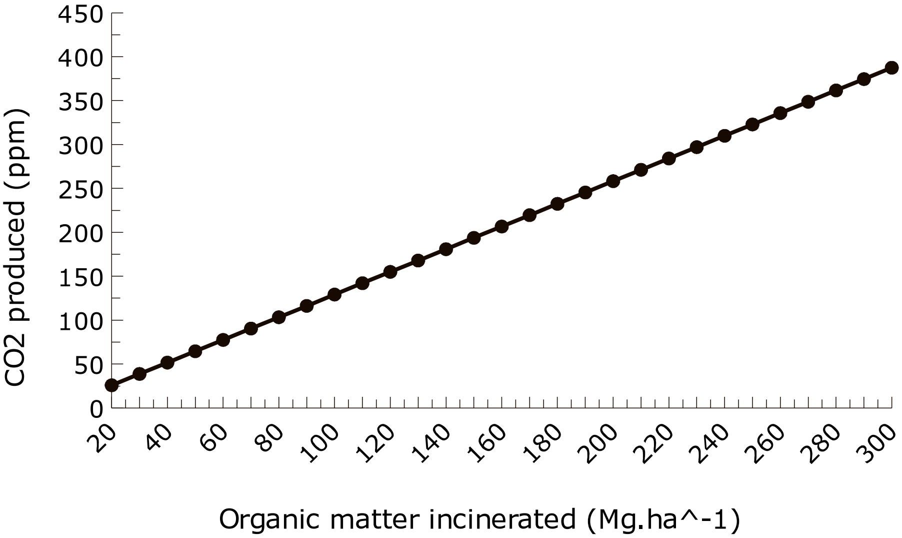


Fig. 4. Quantity of CO_2 produced (ppm) as a function of the amount of organic matter incinerated ($Mg.ha^{-1}$), hypothetically considering 300 $Mg.ha^{-1}$ the maximum amount of vegetal and animal organic matter found in the Earth and incinerated. The amount of CO_2 present in the atmosphere has not been added.

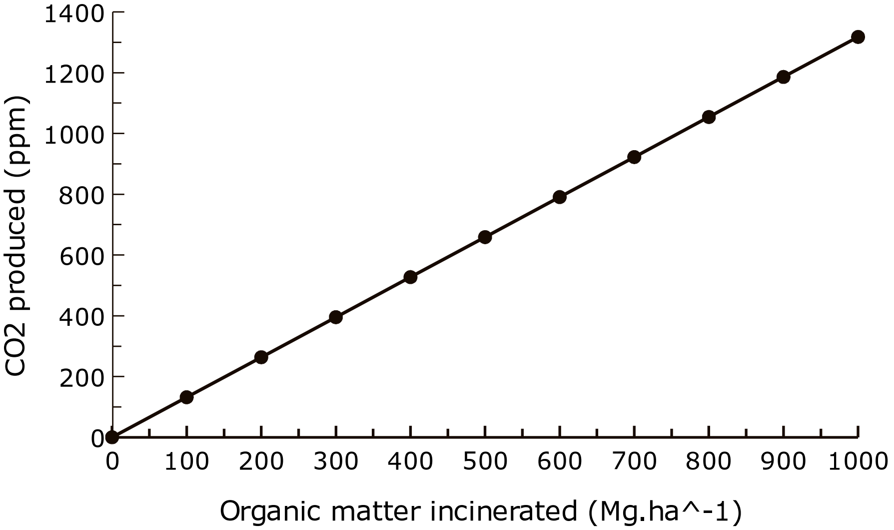


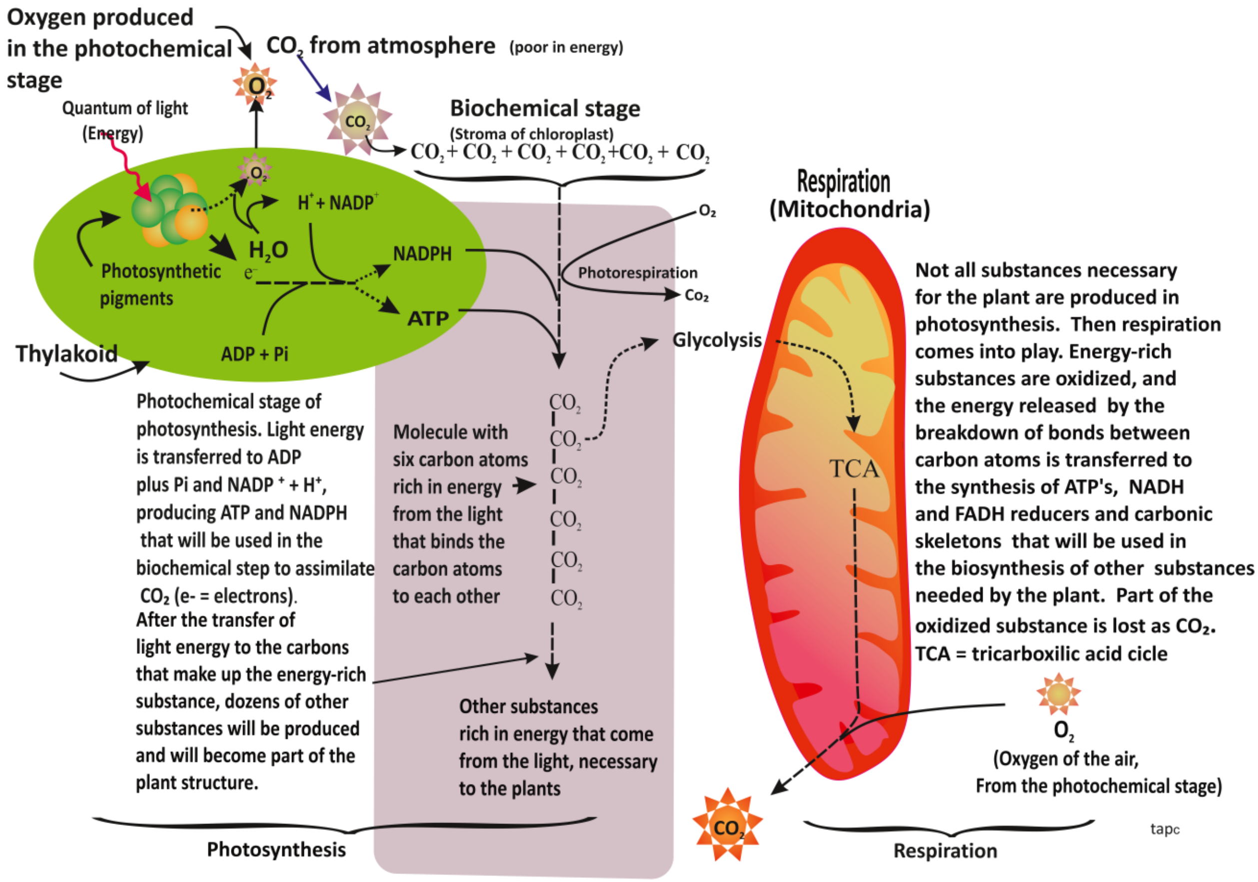
Fig. 5. Quantity of CO_2 produced (ppm) as a function of the amount of organic matter incinerated ($Mg.ha^{-1}$), considering 1000 $Mg.ha^{-1}$ the maximum amount of vegetal and animal organic matter incinerated.

Discussion

In this work we will consider some peculiarities related to carbon and phosphorus, very important elements in photosynthesis and respiration (Fig. 6), after all, in the whole metabolism of plants and animals.

In photosynthesis carbon receives energy from light resulting in large energy-rich molecules, and these molecules are transported within the plant itself and to other organisms leading to energy, and therefore the element can be recognized as the energy transporter. The transfer of energy in the biochemical reactions, resulting in the various substances produced in plants and animals, are carried out with the interference of ATP. Therefore, energy exchanges occur due to the action of the phosphorus element on the ATP molecule (Taiz et al., 2014).

In this situation, carbon is the assignment to transport energy and phosphorus, present in the ATP, to transfer the energy between the various processes involving energy exchanges in living beings. This can then be recognized as an energy transfer. The transfer of energy, in turn,



Photochemical stage of photosynthesis. Light energy is transferred to ADP plus Pi and $NADP^+ + H^+$, producing ATP and NADPH that will be used in the biochemical step to assimilate CO_2 (e- = electrons). After the transfer of light energy to the carbons that make up the energy-rich substance, dozens of other substances will be produced and will become part of the plant structure.

Molecule with six carbon atoms rich in energy from the light that binds the carbon atoms to each other

Other substances rich in energy that come from the light, necessary to the plants

Not all substances necessary for the plant are produced in photosynthesis. Then respiration comes into play. Energy-rich substances are oxidized, and the energy released by the breakdown of bonds between carbon atoms is transferred to the synthesis of ATP's, NADH and FADH reducers and carbonic skeletons that will be used in the biosynthesis of other substances needed by the plant. Part of the oxidized substance is lost as CO_2. TCA = tricarboxilic acid cicle

Fig. 6. Summary of the integration of photosynthetic and respiratory processes. Photosynthesis is divided in the photochemical stages, where ATP production, NADPH, and O_2 release in the chloroplast thylakoids occurs and in the biochemical stage where CO_2 assimilation occurs in the chloroplast stroma. Respiratory oxidation of substrates, produced in photosynthesis, for the release of energy in the form of ATP production of the NADH and FADH reducers and of carbon skeleton initiators or precursors of biochemical reactions occurs in the mitochondria. In photorespiration O_2 competes with CO_2 for the active site of RuBisCO enzyme, resulting in loss of Carbon (Based on Taiz et al. 2014).

occurs because oxygen enters as an oxidizing agent.

Based on these inferences, it can be considered that biochemistry, the chemistry of life, is between photosynthesis and respiration or between carbon and oxygen. And, the biochemistry could be considered as the set of metabolic reactions involving biosynthesis and degradation of substances, starting in the reaction of photosynthesis in the chloroplasts of the plants and ending in the reaction of respiration in the mitochondria of plants and animals.

The definition is not general because some microorganisms, such as chemosynthetizers, are independent of light to generate their own energy and those that use other oxidants than O_2 (Taiz et al., 2014).

Considering that in plants for each assimilated CO_2 an O_2 is released via photosynthesis (Fig. 6), if this relation is hypothetically extrapolated to the whole age or existence of the earth, it would result in a relation similar to that shown in the Fig. 7.

For example, if the CO_2 concentration increases to 210,000 ppm or 21%, that of O_2 should be reduced to around 0%. However, 210,000 ppm of CO_2 if assimilated via photosynthesis, assuming that plants are the only way of producing organic matter in the Earth would result in 159,363.9 $Mg.ha^{-1}$ or 15.936 $Mg.m^{-2}$ of organic matter. An extremely high value, impossible to occur.

These considerations and in light of the results presented using the models suggest that photosynthesis started on the Earth when the CO_2 concentration had already drastically reduced. In the hypothesis that the concentration of the gas is around 1000 ppm (Fig. 7), in this concentration, if all the CO_2 were assimilated via photosynthesis, the average amount of organic matter would be 50 $kg.m^{-2}$, a very high value even for a planet richly covered by forests (Saatchia et al., 2011).

In the hypothesis that plants were res-

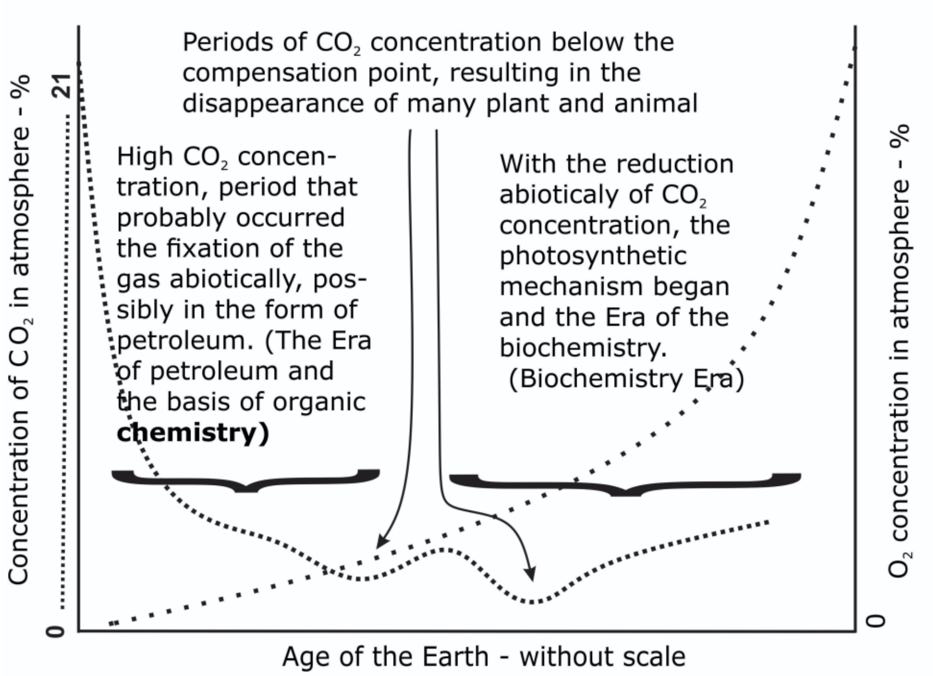


Fig. 7. Hypothetical evolution of CO_2 and O_2 concentrations over the ages of the Earth taking as evidence the ratio of 1:1 between the amount of CO_2 assimilated and O_2 produced in the photosynthesis.

ponsible for reducing the CO_2 concentration from 210,000 ppm to 400 ppm (210,000 minus 400 ppm = 209600 ($\Delta om = omREf - omC$), (Fig. 3), would result, according to the model presented, in approximately 159,060.4 Mg.ha^{-1} or 15.906 Mg.m^{-2} of organic matter an extremely high value, impossible to occur. The results suggest that this CO_2 was somehow reduced by the formation of limestone, petroleum, and other possible forms, until the concentration reached a value favorable to life.

Currently (2018) the CO_2 concentration in the atmosphere is 0.039% or 390 ppmV (part per million by volume), an extremely low value compared to 20.8% of O_2, whereas in photosynthesis for each assimilated CO_2 an oxygen is released, it is deduced that almost all the CO_2 existing in the terrestrial globe is fixed in the diverse organic substances that form the organic fraction of the Earth. If the hypothesis is true, it can be estimated that if the whole organic mass found in the Earth is burned, the concentration of this gas in the atmosphere should reach approximately 20.8% and that of O_2 should drop to 0.039%, that is , there would be a reversal in the concentration of the two gases.

On the hypothesis that life on earth originated when the CO_2 concentration was already below 1000 ppm, burning all organic matter of plant and animal origin should result in a maximum CO_2 concentration of 1000 ppm and the rest would be from other sources in particular petroleum and coal.

While there is evidence that petroleum has a fossil origin, there are still doubts. Based on the models developed and the estimates made, in this work, it is probable that the petroleum was synthesized before the organic matter produced from photosynthesis, or biomass (Fig. 7). That is, petroleum did not originate from photosynthesis it would not be of fossil origin. It is then possible to separate the synthesis of petroleum from the synthesis of vegetable organic matter in two Ages, the petroleum Age (abiotic process), from which had the development of organic chemistry and the Age of biomass (biotic process), from which it had the development of biochemistry.

The synthesis of petroleum probably depended only on the environment of that period, such as high concentration of CO_2, Hydrogen, high temperature, pressure, chemical elements catalysts, among other conditions. In the formation of the petroleum some mechanism triggered the union of the atoms of the carbon resulting molecules with many carbons and rich in energy, as in the photosynthesis. It is assumed that the referred mechanism involved in the formation of petroleum, unlike photosynthesis, was not dependent on sunlight but energy from the Earth itself (Fig. 7 and 8).

The amount of organic matter of plant origin on the Earth should be much higher than it actually is if the CO_2 of 210000 ppm reduced to 390 ppm, the present value, the difference being assimilated photosynthetically.

Life on Earth is assumed to have started in the Proterozoic Eon with the appearance of

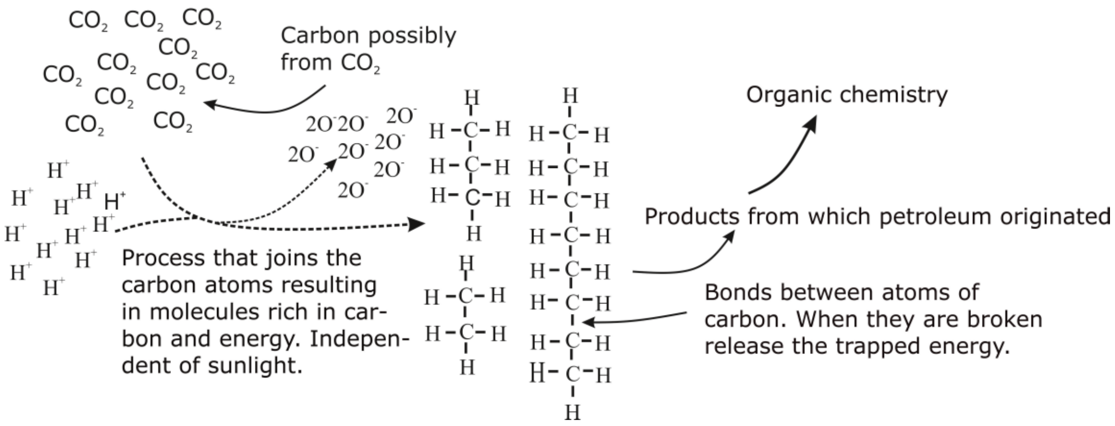


Fig. 8. Hypothesis that gives an idea about the synthesis of petroleum (an abiotic type of CO_2 fixation) that must have occurred before the origin of life on Earth, under appropriate conditions of temperature, pressure and probably in the presence of catalysts.

the first photosynthetic life forms (Ehleringher et al., 2005). At this age the CO_2 concentration should already be relatively low and O_2 relatively high, suitable for vegetable metabolism, especially when considering the ratio of 1:1 between CO_2 assimilated in the biochemical stage of photosynthesis and O_2 released in the photochemical stage.

As the CO_2 concentration was presumably too high prior to the Proterozoic (Ehleringher et al., 2005) to reduce to 1000 ppm, a reasonable value for life, there would be an accumulation of organic matter of about 15,8 $Mg.m^{-2}$ (Fig 3), extremely high value. One hypothesis to try to explain the situation is that large quantities of the gas were fixed abiotically. On the other hand, the literature presents proposals of biogeochemical transformations to explain the removal of organic matter from the active carbon cycle forming carbonates that are ultimately transported to the continental plateau being subtracted from the surface layer of the earth (Ehlerinher et al., 2005). However, in an environment of active vegetal mass production the concentration of O_2 was already high and it is presumed that with rich organic matter and abundant oxygen the oxidation of the organic matter was intense, compromising its accumulation.

Following the model (Eq. 1) and considering the concentration of CO_2 in the atmosphere equal to 400 ppm, when reducing by photosynthesis to 50 ppm, the CO_2 compensation point of most C3 species, the difference would result in 264.4 $Mg.ha^{-1}$ or 26,4 $kg.ha^{-1}$ of organic matter (Fig. 2), which is a high value for annual plants, but acceptable for forests, dominated by perennial plants, C3 (Chave et al., 2003; Saatchia et al., 2011).

The compensation point for CO_2 is the concentration of this gas in the atmosphere below which plants lose more CO_2 via respiration and photorespiration than assimilates via photosynthesis (Tolbert et al., 1995), this causes the plants to lose mass until their death. On the other hand, C4 plants would not suffer from CO_2 shortages, since the compensation point of these plants is around 5 - 10 ppm, much lower than those of C3 (40 – 60 ppm) (Sikolia et al., 2009).

The C4 plants appeared after C3, possibly as an alternative to the CO_2 shortage in the atmosphere, at a time when, presumably, this gas had its concentration reduced to values below 50 ppm (Fig. 7), because the C4 plants can use this gas even at very low concentrations, due to its CO_2 concentrating mechanism, a mechanism absent in C3 plants (Ehleringher et al., 2005; Ehleringer et al., 1997, Ehleringer et al., 1991; Gowik & Westhoff, 2011; Osborne & Beerling, 2006, Sage, 2004, Sage et al., 1999).

If the Earth were to remain untouched for a few million years without human activity, as it is now, this reduction would probably result in the disappearance of many species of plants C3, whose point of compensation is around 40-60 ppm (Sikolia et al., 2009).

The photosynthetic reduction of CO_2 below 50 ppm, prior to the onset of C4 plants, may have led to the disappearance of many plant species whose CO_2 compensation point was around this value (50 ppm), consequently resulting in the extinction of animals that fed on these plants (Bambach, 2006). This period must have occurred between the Paleozoic and Mesozoic Ages in which the extinction of many groups of animals and plants occurred. With the appearance of C4 plants, which have a CO_2 compensation point in the range of 5 to 10 ppm, a possible drastic reduction of CO_2 concentration in the atmosphere could compromise the existence of C3 plants, but not C4 plants due to their CO_2 mechanism concentrator unless the gas concentration reduced below 10 ppm in the atmosphere.

One of the major concerns of recent times is the increase in the temperature of the climate, which is attributed especially to greenhouse gases, in particular to the increase in the atmospheric concentration of CO_2 (Ruzmaikin & Byalko 2015, Salati & Nobre 1991, Shukla et al., 1990). The contribution of this gas to heating is indisputable because it has the property of absorbing infrared rays (Cox et al., 2000; IPCC 2007; Ruzmaikin & Byalko, 2015), but there is another source, perhaps more important, that is the amount of heat released by the biochemical and chemical decomposition of the organic mass of the Earth's surface.

The proportion of guilt attributed to CO_2 over climate change should be much less than the little discussed release of heat by the organic mass decomposed via natural (biochemical) or artificial (chemical and even physical) processes, which must be somewhat exaggeratedly high, sufficient to generate large heat waves at the Earth's surface (Howe et al., 2013). Imagine all the processes that liberate thermal energy working simultaneously on Earth, seen as an isolated system in the Universe, possibly the increase of the temperature of the terrestrial climate would be immediate, on the contrary, if all processes are stopped simultaneously, possibly the temperature will reduce immediately. This hypothesis must be considered by the climate experts and studied through mathematical simulations, being able to test the models in controlled environments and to reach interesting results.

By the models developed and tested in this work, the hypothetical relations between CO_2 concentration vs organic matter produced and organic matter *vs* CO_2 produced is always linear. In fact, this relationship did not occur throughout the age of the Earth because of the great climatic variations that the Earth went through, but nevertheless it illustrates what could have happened along the existence of the Earth, giving an idea of the relations between the concentrations of CO_2 and of O_2 and the formation of organic matter.

In order to facilitate the study of the relationships between CO_2 and total organic matter in the Earth, the term organosphere is proposed in this paper. It can be defined as the layer or profile of the Earth that contains organic matter of biotic and abiotic origin. This layer would be a cover involving the terrestrial globe with variable depth (thickness) as a function of the presence of vegetal, animal, charcoal and petroleum organic matter. In terms of volume would be a small fraction in relation to the total volume of the globe.

Forests, as component of the Earth's vegetation, my not be as important as carbon accumulator (Portes 2020), but they are essential in the formation of rains and maintenance of moisture, especially in areas far from the oceans and seas (Bright et al., 2017; Makarieva & Gorshkov 2007; Portes, 2020; Sheil & Murdiyarso, 2009).

In this work, it may not have been found exact values of what was proposed to find, but the ideas and results presented could help other researchers and groups of researchers, through the use of sophisticated instruments and human resources involved in the subject, to obtain results much more accurate, increasing knowledge about the carbon fluxes in the Earth.

REFERENCES

Abelson, P. H. 1978. Organic matter in the earth's crust. Ann. Rev. Earth Planet. Sci. 6: 325-51.

Bambach, R. K. 2006. Phanerozoic Biodiversity Mass Extinctions, Annu. Rev. Earth Planet. Sci. 34: 127 – 155.

Bellefroid, E. J., A. V. S. Hood, P. F. Hoffman, M. F. Thomas, C. T. Reinhard & N. J. Planavsky. 2018. Constraints on Paleoproterozoic atmospheric oxygen levels. PNAS, 115: 8104-8109. DOI: www.pna.org/cgi/doi/10.1073/pnas.1806216115

Blankenship, R. E. 2014. Molecular mechanisms of photosynthesis. 2. ed. Oxford, Wiley Blackwell.

Bright, R. M., E. Davin, T. O'Halloran, J. Pongratz, K. Zhao & A. Cescatti. 2017. Local temperature response to land cover and management change driven by nonradiative processes. Nat. Clim. Change. 7: 296–302. DOI:10.1038/nclimate3250

Chave, J., R. Condit, S. Lao, J. P. Caspersen, R. B. Foster & S. P. Hubbell. 2003. Spatial and temporal variation of biomass in a tropical forest: result from a large census plot in Panama. J. Ecology. 91: 240-252.

Cox P. M., R. A. Betts, C. D. Jones, S. A. Spall & I. J. Totterdell. 2000. Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model. Nature. 408: 184-187. DOI: https://doi.org/10.1038/35041539

Ehleringer, J. R., R. F. Sage, L. B. Flanagan & R. W. Pearcy. 1991. Climate change and the evolution of C4 Photosynthesis. Trends Ecol. Evol. 6: 95-99. DOI: https://doi.org/10.1016/0169-5347(91)90183-X

Ehleringher, J. R., T. C. Cerling & M. D. Dearing. 2005. A history of atmospheric CO_2 and its effects on plant, animals, and ecosystems. Ecological Studies. v. 177. New York, Springer.

Ehleringher, J. R., T. C. Cerling & B. R. Helliker. 1997. C4 photosynthesis, atmospheric CO_2, and climate. Oecologia. 112: 285-299.

Farquhar, J., A. L. Zerkle & A. Bekker. 2011. Geological constraints on the origin of oxygenic photosynthesis. Photosyn. Res. 107: 11–36.

Farquhar, G. D. & S. Von Caemmerer. 1982. Modelling of photosynthetic response to environmental conditions, pp. 549–588. In: Lange, O. L, P.S. Nobel, C. B. Osmond & H. Ziegler (Eds.). Physiological plant ecology II. Water relations and carbon assimilation, Encyclopedia of Plant Physiology. v. 12B. Berlin/Heidelberg/New York, Springer.

Foucher, P. Y., A. Chédin, R. Armante, C. Boone, C. Crevoisier & P. Bernath. 2011. Carbon dioxide atmospheric vertical profiles retrieved from space observation using ACE-FTS solar occultation instrument. Atmos. Chem. Phys. 11: 255-2470. DOI: https://doi.org/10.5194/acp-11-2455-2011.

Franck, S., K. Kossacki & C. Bounama. 1999. Modelling the global carbon cycle for the past and future evolution of the earth system. Chem. Geol. 159: 305–317.

Graham, D. & E. A. Chapman. 1979. Interactions between photosynthesis and respiration in higher plants. pp. 150-160. In: Pirson, A. & M. H. Zimmerman (Eds). Photosynthesis II. Photosynthetic carbon metabolism and related process. Berlin, Springer-Velag.

Gowik, U. & P. Westhoff. 2011.The path from C3 to C4 photosynthesys. Plant Physiol. 155: 56-63.

Hatch, M. D. & C. R. Slack. 1966.Photosynthesis by sugarcane leaves. A new carboxilation reaction and the pathway of sugar formation. Biochem. J. 101: 103-111.

Heldt, H. W. & B. Piechulla. 2011. Plant Biochemistry. 4 ed. London, Elsevier.

Howe, P. D., E. M. Markowitz, T. M. Lee, C. Y. Ko, & A. Leiserowitz. 2013. Global perceptions of local temperature change. Nat. Clim. Change. 3: 352–356.

IPCC. 2007. Intergovernmental Panel on Climate Change Fourth Assessment Report: Climate Change 2007. Synthesis Report. World Meteorological Organization, Geneva.

Kerbauy, G. B. 2008. Fisiologia Vegetal. 2 ed. Rio de Janeiro, Editora Guanabara-Koogan S. A.

Makarieva, A. M. & V. G. Gorshkov. 2007. Biotic pump of atmospheric moisture as driver of the hydrological cycle on land. Hydrol. Earth Syst.Sci. 11: 1013-1033.

Negron-Mendoza A. & S. Ramos-Bernal. 2000. Chemical Evolution in the Early Earth. pp. 71-84. In: Chela-Flores J., G. A. Lemarchand & J. Oró (Eds). Astrobiology. Dordrecht, Springer. DOI: https://doi.org/10.1007/978-94-011-4313-4_6

Osborne, C. P. & D. J. Beerling. 2006. Nature´s green revolution: the remarkable evolutionary rise of C4 plants. Phil. Trans. R. Soc. B. 361: 173-194. DOI: https://doi.org/10.1098/rstb.2005.1737

Portes T. A., S. I. C. Carvalho, I. P. Oliveira & J. Kluthcouski. 2000. Análise de crescimento de uma cultivar de braquiária em cultivo solteiro e consorciado com cereais. Pesq. Agropec. Brasil. 35: 1349-1358.

Portes, T. A. & S. I. C. Carvalho. 2009. Crescimento e alocação de fitomassa de cinco gramíneas forrageiras em condições de Cerrado. Rev. Bio. Neotrop. 6: 01-14.

Portes, T. A. 2020. Earth CO_2 dynamics: from CO_2 to organic matter and back CO_2, a flow estimate. Rev. Biol. Neotrop. 17: 47-55. DOI: https://doi.org/10.5216/rbn.v17i1.59419

Ruzmaikin, A. & A. Byalko. 2015. On the relationship between atmospheric carbon dioxide and global temperature. Am. J. Clim. Change. 4: 181-186. DOI: http://dx.doi.org/10.4236/ajcc.2015.43014

Saatchia, S. S., N. L. Harris, S. Brown, M. Lefskyd, E. T. A. Mitchard, W. Salas, B. R. Zutta, W. Buermann, S. L. Lewis, S. Hagen, S. Petrova, L. White, M. Silman & A. Morel. 2011. Benchmark map of forest carbon stocks in tropical regions across three continents. PNAS. 108: 9899–9904. DOI: www.pnas.org/cgi/doi/10.1073/pnas.1019576108

Sage, R. F. 1995. Was low atmospheric CO_2 during the Pleistocene a limiting factor for the origin of agriculture? Global Change Biol. 1: 93-106. DOI: https://doi.org/10.1111/j.1365-2486.1995.tb00009.x

Sage, R. F. 1999. Why C4 photosynthesis. pp. 3-16. In: Sage R. & R. K. Monson (Eds.). C4 plant biology. San Diego, Academic Press.

Sage, R. F. 2004 The evolution of C4 photosynthesis. New Phytol. 161: 341-370.

Sage, R. F. 2005. Atmospheric CO_2, Environmental Stress, and the Evolution of C4 Photosynthesis. pp. 185-213. In: Ehleringer, J. R., T. Cerling & M. D. Dearing (Eds.). A history of atmospheric CO_2 and its effects on plants, animals, and ecosystems. New York, Springer.

Salati, E. & C. A. Nobre. 1991. Possible climatic impacts of tropical deforestation. Clim. Change. 19: 177-196.

Sheil, D. & D. Murdiyarso. 2009. How forests attract rain: an examination of a new hypothesis. BioScience. 59: 341–347. DOI: https://doi.org/10.1525/bio.2009.59.4.12

Shukla J., C. Nobre & P. Sellers. 1990. Amazon deforestation and climate change. Science. 247: 1322-1325. DOI: 10.1126/science.247.4948.1322

Sikolia, S., E. Beck, & J. C. Onyango. 2009. Carbon dioxide compensation points of some dicots of the Centrospermeae species and their ecological implications for agroforestry. Int. J. Botany. 5: 67-75.

Schopf, J. W. 1983. Earth's earliest biosphere: Iis origin and evolution. Princeton, University Press.

Taiz, L; E. Zeiger, I. M Møller, & A. Murphy. 2014. Plant physiology and development. 6 ed. Sunderland, Sinauer Associates/ Oxford University Press.

Tolbert, N. E. 1979. Glycolate metabolism by higher plants and algae. pp. 338-351. In: Gibbs, M. & E. Latzko (Eds). Photosynthesis II: Photosynthetic carbon metabolism and related processes (Encyclopedia of Plant Physiology New Ser.6). Berlin, Springer-Verlag.

Tolbert, N.E., C. Benker & E. Beck. 1995. The oxygen and carbon dioxide compensation points of C3 plants: possible role in regulation atmospheric oxygen. Proc. Natl Acad. Sci. 92: 11230-11233.

Walker, D. A. 1992. Energy, plants and Man. Brighton, East Sussex, Oxygraphics Limited.

Walker, J. C. G. 1990. Precambrian evolution of the climate system. Palaeogeogr., Palaeoclimatol., Paiaeoecol. Global Planet. Change. 2: 261-289. DOI: https://doi.org/10.1016/0921-8181(90)90005-W

Received on 30.XII.19
Accepted on 14.VI.20