EARTH CO_2 DYNAMICS: FROM CO_2 TO ORGANIC MATTER AND ORGANIC MATTER BACK TO CO_2 – AN ESTIMATE OF FLUXES

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Abstract: The Earth CO_2 is constantly changing. During photosynthesis CO_2 is assimilated and immobilized in the form of organic matter. In the other way around, under the action of chemical and biochemical processes, the CO_2 of the organic matter is released again into the atmosphere. The current concentration of CO_2 in the atmosphere is about 390 ppm. Based on information from the literature, it is possible to estimate the amount of organic matter produced from the CO_2 available in the atmosphere. On the other hand, by incinerating all the plant and animal organic matter on the Earth, it is possible to estimate the amount of CO_2 produced and released to the atmosphere. In order to test these hypotheses, mathematical models were developed. By the models it is possible to estimate that if all CO_2 in the atmosphere is assimilated via photosynthesis, it would produce 296 $Mg.ha^{-1}$ of organic matter. On the other hand, by incinerating all vegetable and animal organic matter from the Earth, excluding petroleum, coal and other carbon sources, and considering an average value of 100 $Mg.ha^{-1}$ the CO_2 concentration in the atmosphere would increase by 131.8 ppm. This value added to the existing 390 ppm would raise CO_2 concentration to 521.8 ppm. According to the models and results presented, forests may not be as important as carbon accumulators, making the environment conducive to life on Earth, but according to literature they are essential in the formation of rainfalls and maintenance of humidity, especially in areas far from the oceans and seas.

Keywords: CO_2 concentration, earth's atmosphere, greenhouse gas, volume of atmosphere layer.

DINÂMICA DO CO_2: DO CO_2 PARA MATÉRIA ORGÂNICA E DA MATÉRIA ORGÂNICA PARA CO_2 - ESTIMATIVAS DOS FLUXOS

Resumo: O CO_2 da Terra está em constante transformação. Durante a fotossíntese é assimilado e imobilizado na forma de matéria orgânica. Ao contrário, sob a ação de processos químicos e bioquímicos, o CO_2 da matéria orgânica é liberado novamente na atmosfera. A concentração atual de CO_2 na atmosfera é de cerca de 390 ppm. Tomando por base informações da literatura é possível estimar a quantidade de matéria orgânica produzida a partir do CO_2 disponível na atmosfera. Por outro lado, incinerando toda a matéria orgânica vegetal e animal na Terra, é possível estimar a quantidade de CO_2 produzida e liberada para a atmosfera. Para testar estas hipóteses, modelos matemáticos foram desenvolvidos. Pelos modelos é possível estimar que se todo o CO_2 na atmosfera fosse assimilado via fotossíntese, produziria 296 $Mg.ha^{-1}$ de matéria orgânica. Por outro lado, incinerando toda a matéria orgânica vegetal e animal da Terra, excluindo petróleo, carvão e outras fontes de carbono, e considerando um valor médio de 100 $Mg.ha^{-1}$, a concentração de CO_2 na atmosfera aumentaria em 131,8 ppm. Este valor adicionado aos 390 ppm existentes aumentaria a concentração de CO_2 para 521,8 ppm. De acordo com os modelos e resultados apresentados, as florestas podem não ser tão importantes como acumuladoras de carbono, tornando o ambiente propício à vida na Terra, mas de acordo com a literatura são essenciais na formação de chuvas e manutenção da umidade, especialmente em áreas distantes dos oceanos e mares.

Palavras-chave: Concentração de CO_2, atmosfera terrestre, gás de efeito estufa, volume da camada atmosférica.

Introduction

The Earth is constituted by a mineral and an organic fraction. The living and dead organic fraction of plant, animal and microorganism origins is present in the Earth's crust, which consists of substances containing the essential mineral nutrients – including the carbon as its main component (Marschner, 1995). The carbon present in the organic fraction is attached to each other forming long carbon chains (Brady & Weil, 2010; Conant, 2011; Kirschbaun, 1995; Portes & Melo, 2014; Taiz et al., 2014).

The bonding between the carbon atoms results of a reaction that consumes energy, which comes from the sunlight via photosynthesis. From photosynthesis it is assumed that is formed practically all the vegetable and animal organic matter found on the surface of the earth, with indications that it is also responsible for the formation of fossil fuels (Walters, 2017).

The atmospheric concentrations of the CO_2 (a greenhouse gas) have increased since 1750 due to human activity, such as the burning of fossil fuels and deforestation. In 2011, it corresponded to 391 ppm and exceeded the pre-industrial levels by about 40%, which substantially exceed the highest concentrations recorded in ice cores during the past 800,000 years (IPCC, 2013). The aforementioned human activity has resulted in global warming and climate change, which can cause serious instability to the environment and humankind (Cox et al., 2000; IPCC, 2014; IPCC, 2013).

Several techniques have been applied to estimate CO_2 gas concentrations, both for the distant past and for the future. Although the results may seem interesting, it is noticed that there is still a great gap to be filled (Caillon, et al., 2003; Cox et al., 2000; Davis, 2017; Ruzmaikin & Byalko, 2015). The proposal presented in this paper may contribute to a better understanding of gas concentrations throughout the existence of the Earth.

This paper proposes mathematical models to estimate the dynamics of CO_2 on the Earth, which can contribute to the study of this gas in the environment.

The objectives on this work are to estimate, through a mathematical models a) the amount of dry matter produced from the CO_2 present in the atmosphere, and b) the concentration of CO_2 in the atmosphere if all the organic, vegetal and animal mass in the biosphere were incinerated.

Material and methods

Calculating the amount of organic matter (*OM*) produced from a given amount of CO_2 found in an environment

To simulate the volume of the atmospheric layer and develop the first model, a cube of known volume (*Vc*) equal to 1000 m^3 or 1000000 L was used.

Assuming that the CO_2 concentration inside the cube is equal to 380 ppm (0.0380%), it is possible to calculate the amount of organic matter produced from this CO_2 using the following equation:

$$Qom = \left(ppm\,CO_2 \times Vc \times 10^{-6} \times 44/22.4 \times 12/44 \times \left(100/C\,\%\right)\right) = gOM$$

The result is in grams of organic matter as a function of the amount of CO_2 in the cube. Being:

Qom = amount of dry mass in grams.

ppmCO₂ = amount of CO_2 in µL of CO_2/L of air from which *Qom* will result.

10^{-6} = transform microlitre to Litre of CO_2.

44/22,4 = transform volume of CO_2 into mass of CO_2. One mole of CO_2, 44 g, occupies a space of 22.4 L (at NTP, zero degree and 1 atm).

12/44 = transform mass of CO_2 into mass of carbon. One mol of CO_2, 44 g, has 12 g of carbon.

Vc = volume of the cube by which $ppmCO_2$ must be multiplied:

(100/C%) = proportion of carbon within the total organic dry matter of the plants.

The amount of carbon in the organic matter is variable but can be considered as around 45% (Walker, 1992), the rest are other nutrients (Marschner, 1995). To facilitate calculation, the proportion of 45% carbon in organic matter was considered for both plants and animals.

The previous equation can be simplified. The product *44/22,4 x 12/44 = 0.5357142857* and *100/C% = 10^2/C%*. The product *$10^{-6}*10^2 = 10^{-4}$* and the final equation is:

$$Qom = \left(ppm\,CO_2 \times Vc \times 5.357142857\,x\,10^{-5}\right)/C\,\% = gOM\ (Eq\,1)$$

The result obtained is in grams of organic matter produced from the CO_2 contained in the 1000000 L cube.

General model for determining the quantity of organic matter (*Qom*) in Megagram (Mg) per hectare (ha), produced from the CO_2 found in the atmosphere (*Vatm*).

Considering the previous equation (Eq. 1) and substituting in the equation *Vc* (volume of the cube) by *Vatm* (volume of the atmosphere) results in the equation:

$$Qom = \left(ppm\,CO_2 \times Vatm \times 5.357142857\,x\,10^{-5}\right)/C\,\% = gOM$$

With result in grams of dry organic matter produced from the CO_2 of the atmosphere. Transforming grams of organic matter into Mg, the result must be divided by 1000000 or 10^6. Hence, the equation:

$$Qom = ppm\,CO_2 \times Vatm \times 5.357142857\,x\,10^{-5} / C\% \times 10^6 = MgOM$$

After transferring the value 10^6 to the numerator, the equation will look like this:

$$Qom = ppm\,CO_2 \times Vatm \times 5.357142857\,x\,10^{-11} / C\% = MgOM$$

Now, the amount of organic matter (*Qom*)is in Mg, which is the organic matter originating from all the CO_2 in the atmosphere.

It is more appropriate to express the organic matter in Mg per hectare so the amount of organic matter produced from all the CO_2 contained in the atmosphere must be divided by the desired area (Earth surface). The Earth surface (hereafter *Earthsurf*) was considered equal to 510200000 of km^2 being 148 million covered by land (hereafter *emergedsurf*) and 362.2 million water surfaces (hereafter *submergedsurf*) (Pidwirny, 2006), below which there is organic matter. The resulting equation is:

$$Earthsurf = (emergedsurf) + (submergedsurf)$$

This equation represents the proportion (X/100) of *emergedsurf* corresponding to approximately 148000000 km^2 or 14800000000 ha, plus the proportion (Y/100) of the *submergedsurf* corresponding to approximately 362200000 km^2 or 36220000000 ha, X corresponds to the percentage of emerged surf where it is possible to find organic matter, and Y corresponds to the percentage of water surface, below which organic matter can be found and is considered here as submerged surf. In this way, the resulting equation becomes:

$$Earthsurf(ha) = \frac{X}{100} \times emergedsurf(ha) + \frac{Y}{100} \times submergedsurf(ha)\ (Eq\,2)$$

It is highly complicated to find a reasonable value for X and Y, but in order to make the calculations, it was considered in this paper X to be equal to 90% and Y equal to 30%.

The equation to estimate *Qom* is as follows:

$$Qom = ppm\,CO_2 \times Vatm \times 5.357142857 \times 10^{-11} / C\% \times Earthsurf\ (Eq\,3)$$

Then, *Qom* in Mg of organic matter per hectare of land ($Mg.ha^{-1}$).

Calculating the amount of CO_2 released in a given environment when a certain amount of organic matter is incinerated in this environment

As before, the cube of 1000000 L will be used as an example. If 1000 g of organic matter (*OM*) is incinerated inside the cube, what is the amount of CO_2 produced (*$ppmCO_2$*)? The equation for this calculation is:

$$ppm(CO_2) = OM_g \times C\% \times 1.8666666667 \times 10^4\,\mu L / Vc(L)\ (Eq\,4)$$

Firstly, it is necessary to determine the amount of Carbon (C) in 1000 g of OM.

Considering that the *OM* has 45% (C% = 45) of Carbon (Walker,1992), then:

1000 g of *OM* x *45/100 = 1000 * 0.45 = 450* g of C

Transforming g of C to g of CO_2.

According to chemical literature (Peruzzo & Canto,1998) 44 g of CO_2 contain 12 g of C, then how much CO_2 would result from 450 g of C originated from the burned *OM*? The answer is:

$$450\,g \times 44/12 = 1650\,g\ of\ CO_2$$

The oxygen of the CO_2 molecule resulting from the burning of organic matter comes from the photochemical stage of photosynthesis, which was released into the atmosphere (Taiz et al., 2014). In the process of oxidation of the organic matter (burn), a carbon was released into the atmosphere from the organic matter, and an O_2 was withdrawn from the atmosphere.

Transforming CO_2 from g into litters. According chemical literature, (Peruzzo & Canto, 1998) one mol of CO_2 (44 g) fills a volume of 22.4 L (NTP, zero degree and 1 atm), then what would be the volume of CO_2 (*VCO_2*) filled by 1650 g of CO_2?

$VCO_2 = 1650 \times (22.4/44)$, or $VCO_2 = 1000g \times 45/100 \times 44/12 \times 22.4/44$

but, $44/12 \times 22.4/44 = 22.4/12 = 1.8666666667$

Multiplying C%/100 by 1.8666666667, results:

$$C\% \times 1.8666666667 \times 10^{-2}$$

Considering C% = 45 (Walker, 1992):

$$V\,CO_2 = 1000 \times 45 \times 1.8666666667 \times 10^{-2}$$

The result will be in L, but it must be converted to µL, then multiplied by 1000000 or

10^6, and the equation becomes:

$$V\,CO_2 = 1000 \times 45 \times 1.8666666667 \times 10^{-2} \times 10^{6}$$

The product 10^{-2} x 10^6 = 10^4, then:

$$V\,CO_2 = 1000 \times 45 \times 1.8666666667 \times 10^{4} = 8400000000\,\mu L$$

In this way, what will be the CO_2 concentration in ppm inside the cube? As its volume is 1000000 litters the following division is made:

$$ppm\,CO_2 = 840000000/1000000\,L = 840\ ppm\,ou\,840/10000 = 0{,}0840\,\%$$

With this equation it is possible to estimate the CO_2 concentration inside the cube (*Vc*) as a function of the burning (oxidation) of a certain amount of organic matter inside the cube.

General model for determining the final CO_2 concentration in the Earth's atmosphere (*ppm-CO_2*) from a quantity of organic matter incinerated, in $Mg.ha^{-1}$

Considering the equation above (Eq. 4):

$$ppm(CO_2) = OM_g \times C\,\% \times 1.8666666667 \times 10^{4}\,\mu L / Vc(L)$$

Firstly, multiply the equation by 10^6 transforming *OM* from grams (g) into Mg, and replace *Vc* by the volume of the atmosphere (*Vatm*), the equation becomes as follows:

$$ppm(CO_2) = OM_{Mg} \times 10^{6} \times C\,\% \times 1.8666666667 \times 10^{4}\,\mu L / Vatm(L)$$

Knowing that $10^6 \times 10^4 = 10^{10}$, the equation becomes:

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

ppm (CO_2) = µL of CO_2 produced from organic matter in Mg incinerated / *Vatm* (*µL*)

The total organic matter of the Earth (*OM(Mg)*) – from plant and animal origin – is obtained by multiplying the amount of organic matter found in one hectare of area ($Mg.ha^{-1}$) by the surface of the Earth in hectare (*Earthsurf* – Eq. 2). *OM($Mg.ha^{-1}$) x Earthsurf = OM(Mg)* total in Mg.

The profile depth where the organic matter can be found is variable, but it will be considered an average value for the whole existing organic matter on Earth.

In order to express the result in ppm (*µL/L*), it is necessary to divide the result by the volume of the atmosphere (*Vatm*).

Finally, the general model for determining the amount of CO_2 released to atmosphere is:

$$ppm(CO_2) = OM_{Mg/ha} \times C\% \times Earthsurf \times 1.8666666667 \times 10^{10}\,\mu L\,of\,CO_2 / Vatm(L) = \mu L/L\ (Eq\,5)$$

The result should be added to the CO_2 concentration of air = 390 ppm to find the total amount of CO_2 in the atmosphere after the incineration of organic matter (*OM*).

$$ppm\,total(CO_2) = ppm(CO_2) + 390$$

$$ppm\,total(CO_2) = final\ concentration\ of\ CO_2\ in\ the\ atmosphere$$

Origin of organic matter from which there is release of CO_2:
- *Emerged lands*: Soils (living and dead organic mass from aboveground and belowground), humans, animals (domesticated and wild), others.
- *Submerged lands*: Seas (algae, animals, plankton etc). The surface area of the Earth occupied by the seas is 362.2 million km^2. Assuming that 30% of this area – between the surface of the submerged soil and the surface of the water – contains live and dead organic matter from plants and animals, the amount of carbon in this area can be roughly estimated.

Large volume of CO_2 is dissolved in the waters of the seas, lakes, rivers, etc but will not be considered in the estimates of this work. It should be taken into account that a certain amount of CO_2 will diffuse into the empty spaces of the soil; this space should be around 2% of the soil volume. It is very variable, as it depends on the granulometry and depth of the soil and its water content.

Since it is very complicated the exact estimation of the total organic matter of the aforementioned sources, this work considers extreme values – minimum and maximum – whose exact value must be within the considered range.

Estimating the volume of the atmospheric layer (*Vatm*) as a function of its height (*h*) above ground level

Once the volume of the atmosphere (*Vatm*) is defined, it must be considered in the equations previously deduced (models). The volume was estimated using the equation that results in the volume of a sphere, although the earth is not exactly spherical.

The *Reh* and *Reh2* radius are those of two spheres under consideration: *Reh* being the radius of the Earth, and *Reh2* the radius of the Earth (*Reh*) plus the height of the atmospheric layer (*h*) (Fig. 1).

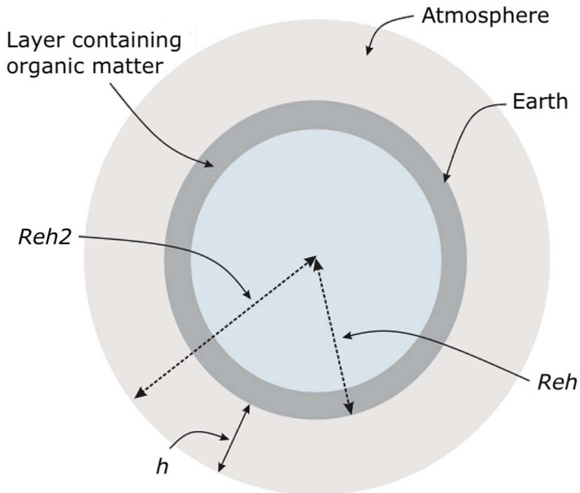

Fig. 1. Sphere showing the *Reh* radius of the Earth and *Reh2* of the Earth plus the height *h* of the atmosphere. (*Reh2 = Reh + h*). Considering the Earth as a sphere, to facilitate calculations.

The difference between of the volumes of the spheres whose radius are *Reh* and *Reh2* will result in the volume of the considered environment, which is the volume of the atmosphere (*Vatm)*:

$$Vatm = (VolReh2 - VolReh)$$

Reh2 is the sum of the radius of the Earth (*Reh*) plus the height *h* of the atmosphere. *Reh* is constant, but *h* can vary depending on the height of the CO_2 profile in the atmosphere.

The Earth is not exactly spherical, but to ease the calculations of the volumes, the equation that corresponds to the volume (*V*) of a sphere was used:

$$V = 4\pi r^3/3$$

Calculating the volume of the spheres whose radiuses are *Reh* and *Reh2* (Fig. 1):

$$VolReh = 4\pi(Reh)^3/3 \qquad VolReh2 = 4\pi(Reh2)^3/3$$

The difference between the volumes of the two spheres is the volume of the atmosphere layer (*Vatm*):

$$Vatm = 4\pi(Reh2)^3/3 - 4\pi(Reh)^3/3$$

As *Reh2 = Reh + h*, where h is the height or profile of the atmospheric layer where presume CO_2 is present, hence, the equation becomes:

$$Vatm = 4\pi(Reh+h)^3/3 - 4\pi(Reh)^3/3$$

Knowing the values of π = 3.1416 and, considering constant the radius of the Earth equal to 6380 km (Williams, 2020), the equation to estimate the volume of the atmosphere can be simplified, so that it can be estimated from its height (*h*):

$$Vatm = 1/3\left((12{,}5664(6380+h)^3) - 12{,}5664 \times (6380)^3\right)$$

As:

$$(6380+h)^3 = 2.5969407 \times 10^{11} + 122113200\,h + 19140 \times h^2 + h^3$$

And:

$$12{,}5664 \times (6380)^3 = 3{,}26342 \times 10^{12}$$

Then, the equation becomes:

$$Vatm = 4.1888 \times h^3 + 80173.632 \times h^2 + 511507772.17 \times h = km^3$$

In order to convert it to litres simply multiply by 1000000000000 or 10^{12}, resulting the following equation:

$$Vatm = (4.1888 \times h^3 + 80173.632 \times h^2 + 511507772.17 \times h) \times 10^{12} = Litres\,(Eq\,6)$$

And *1 km³* corresponds to *1000000000 m³*. One m³ corresponds to *1000 dm³ = 1000 L*, since *1 dm³ = 1 L* then 1 km³ corresponds to *1000000000000 L = 10¹² L*.

In this way, the volume of the atmosphere is a function of the height *h*, which is presumed to have CO_2.

This equation (Eq. 6) that calculates the volume of the atmosphere is used in the equations developed to estimate the values of *Qom* (Eq. 3) and $ppmCO_2$ (Eq.6).

A software was developed to perform the calculations from the models developed in this work, available at *https://botanica.icb.ufg.br/p/32959-pesquisa-e-inovacao-inovacao-aplicativos-de-fisiologia-vegetal*.

Results

Quantity of organic matter (*Qom*) produced as a function of the atmospheric CO_2 consumption through photosynthetic assimilation

The equation designed to estimate the amount of organic matter produced (*Qom*) in function of the concentration of CO_2 ($ppmCO_2$) in the atmosphere is as follows (Eq. 3):

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

Vatm = volume of atmosphere where CO_2 is found (Eq. 6). The atmospheric 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). Here, to facilitate calculation, an average altitude (*h*) of 30 km from the Earth surface was considered as having a constant amount of 390 ppm of CO_2, based on the results of the aforementioned authors. The amount of CO_2 dissolved in water (rivers, lakes and seas) was not considered.

C% = proportion of carbon within the total of organic matter. To facilitate calculation, the proportion of 45% carbon (C% = 45) in organic matter was considered for both plants and animals.

Earthsurf = surface of the Earth (emerged and submerged surface) where there is organic matter from vegetable and animal origin (Eq. 2). In this equation X was considered, hypothetically, equal to 90% and Y equal to 30%.

Following the proposed model (Eq. 3) and considering as a hypothesis the concentration of CO_2 in the atmosphere equal to 1000 ppm, if fully assimilated via photosynthesis would be enough to produce 758.9 $Mg.ha^{-1}$ of organic matter or 75.4 $kg.m^{-2}$ (Fig. 2). Considering the concentration of CO_2 in the atmosphere equal to 400 ppm, this amount of the gas, if fully assimilated via photosynthesis, would result in 303.6 $Mg.ha^{-1}$ or 30.36 $kg.m^{-2}$ of dry organic matter. A relatively low value when forests are considered (Chave et al., 2003; Saatchia et al., 2011).

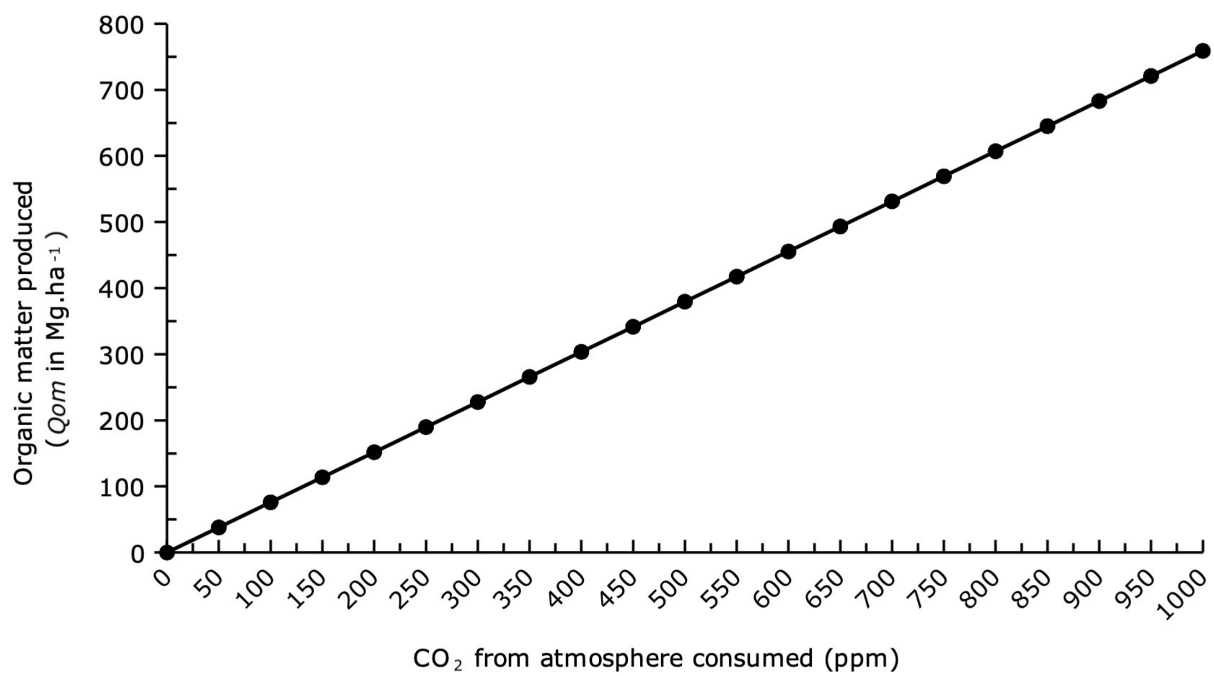

Fig. 2. Amount of organic matter produced (Y) as a function of the concentration of CO_2 in the atmosphere (X).

ESTIMATED AMOUNT OF CO_2 PRODUCED AS A FUNCTION OF A GIVEN AMOUNT OF INCINERATED ORGANIC MATTER.

The model (Eq. 5) was designed to estimate the amount of CO_2 produced (ppm CO_2) as a function of the amount of organic dry matter incinerated (*OM* in $Mg.ha^{-1}$):

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

Considering as hypothesis that in the earth currently has an average of 100 $Mg.ha^{-1}$ of vegetal and animal organic matter, if totally incinerated would result, by the proposed model, in 131.8 ppm of CO_2 (Fig. 3). By incinerating 300 $Mg.ha^{-1}$, a relatively high value would result in 395.3 ppm. However, imagining that this value was real, added to the 390 ppm currently existing in the Earth's atmosphere, would result in approximately 785,3 ppm of the gas, thus reaching not even 1000 ppm.

The lower the amount of CO_2 in the atmosphere the greater the amount of organic matter available. The greater the amount of CO_2 in the atmosphere, the less the amount of organic matter produced through the photosynthetic

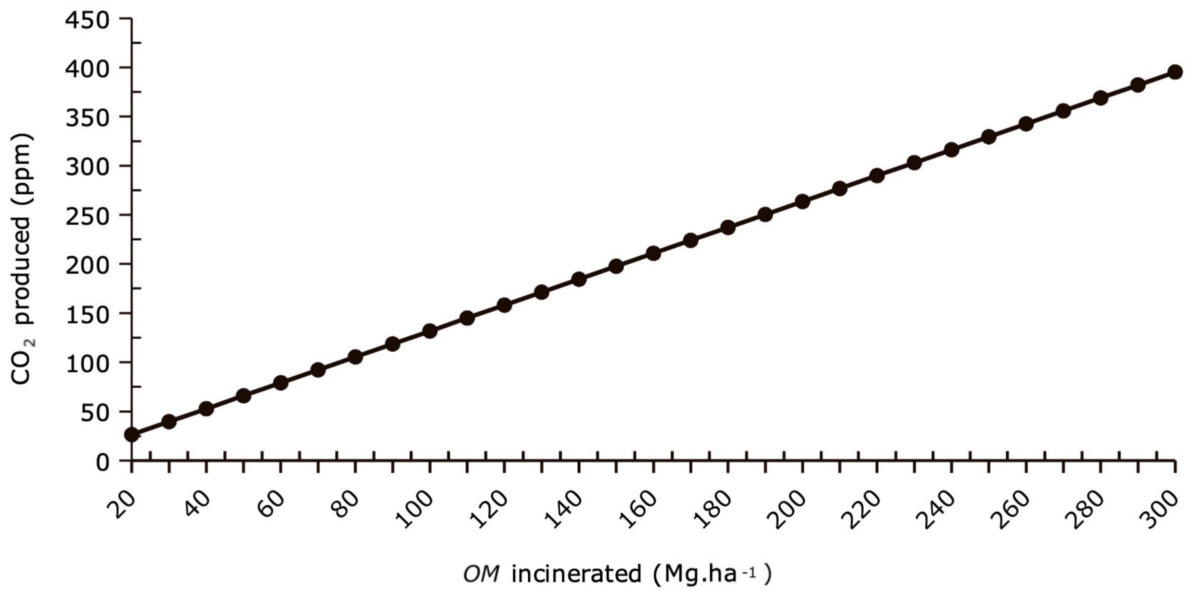

Fig. 3. Quantity of CO_2 produced (ppm) as a function of the amount of vegetal and animal organic matter (*OM*) incinerated (Mg.ha^{-1}), considering 300 Mg.ha^{-1} the maximum amount of organic matter in the biosphere. The amount of CO_2 present in the atmosphere has not been added.

process, that is, the amount of organic matter in the Earth is inversely proportional to the amount of CO_2 available in the atmosphere (Fig. 3).

Discussion

One of the major concerns of recent times regarding the environment is the planet temperature increase, which is attributed especially to greenhouse gases, in particular to the increase in the CO_2 atmospheric concentration. Undoubtedly this gas contributes to the heating of the atmosphere because it has the property of absorbing the infrared rays (Cox et al., 2000; IPCC, 2014; IPCC, 2013; 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, including petroleum and coal (Howe et al., 2013; Mac Dowell et al., 2017; Shanahan et al., 2016).

By the models developed and tested here, the hypothetical relations between CO_2 concentration *vs.* organic matter produced and organic matter *vs.* CO_2 produced are always linear. In fact, this relationship must not have occurred throughout the Earth's geological history due to the great climatic variations that it has gone through (Barral et al., 2017). However, those estimates illustrate what may have occurred throughout the existence of the planet, giving an idea of the relationship between the concentrations of CO_2 and the formation of organic matter.

This study may not have found exact values of what was proposed, 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 more accurate results and increase knowledge about carbon flows on Earth.

According to the models and results presented in this paper, forests and other sources of organic matter on the Earth's surface, as component of total organic matter, may not be as important as carbon accumulators, but forests making the environment propitious to life on Earth, because they are essential in the formation of rains and maintenance of moisture, especially in areas far from the oceans and seas. This function of forests is in explained by an interesting and very consistent hypothesis developed by Makarieva & Gorshkov (2007). These authors have developed a premise that attributes to forests the function of a biotic pump of atmospheric moisture as driver of the hydrological cycle on land. The hypothesis of Makarieva & Gorshkov (2007) is reinforced by Sheil & Murdiyarso (2009). In this case, the postulation provides the compelling motivation for forest conservation (Bright et al., 2017; Sheil & Murdiyarso, 2009).

If forests are not the main source responsible for the increase in CO_2 concentration in the atmosphere, which results in the greenhouse effect, this activity should be attributed to the petroleum and other carbon sources.

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