

Human Discharge and Phytoplankton Takeup for the Atmospheric Carbon Balance*

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Abstract

By the data of the Jiaozhou Bay (Shandong, China) from May 1991 to February 1994 and those of Hawaii from March 1958 to December 2007, with the statistics and differential equations analyzed were the seasonal variations in atmospheric carbon in the Northern Pacific Ocean (NPO), and in phytoplankton primary production in the Jiaozhou Bay, and its relationship in the study regions. The study unveiled that the seasonal change of the atmosphere carbon and primary production has the same period. In a year, the primary production and atmosphere carbon had two balance points: the points of May and October, during which the amount of atmosphere carbon decreased. As phytoplankton absorbed atmosphere carbon, When primary production in spring > 181.60 ($\text{mg}/\text{m}^2 \text{d}$) - 297.57 ($\text{mg}/\text{m}^2 \text{d}$) or 754.74 ($\text{mg}/\text{m}^2 \text{d}$) - 1160.13 ($\text{mg}/\text{m}^2 \text{d}$) in September or 552.94 ($\text{mg}/\text{m}^2 \text{d}$) - 890.69 ($\text{mg}/\text{m}^2 \text{d}$) in October, the atmosphere carbon fell. Therefore, it is considered that from May to October every year, phytoplankton growing in bloom controlled the increase of atmosphere carbon. From December to next April, human discharging the carbon controlled its increase. The results supported the viewpoint shown by Yang (2010): the variation in atmospheric carbon was determined by human discharge and phytoplankton growth. The result in this paper showed that the earth ecosystem kept the percentage of the decrease amount of atmospheric carbon to its amount taken up by phytoplankton as 1.60% - 0.34% and maintained the dynamic balance of carbon by emitted by human being into the atmosphere and absorption of phytoplankton to atmosphere carbon. Therefore, the ecosystem was considered to be of the great power and accuracy.

Keywords: Atmospheric Carbon, Human, Phytoplankton, Dynamic Balance, Jiaozhou Bay, Hawaii

1. Introduction

Since industry revolution, the atmosphere carbon concentration rises obviously every year, which leads to global warming and affects the climate and environment of the earth. 95% of the carbon in ecological circle lies in ocean, which is the largest carbon store of the earth. It contains the CO_2 not only from atmosphere but also from mankind within river water, that is, the recycling mechanism and the physical, chemical and biological process, where oceans absorb and transfer CO_2 in atmosphere and ocean will change with season, area and space. Therefore, ocean is of great meaning to adjust the CO_2 in atmo-

sphere.

In central area of the North Pacific, Hawaii Mauna Loa Monitoring Station found that atmosphere carbon is not affected by partial carbon emission and the data of the carbon reflects the change of atmosphere carbon in north Pacific. Along the coast line of the north Pacific, the Jiaozhou bay with suitable location [1-9] is chosen to observe the effect of phytoplankton growth on atmosphere carbon. The data from Mauna Loa Monitoring Station were valid and reliable, which were used by many researchers [10-13].

This paper showed the seasonal change of phytoplankton primary production in the Jiaozhou Bay from 1992 to 1994, that of atmospheric carbon from 1958 to 2007 in Mauna Loa in NOAA Earth System Research laboratory in Hawaii that of the atmosphere in the North Pacific ocean. By the equations, calculated were monthly

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average value of primary production, their balance points and balance amounts, making us fully understand the phytoplankton growth role in atmospheric carbon elimination.

2. Materials and Method

2.1. The Jiaozhou Bay and the Phytoplankton Data

Jiaozhou Bay is semi-closed at $35^{\circ}55' N - 36^{\circ}18' N$, $120^{\circ}04' E - 120^{\circ}23' E$, its area is 390 km^2 with 7 m in average depth in the eastern China. The observation data of primary production (14C-monitoring) from May 1991 to February 1994 are provided by the Ecological Station of Jiaozhou Bay, and obtained by Wu *et al.* [14]. Each time monitoring was taken in 2 days. On-site the investigations were made in February, May, August, and November during the years, representing winter, spring, summer, and autumn, respectively. There were 12 voyages in 10 stations (except Station 3) (Figure 1). The water samples of standard water layer were collected at 0, 5, 10, ..., to the bottom).

2.2 Mauna Loa and Source of Atmospheric Carbon Data in Hawaii

Mauna Loa is located at $19.539 N/155.578 W$ in Hawaii (Figure 2), its altitude is 4170 m high and its area is 97 km in length and 48 km in width. The observation data on atmospheric carbon in 1958-2007 are from Mauna Loa in NOAA Earth System Research laboratory in Hawaii.

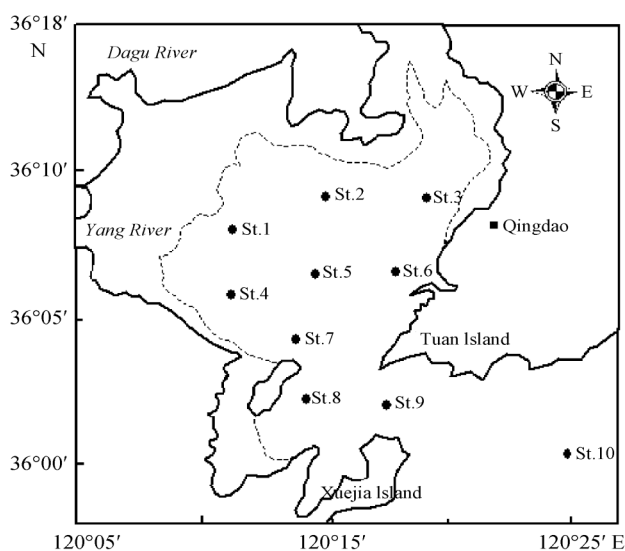


Figure 1. Station locations in Jiaozhou Bay.

The change of atmosphere carbon is a curve of fluctuating rise. This change is produced by the combination of trending increase and periodic fluctuation [9]. The thesis researches the change of curve period and makes comparison analysis according to the curve period change calculated by monthly average value to discuss the effect of primary productivity to seasonal change of atmosphere carbon.

Variation in atmospheric carbon shows cycle oscillation in curved shape, resulted jointly from the increasing trend and periodic oscillations [9]. The seasonal variations in atmospheric carbon and primary production were compared and analyzed by the calculated monthly average (Figures 3-4), by which their balance points and balance amounts were obtained.

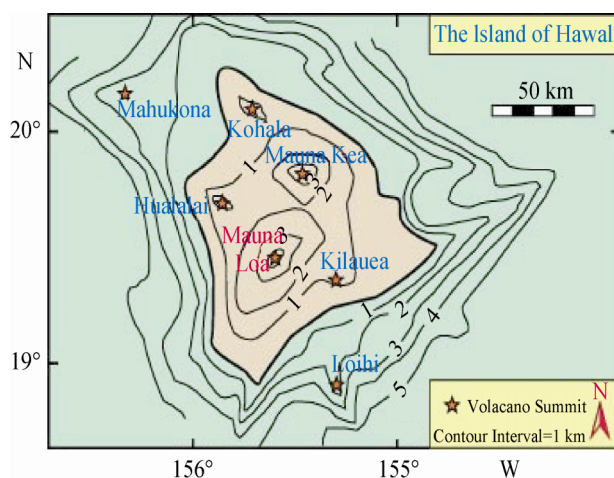


Figure 2. Geographic feature of Mauna Loa monitoring station (from NOAA Earth System Research Laboratory, http://www.esrl.noaa.gov/gmd/ccgg/trends/co2_data_mlo.html, seen on the 20th February in 2008).

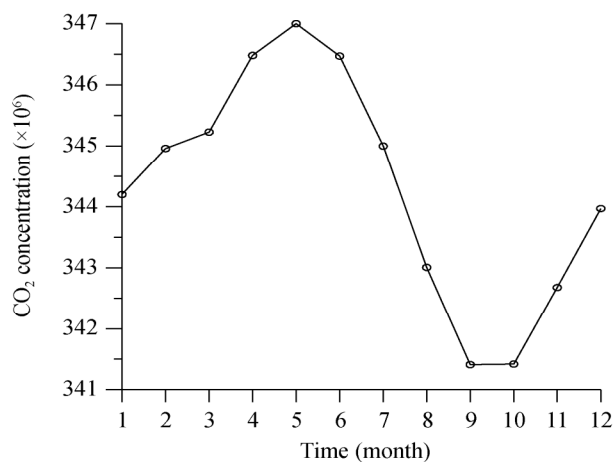


Figure 3. The variation in atmospheric carbon with a monthly average from March 1958 to December 2007.

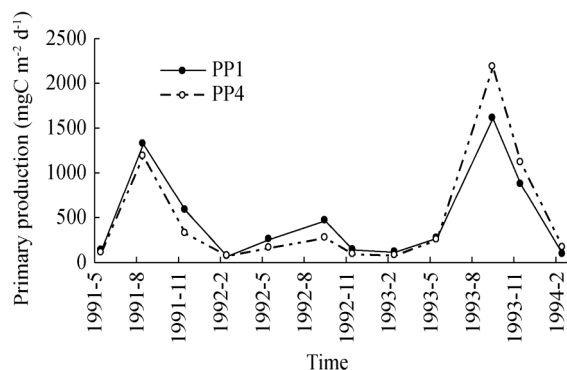


Figure 4. Seasonal variations of primary production at Stations 1 and 4 ($\text{mgCm}^{-2}\text{d}^{-1}$).

3. Results

3.1. Seasonal Variation in Atmospheric Carbon

According to the monthly average value of atmospheric carbon concentration from 1958 to 2007, the seasonal variation in it reaches the peak in spring, higher than in other three seasons, while it arrives to the bottom in autumn. The average atmospheric carbon from November to next May all the times rises, and reaches the highest value 347 ppm in May in a year, and then begins to go down in May and falls all the time from May to October for five months. In August it falls faster, then in September it falls slowly and reaches the lowest value 341.41 ppm in September, then kept the lowest value 341.42 ppm in October. Moreover, it begins to rise in November and reaches again the peak until the next May for seven months, in April, it rises faster and reaches the peak of 347 ppm in May again. Then, a new cycle appeared again (**Figure 3**).

3.2. Seasonal Variation in Primary Production

In Jiaozhou bay, the seasonal change tendency of primary production is obvious. The primary production is the highest in summer. In the same station, the primary production peak value of every year is different. The peak value in the same station is not the same in different years. The peak value is in the range of $1600 \text{ mgC}/\text{m}^2 \text{ d}$ - $2500 \text{ mgC}/\text{m}^2 \text{ d}$. The bottom value of primary production is in winter with the range of $35 \text{ mgC}/\text{m}^2 \text{ d}$ - $104 \text{ mgC}/\text{m}^2 \text{ d}$. Primary production from February to May rises slowly and rises fast after May till peak period. It will then fall sharply till November and then falls slowly from November to February and slides to bottom value. The primary production remains low from November to the next May. Then the cycle continues, such as Stations 1 and 4 (**Figure 4**).

Primary production and atmospheric carbon have the clear seasonal variation and the same cycle.

3.3. Monthly Average Value of Primary Production

By the primary production data of May, August and November in 91, 92, 93, approximate formula is set up with parabola formula least squares. The variable is time t with the unit of month. The month is 30 days and function is primary production (**Table 1**).

$$Y(t) = at^2 + bt + c \quad (1)$$

Function $Y(t)$ was obtained by carrying out integral to primary production function $Y(t)$ and the average value of primary production for every month was calculated. $Y(t) = \int y(t) dt(2)$.

From (2), the primary production average value of May, September and October can be worked out (**Table 2**).

Table 1. Values of the parameters a, b, c in Equation (1).

S \ P	1	4	6	7	8	9
a	-85.04	-99.07	-69.87	-61.00	-114.04	-85.65
b	1479.81	1724.32	1192.24	1045.63	1926.34	1465.68
c	-5306.05	-6283.54	-4256.25	-3667.57	-6837.91	-5239.47
r2	0.54	0.41	0.51	0.49	0.54	0.24

S: Station, P: Parameter.

Table 2. Month average values of the primary production ($\text{mg}/\text{m}^2 \text{ d}$).

S \ M	1	4	6	7	8	9
May	253.24	194.99	181.60	232.79	297.57	223.65
Sep.	1069.86	1147.84	758.16	754.74	1160.13	947.19
Oct.	848.79	890.69	552.94	580.18	805.54	699.81

S: Station, M: Month.

The monthly average value of primary production in May was in the range of 181.60 (mg/m² d) - 297.57 (mg/m² d), in September in the range of 754.74 (mg/m² d) - 1160.13 (mg/m² d), and in October in the range of 552.94 (mg/m² d) - 890.69 (mg/m² d).

3.4. The Balance Point of Primary Production and Atmosphere Carbon

The atmosphere carbon increases before May and decreases after May. In May, the atmosphere carbon reaches the peak value of 347 ppm. At the same time, primary production increases from February to August, during which primary production decreases atmosphere carbon. In May, atmosphere carbon and primary production reaches the balance, that is, the absorption amount of phytoplankton for atmosphere carbon is equal to the increase amount of atmosphere carbon. This result shows that in spring, the primary production rises, and that its month average value exceeds 181.60(mg/m² d) - 297.57 (mg/m² d), atmospheric carbon begins to fall.

Atmosphere carbon decreases before September and October, and increases after September and October. In September and October, atmosphere carbon reaches the lowest values 341.41 ppm and 341.42 ppm, and then primary production falls to the bottom value from August to next February, during which, primary production makes the atmospheric carbon decreasing, but as primary

Production falls, the atmospheric carbon correspondingly increases. So, In September and October, atmospheric carbon and primary production reaches the balance, that is, the absorption amount of phytoplankton for atmosphere carbon is equal to the increase amount of atmosphere carbon. This result shows that in autumn, the primary production falls, and that its month average value reaches lower than 754.74 (mg/m² d) - 1160.13 (mg/m² d) in September or 552.94 (mg/m² d) - 890.69 (mg/m² d) in October, atmospheric carbon begins to rise.

3.5. The Balance Amount of Primary Production and Atmosphere Carbon

Primary production and atmosphere carbon have two balance points. The accumulation amount between them is called balance amount of primary production and atmosphere carbon. So, the accumulation amount of primary production is defined the balance amount of atmospheric carbon between primary production and atmosphere carbon by authors, in this way the accumulation amount of atmospheric carbon is called the balance amount of atmospheric carbon between primary production and atmosphere carbon.

From Formula 2 obtained was the average value of primary production 600.18 - 931.71 (mg/m² d) from May to October.

There is six months in all from May to October; every month is 30 days, namely 180 days. Then there the accumulation amount of primary production for six months, that is, the balance amount of primary production between primary production and atmosphere carbon for six months (**Table 3**), its range is 108031.95 - 167707.62 (mg/m²).

By calculating the data of primary production in the Jiaozhou Bay and atmospheric carbon in Hawaii, set up was the Equation (3): $c(t) = -kp(t) + b$ (3)

In (3), parameter k is the amount of atmospheric carbon absorbed by unit primary production as 0.00321 (ppm)/(mgC m⁻²·d⁻¹) - 0.00974 (ppm)/(mgC m⁻²·d⁻¹), that is, a unit primary production can absorb 0.003²¹ ppm - 0.00974 ppm of the atmospheric carbon (Yang, *et al.*, 2010). With (3) the atmospheric carbon average from May to October is calculated, the range of low value is 1.93 ppm - 2.99 ppm and that of high value is 5.85 ppm - 9.07 ppm. The whole range is 1.93 ppm - 9.07 ppm. There is six months in all from May to October; every month is 30 days, namely 180 days. Then there the accumulation amount of atmospheric carbon for six months, that is, the balance amount of atmospheric carbon between primary production and atmosphere carbon for six months (**Table 4**), its low range is 346.78 ppm - 538.34 ppm; its high range 1052.23 ppm - 1633.47 ppm; The whole range is 346.78 ppm - 1633.47 ppm.

Table 3. Average value (mg/m² d) and balance amount (mg/m²) of the primary production between the primary production and the atmospheric carbon for six months.

Primary production	PP1	PP4	PP6	PP7	PP8	PP9
Average value of six months	834.50	873.09	600.18	609.85	931.71	747.24
Balance amount	150209.17	157155.71	108031.95	109773.85	167707.62	134503.24

Table 4. Average value and balance amount of the atmospheric carbon between the primary production and the atmospheric carbon for six months (ppm).

Atmosphere carbon amount absorbed by primary production unit	Atmosphere carbon	1	4	6	7	8	9
0.00321 (ppm)/(mgC m ⁻² ·d ⁻¹)	Average value of 6 months	2.68	2.80	1.93	1.96	2.99	2.40
0.00974 (ppm)/(mgC m ⁻² ·d ⁻¹)	Average value of 6 months	8.13	8.50	5.85	5.94	9.07	7.28
0.00321 (ppm)/(mgC m ⁻² ·d ⁻¹)	Balance amount	482.17	504.47	346.78	352.37	538.34	431.76
0.00974 (ppm)/(mgC m ⁻² ·d ⁻¹)	Balance amount	1463.04	1530.70	1052.23	1069.20	1633.47	1310.06

4. Discussion

4.1. Rise of CO₂ in Atmosphere

Human beings by burning oil emitted a huge amount of CO₂ into the atmosphere, so CO₂ concentration has been rising from 270 ppm of the industrial revolution to 315.24 ppm in 1958, 318.46 ppm in 1962 after 5 years, 322.18 ppm in 1967 after 10 years, and 383.71 ppm in 2007 after 50 years [9]. Therefore, because of human beings, the CO₂ in the atmosphere increases faster and faster. During the period of 1958-2007, by virtue of monthly average value, the equation of atmosphere carbon curve was set up [9], by which it can be calculated that the acceleration of atmospheric CO₂ is 0.0244 since 1958, and in the future, the its increasing speed would look faster. Therefore, the rise of CO₂ in the atmosphere is faster and faster.

4.2. Absorption of Primary Production for Atmosphere Carbon

Oceans are the largest absorbing body of CO₂ as CO₂ can be solved in sea water; a large amount of atmosphere carbon is in sea water. Phytoplankton absorbs carbon and settles it at the bottom of ocean. The phytoplankton in the ocean transfers the carbon into the sea bottom [15-18]. One of two functions of phytoplankton growth is the basis of food chain and the core of ecosystem, the other one is the elimination of the atmospheric CO₂ by phytoplankton photosynthesis. Therefore, phytoplankton growth would keep the ocean ecosystem to sustain and decrease the atmospheric CO₂ emitted by the humans [9].

Atmospheric carbon has a close relationship with phytoplankton primary production. Jiaozhou Bay phytoplankton is relevant to Hawaii atmosphere carbon. A good correlation between phytoplankton in Jiaozhou Bay and atmospheric carbon in Hawaii showed the process of phytoplankton taking up carbon from atmosphere and sinking to the ocean bottom.

The carbon-phytoplankton model [9,16] showed that if the primary production rises, the atmospheric carbon will fall; if the primary production falling, the result on the contrary. In addition, under the effect of phytoplankton, atmospheric carbon has the same period of phytoplankton, which means the phytoplankton growth determined the cyclic fluctuation and the amplitude of atmosphere carbon.

From the carbon-phytoplankton model [9,16], 0.00321 - 0.00974 ppm of the atmospheric carbon is absorbed by every primary production unit. In the way, 0.28963 ppm - 0.87884 ppm of the atmospheric carbon is absorbed in winter, 6.88689 ppm - 20.89668 ppm in summer, which unveiled that the amount of atmospheric carbon is very different in the absorption of phytoplankton between winter and summer. Therefore, phytoplankton growth in bloom and decline determines the fall and rise variation in atmospheric carbon.

4.3. Balance Point of May

The atmosphere carbon increases from February to May continuously, then primary production increases from February to August continuously. During this period, the increase amount of primary production becomes large, the corresponding increase amount of atmospheric carbon becomes smaller. In this way, primary production increased fast and the corresponding atmospheric carbon increased slowly. So, in May, the balance of atmosphere carbon and primary production appears, that is, the absorption amount of phytoplankton for atmosphere carbon and the increase amount of atmosphere carbon reaches the balance, and then the atmosphere carbon reaches the peak value of 347 ppm. This result indicated that in spring, the primary production rises, and that when the monthly average value of primary production exceeds 181.60(mg/m² d) - 297.57(mg/m² d), atmospheric carbon begins to decrease. Therefore, the bloom of phytoplankton growth might control the rise of atmospheric carbon.

The largest increase rate of primary production is in May [1-3,19], That is, it is time that the phytoplankton begins to grow in bloom, the absorption amount of phytoplankton for atmosphere carbon and the increase amount of atmosphere carbon is identical, resulting in rise of atmosphere carbon as zero.

4.4. Balance Point of October

Atmosphere carbon decreases all along from May to September and October, then atmospheric carbon increases all along, but decreases from August to November, during this period the increase amount of primary production becomes smaller, the corresponding increase amount becomes larger. In this way, since August, the primary production rises slowly, the corresponding atmospheric carbon rises fast. So in September and October the second balance point appears, that is, the absorption amount of phytoplankton for atmosphere carbon and the increase amount of atmosphere carbon reaches the balance in September and October, and then the atmosphere carbon reaches separately the bottom values of 341.41 ppm and 341.42 ppm in September and October. This result indicated that in autumn, the primary production falls, and that when the monthly average value of primary production is lower than 754.74 (mg/m² d) - 1160.13 (mg/m² d) in September or 552.94 (mg/m² d) - 890.69 (mg/m² d) in October, atmospheric carbon begins to rise. Therefore, the decline of phytoplankton growth might not control the rise of atmospheric carbon.

The largest decrease rate of primary production is in November [1-3,19], That is, it is before that the phytoplankton begins to grow in weak, the absorption amount of phytoplankton for atmosphere carbon and the increase amount of atmosphere carbon is identical, resulting in rise of atmosphere carbon as zero.

Therefore, in one year, from May to October, phytoplankton growth all along controls the rise of atmospheric carbon.

4.5. Average Value of Primary Production and Atmospheric Carbon

From May to October, the average primary production is 600.18 (mg/m² d) - 931.71 (mg/m² d) and the primary production growth controls the rise of atmosphere carbon. During this period, the atmospheric carbon amount absorbed by the primary production has the low range of 1.93 ppm - 2.99 ppm and high range of 5.85 ppm - 9.07 ppm. So, the total range is 1.93 ppm - 9.07 ppm. This result represents that from May to October, phytoplankton growth every day absorbed the low range of atmosphere carbon: 1.93 ppm - 2.99 ppm and high range: 5.85

ppm - 9.07 ppm. Therefore, no matter what low range or high, phytoplankton plays an important role in absorbing atmosphere carbon from time to time.

4.6. Balance Amount of Primary Production and Atmospheric Carbon

In one year, primary production and atmosphere carbon have two balance points: two points of May and October. Between two ones, the balance amount of primary production between primary production and atmosphere carbon is 108031.95 (mg/m²) - 167707.62 (mg/m²), The balance amount of atmosphere carbon between them is 346.78 ppm - 1633.47 ppm. From May to October, the atmosphere carbon decreases by 347 - 341.41 = 5.59 ppm or 347 - 341.42 = 5.58 ppm, which unveils that the carbon discharged by human into atmosphere should be 346.78 ppm - 5.58 ppm ~ 1633.47 ppm - 5.58 ppm, namely 341.20 ppm - 1627.89 ppm or 346.78 ppm - 5.59 ppm ~ 1633.47 ppm - 5.59 ppm, namely 341.19 ppm - 1627.88 ppm.

From every May to October every year, human discharged 341.20 - 1627.89 ppm or 341.19 - 1627.88 ppm. Therefore, the earth ecosystem every year not only eliminates the carbon emitted by humans into atmosphere and but also reduces the carbon in atmosphere by 5.59 ppm or 5.58 ppm, and the falling amount of atmospheric carbon in proportion to the absorption amount of phytoplankton for atmospheric carbon is 0.0160 - 0.0034, or 1.60% - 0.34%. The earth ecosystem every year could keep the atmospheric carbon falling 1.60% - 0.34%, it is of so great precision.

As humans continuously has been increasing amount of carbon into atmosphere, the earth ecosystem would make the primary production of phytoplankton continuously increase every year in order to reduce atmospheric carbon by 5.59 ppm or 5.58 ppm from May to October. In this way, the earth ecosystem would settle the large amount of carbon in atmosphere to bottom of the sea by phytoplankton to eliminate the carbon discharged by human beings to keep the dynamic balance of carbon emission and absorption of phytoplankton to atmosphere carbon. Therefore, the earth ecosystem is of so great power.

In recent years, phytoplankton has been blooming, result in the global red tides increasing, their frequency, strength, area and scale rapidly enlarging [16,18,20], which strengthen that the earth ecosystem controls atmospheric carbon from May to October to adapt to the increase amount of atmospheric carbon. On the basis of the three complementary mechanism: the complementary mechanism of silicon in the Earth's ecosystem, the complementary mechanism of air temperature and water

temperature in the Earth's ecosystem, the complementary mechanism of carbon in the Earth's ecosystem by Yang, *et al.* [16,18,21], air temperature and water temperature reaches the dynamic balance by phytoplankton.

5. Conclusions

Atmosphere carbon has obvious season change and one spring peak and one fall bottom. While the primary production has seasonal change with a summer peak and a winter bottom. Atmosphere carbon and primary production has the same seasonal change period. In one year, primary production and atmosphere carbon have two balance points: the balance points of May and October. Atmosphere carbon changes from balance point of May to that of October. During this period, atmosphere carbon all along keeps falling. The atmosphere carbon began to fall at the one balance point of May till it finished at the other balance point of October. As phytoplankton absorbs atmosphere carbon, primary production exceeds 181.60 (mg/m² d) - 297.57 (mg/m² d) in spring and 754.74 (mg/m² d) - 1160.13 (mg/m² d) in September or 552.94 (mg/m² d) - 890.69 (mg/m² d) in October. the atmosphere carbon all the time falls from May to October. Therefore, it is considered that phytoplankton growth in bloom might control the rise of atmosphere carbon.

From May to October, the average primary production is 600.18 (mg/m² d) - 931.71 (mg/m² d), the average carbon of whose absorption is 1.93 ppm - 9.07 ppm. So, blooming phytoplankton growth all the time controls the rise of atmospheric carbon. From May to October, the balance amount of primary production between primary production and atmosphere carbon has its range 108031.95 (mg/m²) - 167707.62 (mg/m²), the balance amount of atmospheric carbon between them has its range 346.78 ppm - 1633.47 ppm. So, phytoplankton plays an important role in absorbing atmosphere carbon. Every year from May to October, the carbon discharged by humans into atmosphere should reach 341.20 ppm - 1627.89 ppm or 341.19 ppm - 1627.88 ppm. Moreover, the earth ecosystem every year not only eliminates the carbon emitted by humans into atmosphere and but also reduces the carbon in atmosphere by 5.59 ppm or 5.58 ppm, and the falling amount of atmospheric carbon in proportion to the absorption amount of phytoplankton for atmospheric carbon is 0.0160 - 0.0034, or 1.60% - 0.34%, it is of so great precision.

As humans continuously has been increasing amount of carbon into atmosphere, the earth ecosystem would make the primary production of phytoplankton continuously increase every year in order to reduce atmospheric carbon by 5.59 ppm or 5.58 ppm from May to October. In this way, the earth ecosystem would keep the dynamic

balance of carbon emission and absorption of phytoplankton to atmosphere carbon. Therefore, the earth ecosystem is of so great power.

The results showed that from May to October phytoplankton growth blooming controls the rise of atmosphere carbon, and phytoplankton could make the atmospheric carbon fall in spite of humans' emission; in other months in every year phytoplankton growth declining could not control the rise of atmosphere carbon, so under the humans' emission the atmosphere carbon increases. Therefore, the bloom and decline period of phytoplankton growth determines the cycle and amplitude of atmospheric carbon variation.

By virtue of the results above, author considered that every year from May to October the phytoplankton growth blooming controls the atmospheric carbon, while from November to next April, the human's emission controls the atmosphere carbon increase, which further supported the viewpoint [9]: both the increase of carbon and its cyclic variation, respectively determined by human discharge and phytoplankton growth, synthetically and harmoniously showed a dynamic process of the atmospheric carbon variation.

Authors considered that the earth ecosystem would not only keep 1.60% - 0.34% of the falling amount of atmospheric carbon in proportion to the absorption amount of phytoplankton for atmospheric carbon and but also maintain the dynamic balance of the carbon of humans emission into atmosphere and the phytoplankton absorption to atmosphere carbon. Therefore, the earth ecosystem is certain of so great accuracy and power.

Authors deeply exclaimed that the earth is so perfect, while I am so tiny!

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