An Analysis of Fossil Fuel CO_2 in the Atmosphere with Regional Characteristics: in Gyeongju

Min-Ji Kong, Sang-Hoon Lee, Sae-Hoon Park and Yu-Seok Kim*
Dongguk University Gyeongju
**Corresponding author: unison@dongguk.ac.kr*

1. Introduction

Since industrialization, the CO_2 in the atmosphere is increased rapidly, and the abnormal climate change has taken place all over the world. The main cause of the increase in CO_2 levels is the use of fossil fuels. Carbon stored in lithosphere was moved into the atmosphere in CO_2 form. This phenomenon is called Suess effect. Because of climate change, Kyoto protocol for regulation of greenhouse (CO_2 and CH_4) gas generation was established [1].

The regional Suess effect was observed when investigate concentration of fossil fuel CO_2 in Busan, Korea [2]. Regional Suess effect is a phenomenon in which concentrations of fossil fuel CO_2 depending on the region where the samples are collected.

The samples are collected from 4 areas based on 3 variables in Gyeongju (Korea). It can be seen the difference between each area where traffic site (including parking lot, road and railway areas) and building site are widely distributed, or areas where forest is widely distributed. We can compare fossil fuel CO_2 and regional characteristics such as building site or traffic site and forest field. Using AMS (Accelerator Mass Spectrometer), located in Dongguk University Gyeongju, measure the $^{14}C/^{12}C$. The fossil fuel CO_2 was calculated from the $^{14}C/^{12}C$ data was compared with the local characteristics.

2. Material and method

Four locations are selected based on the ratio of area forest field or building site or traffic site to each region area. The area ratio means:

$$(\text{area ratio}) = \frac{area\ of\ variable(km^2)}{area\ of\ region(km^2)} \quad (1).$$

Sannae-myeon has the highest ratio of forest field in the Gyeongju. On the other hand, Hwango-dong has the lowest rate of forest field at 0.00. The traffic site ratio is the highest and the building site ratio is the second highest in the Gyeongju. Seondo-dong and Geoncheon-eup were selected in the middle area ratio of Sannae-myeon and Hwango-dong. All samples were collected near public institutions by region. The building site ratio of Seondo-dong is 44.5% higher than Geoncheon-eup, but traffic site ratio of Geoncheon-eup is 6.94% higher than Seondo-dong in Table Ⅰ.

Table I: The ratio of forest field, building site and traffic site of regional area at the sampling place. (Based on statistics provided in Gyeongju, 2017)

region	building site	forest field	traffic site
Sannae-myeon (35° 45`27``N, 129° 2` 49``E)	0.0102	0.8242	0.0116
Geoncheon-eup (35° 50` 58``N, 129° 6` 7``E)	0.0199	0.6499	0.0431
Seondo-dong (35° 50` 39``N, 129° 10` 29``E)	0.0359	0.6071	0.0403
Hwango-dong (35° 50` 44``N, 129° 12` 51``E)	0.4300	0.0000	0.2600

To measure fossil fuel CO_2 in the atmosphere for a year, we used the cherry tree leaf the common street trees in Gyeongju. It uses the CO_2 in the air for photosynthesis. The photosynthesis is a chemical reaction that occurs at the leaves to store form of carbon organic using the CO_2. It is the chemical process, the $^{14}C/^{12}C$ and $^{13}C/^{12}C$ in the leaves is lower or similar than in the atmosphere. This phenomenon is called the Fraction effect. Fraction effect has the characteristic that each material has its own value, so it can be corrected with fraction factor [3].

Samples are kept dry before pre-treatment and after physical treatment, impurities are removed through the ABA chemical treatment. After pre-treatment, samples were oxidized at high temperature (more than 950℃) with EA (element Analysis) to extract the carbon from the leaf. After that, it reacts with Fe by reducing carbon for measure with AMS.

To calculate the fossil fuel CO_2 ratio in total CO_2 in atmosphere ($CO_{2,\ fossil}$) in each region, we used follow equations [4, 5] :

$$ff = \frac{CO_{2,fossil}}{CO_{2,city}} = \frac{\Delta^{14}C_{bg} - \Delta^{14}C_{city}}{\Delta^{14}C_{bg} + 1000} \quad (2).$$

$CO_{2,\ city}$ is the total CO_2 in each region, $\Delta^{14}C_{bg}$ and $\Delta^{14}C_{city}$ is $\Delta^{14}C$ in the background and each region.

3. Results and Discussion

Using the $^{14}C/^{12}C$ data, calculate the value of $\Delta^{14}C$ and ff ($=CO_{2,\ fossil}/CO_{2,\ city}$) and compare with building site or traffic site per forest field.

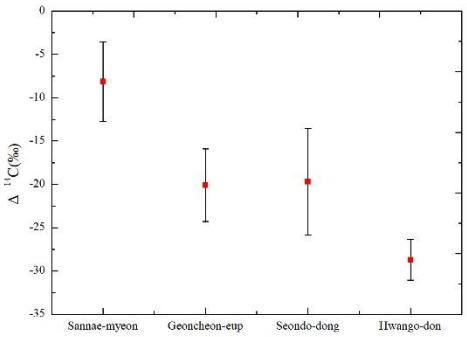

Fig. 1. The data of $\Delta^{14}C$ each region

Table II: The ratio of building to forest field, traffic to forest field and the value of ff.

region	Building/Forest	Traffic/Forest	ff
Sannae-myeon	0.0396	0.0454	0.0000
Seondo-dong	0.0710	0.0711	0.0117
Geoncheon-eup	0.0304	0.0745	0.0121
Hwango-dong	151.2136	46.9013	0.0208

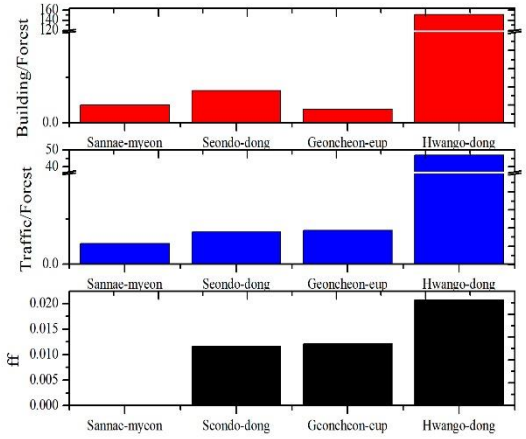

Fig. 2. Compare with building/forest, traffic/forest, and the value of ff.

The Building/Forest (which is building site ratio per forest field ratio) and Traffic/Forest (which is traffic site ratio per forest field ratio) is the lowest at Sannae-myeon and the highest at Hwango-dong. Comparing Seondo-dong and Geoncheon-eup, the Building/Forest is higher at Seondo-dong, but the Traffic/Forest is higher at Geoncheon-eup. Traffic/Forest, Building/Forest and ff value are shown in Table Ⅱ.

When $\Delta^{14}C$ is -1000 ‰, the sample is only affected by fossil fuel. The average $\Delta^{14}C$ value is shown at Fig. 1. The average $\Delta^{14}C$ of Sannae-myeon is highest among regions, so we used it for the regional reference background. The ff is shown in Fig. 2.

According to Table Ⅱ, The average value of ff is shown 0.00 at Sannae-myeon, because that is region reference background. Hwango-dong ff value is highest about 0.0208. The ff value of Geoncheon-eup is higher than Seondo-dong about 0.0004, it is 3.31% of Geoncheon-eup. Seondo-dong is much higher Building/Forest about 52.11% and lower Traffic/Forest about 20.83%, but the ff is lower than Geoncheon-eup. It means Traffic/Forest is more effect on ff value. The Traffic/Forest graph is much closer ff graph than the Building/Forest graph, as Shown in Fig. 2.

There are too few variables and samples to conclude that Traffic/Forest ratio is cause of fossil fuel CO_2 occurrence. Thus, the research about relation of fossil fuel CO_2 and regional characteristics should be kept going to use more region samples and variables.

4. Conclusions

For a compare with fossil fuel CO_2 concentration and regional characteristics like traffic site and building site by forest field, we measured $^{14}C/^{12}C$ of each regional sample using the AMS and calculate the fossil fuel CO_2 concentration. By comparing the variables with calculated fossil fuel CO_2 concentration, the fossil fuel CO_2 also tends to increase as the traffic site of forest field increases in Fig. 2.

However, the number of variable and sampling region is too small to define the exact relationship. Thus, the research will be proceeded with more variables and sampling regions to find the cause of the regional Suess effect.

REFERENCES

[1] T. M. L. Wigley, "The Kyoto Protocol: CO_2 CH_4 and climate implications," *GEOPHYSICAL RESEARCH LETTERS*, vol. 25, no. 13, pp. 2285-2288, 1998.

[2] 성기석, 박중헌, 홍완, 박규준, N. Roshimich and 이종걸, "가속기 질량분석법을 이용한 부산지역의 화석연료 기원 이산화탄소 농도 분포 측정 및 연간 변화량 비교," in *Korean Meteorological Society*, 2012.

[3] K. E. stenstrom, G. Skog, E. Georgiadou, J. Genberg and A. Johansson, "A guide to radiocarbon units and calculations," Lund University, Nuclear Physics, 2011.

[4] M. Molnár, L. Haszpra, É. Svingor, I. Majkor and I. Svetilk, "Atmospheric fossil fuel CO_2 Measurement using a field unit in a central european city during the winter of 2008/09," *Radiodaron*, vol. 52, no. 2, pp. 835-845, 2010.

[5] L. Ingeborg, D. Bernd, S. Martina and S. Hartmut, "A novel approach for independent budgeting of fossil fuel CO_2 over Europe by $^{14}CO_2$ observations," *GEOPHYSICAL RESEARCH LETTERS*, vol. 30, no. 23, p. 5, 4 12 2003.