

How is Human Breathable Air Changed by Forests? : The Characteristics of Natural VOC in Birch Forests

Geonwoo Kim¹, Sujin Park¹, Yeji Choi¹, Soojin Kim¹ and Eunsoo Kim¹

¹Forest Human Service Division, Future Forest Strategy Department, National Institute of Forest Science, Seoul 02455, Korea; Correspondence: bkim5020@korea.kr

INTRODUCTION

- People have comfortable lives with industrialization and urbanization, but paradoxically are more exposed to many stressful environments as their urban lives become more advanced.
- From the human perspectives, the natural environment can be defined as a forest that restores the balance and harmony of the human body and provides comfort and restfulness.
- In countries that consider a forest environment as a means of healing, there is a growing social demand to promote health and well-being by utilizing forests as a therapeutic space.
- Natural volatile organic compounds (NVOC), representing the healing forest factor, are widely known as 'phytoncides' in Korea.
- Several studies have shown that NVOC emitted from forests have various noticeable therapeutic effects such as disease prevention and health improvement.

SCOPE AND OBJECTIVE

- Several empirical studies of which showed that a forest environment affects humans in both physical and mental health have been released.
- However, the previous studies focused on experiments about the crossover comparison of the groups through certain activities like meditation, walking or recreation.
- On the other hand, the experiments that attempted to analyze the factors for forest therapeutic environment (such as NVOC, light, wind, anion or thermal environment) are relatively insufficient due to financial and other difficulties.
- Thus, this study aimed to develop a prediction model for NVOC concentration based on a microclimate environment in order to predict NVOC concentration more effectively.
- The study was also performed to scientifically suggest the potentiality of a forest as a healing space by providing real time information of NVOC concentration.

METHODOLOGY

- Study Site**
 - The study site is a birch forest located in the *Betula platyphylla* var. *japonica* forest, a mountain Maebong (37°58'42" N, 128°14'50" E, 690m above sea level).
 - The birch forest contains 700,000 trees planted in 138ha.

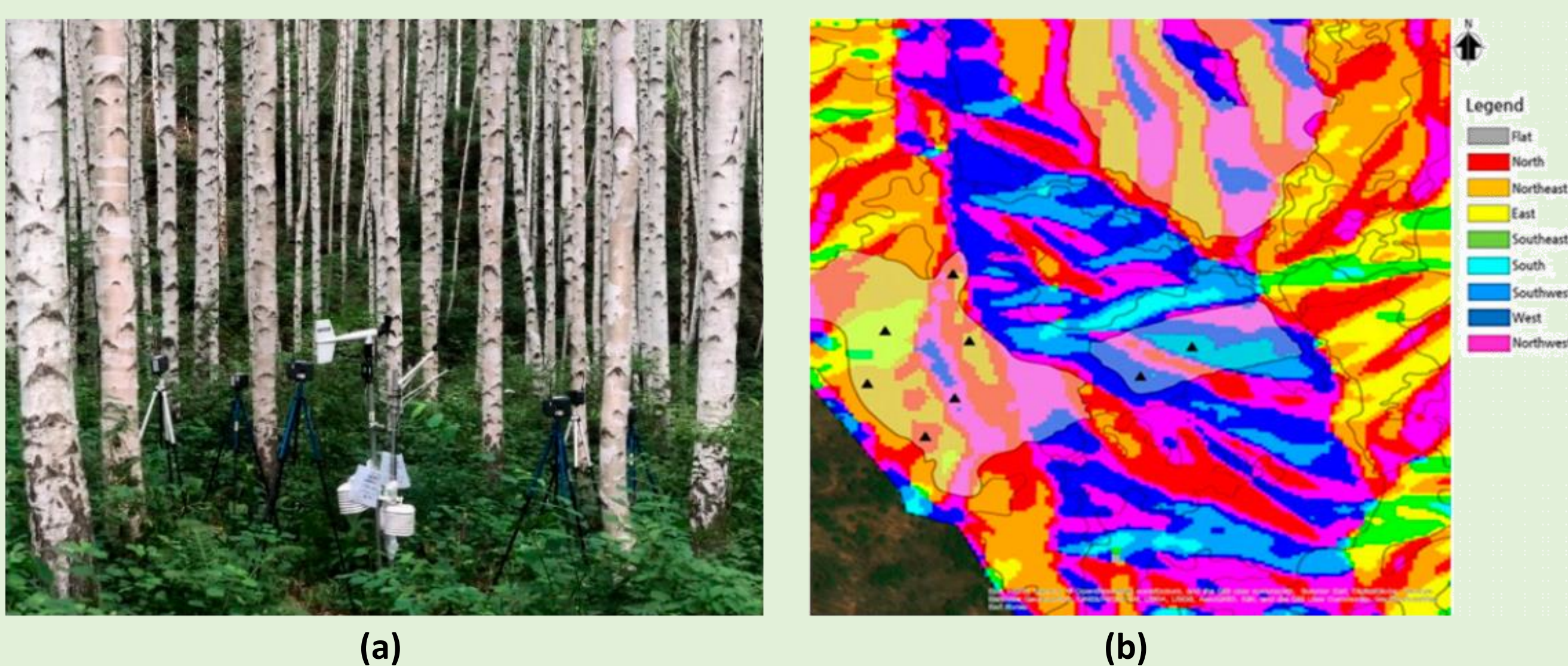


Figure 1. (a) Placing measurement devices on the site. (b) The classification map of site types.

- Measurement Factors and Methods**
 - In this study, NVOC were collected in November 2018, May and July 2019.
 - The study sites were set up at 20m intervals and 6 pumps were placed at each point of the study site in consideration of the vegetation characteristics.
 - The NVOC concentration was detected from sunrise to sunset, nine times a day.
 - A total NVOC volume of 9L was collected at a flow rate of 150mL/min.
 - The sampling equipment was installed on a tripod, 1.5m from the ground.
 - Microclimate environment factors were measured by a portable multifunction meter (HOBO-U23 V2, Onset, Bourne, MA, USA), solar radiation sensor (S-LIB-M003, Onset, Bourne, MA, USA), photosynthetically active radiation sensor (S-LIA-M003, Onset, USA) and wind monitoring sensor (Wind monitor O5103-45, R.M.Y., Logan, UT, USA) at intervals of 5 min.
- Data Analysis**
 - Total of 380 samples were analyzed through Statistical Package for Social Science Software, Version 23 (IBM corp., SPSS Inc., Armonk, NY, USA).

KEY FINDINGS

Characteristics of NVOCs at *Betula platyphylla* Forest

- The comparison of the construction of NVOCs in the forest in the spring and summer are shown below with 27% of α -pinene ($0.37 \mu\text{g}/\text{m}^3$), followed by 10% of camphor ($0.14 \mu\text{g}/\text{m}^3$) and 9% of β -pinene ($0.12 \mu\text{g}/\text{m}^3$).

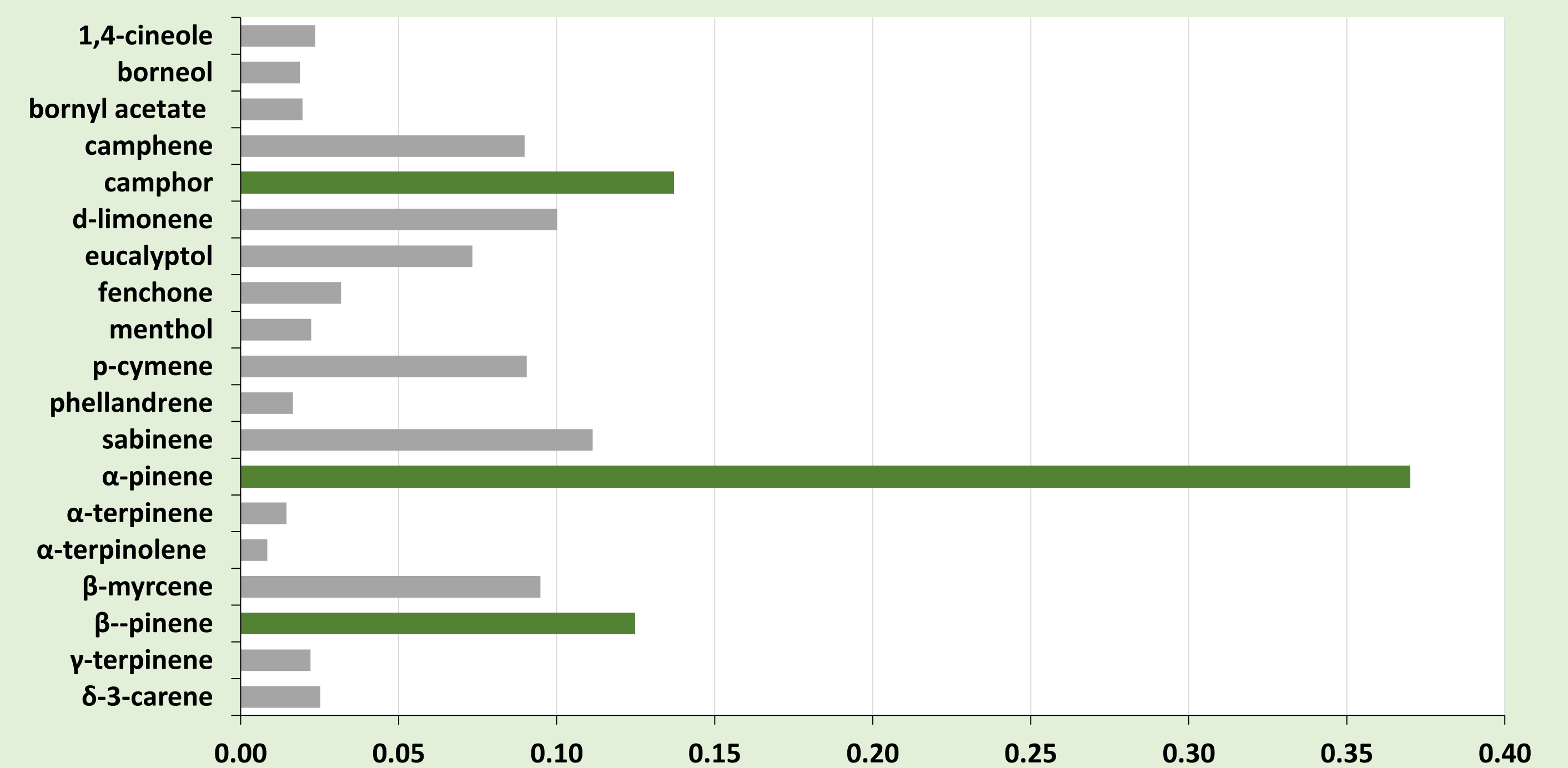


Figure 2. NVOCs concentration characteristics of the study site ($\mu\text{g}/\text{m}^3$)

The Intraday Variation of NVOC Concentration

- α -pinene and camphor were detected at high concentrations during the sunset.
- Based on thorough investigation of other substances that were detected at low concentration, it was confirmed that sabinene, α -terpinene, etc. were detected high concentrations during culmination.
- Most of the cases were influenced by wind velocity, but some of the substances experienced the change in concentration by photo environment.

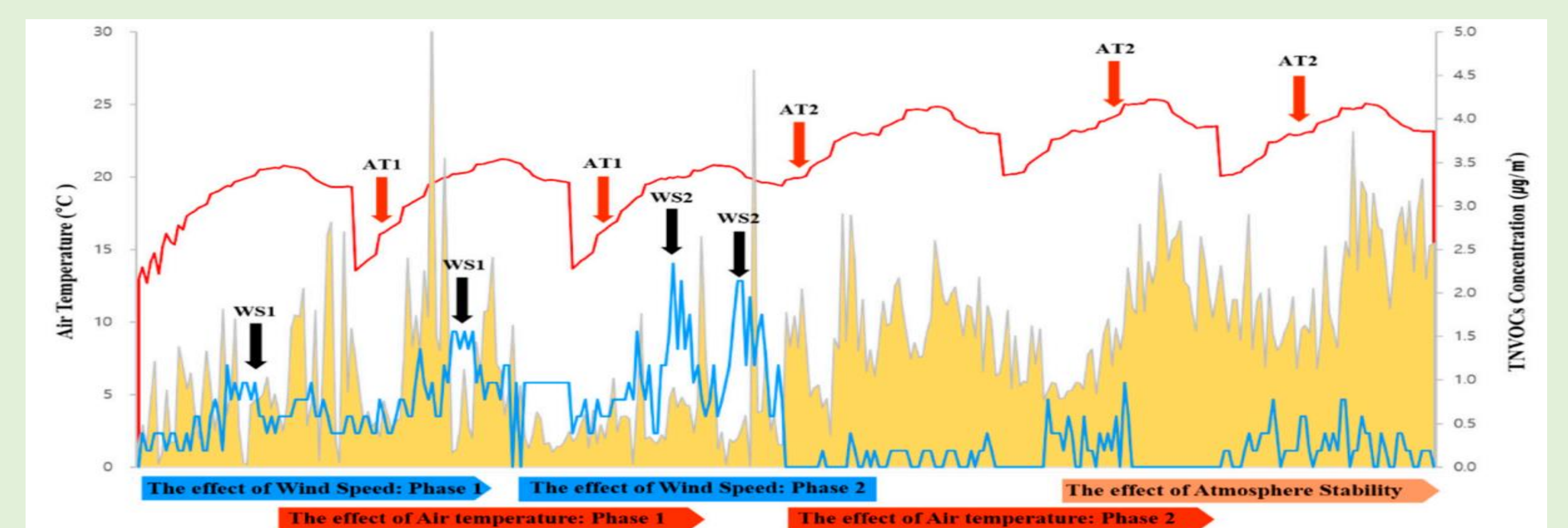


Figure 3. Concentration effect of NVOC by the influence of wind speed and air temperature

Relationship between NVOC and Microclimate

- Negative linear relationship was confirmed with wind velocity.
- Positive linear relationships were confirmed with temperature and humidity.

Prediction Model for NVOC Concentration

- The multiple regression analysis results presented a significant regression model with an F value of 83.296. The R^2 was as high as 60.1%.
- Durbin-Watson value was 1.990, and the variance inflation factor (VIF) was near 2.
- Model of NVOC Concentrations from *B. platyphylla* forest
 $= -1.204 + 0.096 * (Temp) + 0.008 * (Hum) - 0.261 * (Vel)$

CONCLUSION AND RECOMMENDATIONS

- To achieve sustainable development of white birch forest, this study was conducted to identify the potential of these forests as healing spaces with forest value.
- To complement the financial and technical issues of existing NVOC measurement techniques, the study collected a total of 380 samples and detected 19 types of NVOC substances.
- In this study, a prediction model for the NVOC concentration of *B. platyphylla* was proposed considering the concentration changes related to the microclimate.
- However, with the lack of validation samples and high analysis costs, it is necessary to obtain samples for comparative validation in the future studies and the model should be supplemented after considering various physical factors.
- With the results of this study, it is hoped that the prediction model for NVOC concentration that this study proposes will be more connected to the data from the forest meteorology net of South Korea, so that it can provide real time information of NVOC concentration in the therapeutic forests in the country.