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Research on Fungi Evolution Trend Based on Entropy Method

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Abstract: It is often said that where there is carbon, there are fungi ready to break it down. Fungi, as nature's greatest decomposers, always have great interest in dead plants or animals. Without them, the carbon cycle would not work. Therefore, it is necessary to study the factors that influence their decomposition rate. In this paper, some mathematical models were established to study fungi's decomposition of woody fibers and plant material.

1. Introduction

The carbon cycle, which allows carbon to be exchanged throughout the biosphere, is one of the most significant cycles of the Earth. Green plants on the ground capture carbon dioxide through photosynthesis and then store carbon in the form of cellulose and lignin. When the plants die, fungi have the ability to break down the remains of them. They obtain nutrients by decomposing large molecules to smaller ones used for breathing and eventually turn them into carbon dioxide for reuse by the nature. After 'eating fill with glucose', the fungi's hyphae will sprout di˙erent kinds of fruiting bodies, such as mushrooms we know, see Figure 1.

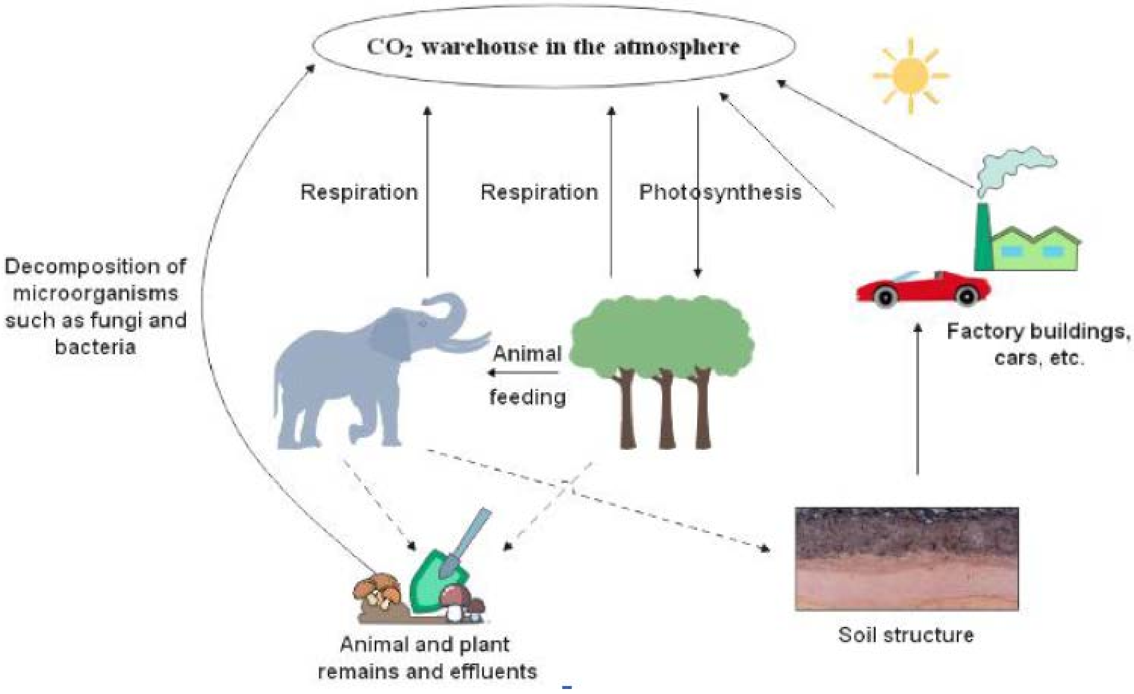

Figure 1: The carbon cycle

Since the decomposition of fungi can make the Carbon constantly recycl in nature, it plays an important roal in the carbon cycle. Where carbon is present, there are fungi that are ready to degrade it. But how does the fungi break down the cellulose and lignin? The growth rate of the fungus, the fungus' tolerance to moisture and various factors can influence the eÿciency of fungi's decomposition. So, figuring out the mechanism of decomposition is helpful to find the top decomposition rate and make better use of fungi.

2. Decomposition rate model of single fungi

2.1 Decomposition mechanism of wood fiber

For their own growth, reproduction and other physiological activities, fungi obtain energy by decomposing the breakdown of ground litter and woody fibers, whose main components are cellulose, hemicellulose and lignin.

Wood rot fungi, including white rot fungi, brown rot fungi and soft rot fungi, is crucial to the biodegradation in nature. It is generally believed that white rot fungi is the most important lignin degrading microorganism because it can secrete extracellular oxidase.

The decomposition mechanism of cellulose is as follows

$$\text{Crystal cellulose} \xrightarrow{C_1} \text{Amorphous cellulose} \xrightarrow{C_x} \text{Cellulose} \xrightarrow{\beta\text{-glucosidase}} \text{Glucose}$$

The decomposition of lignin by fungi depends on a complex extracellular peroxidase system, which is mainly composed of three enzymes, namely, Laccase, Manganese-dependent peroxidase (Mnp) and Ligninase (Lip).

Respiration of fungi. Using glucose, fungi usually carry out Aerobic respiration, that is, the conversion of glucose to CO2 and H2O, accompanied by the energy conversion of ATP and ADP. In addition, if anaerobic respiration, it will produce ethanol and other substances.

$$C_6H_{12}O_6 + 6H_2O + 6O_2 \overset{enzyme}{\rightarrow} 6CO_2 + 12H_2O + \text{ ATP(more)}$$

$$C_6H_{12}O_6 \overset{enzyme}{\rightarrow} 2C_2H_5OH + 2CO_2 + \text{ ATP(less)}$$

The factors that a˙ect the decomposition rate. In terms of environmental factors, after analyzing the above mechanism and consulting the relevant data, we think that the reaction rate is greatly a˙ected by the enzyme activity, and the enzyme activity is a˙ected by temperature, humidity and other environmental factors. Besides, oxygen concentration in respiration is a parameter that can not be ignored. In terms of the characteristics of fungi, it is known that growth rate, moisture tolerance and mycelium density are the main influencing factors.

For multi-fungal systems, we set a parameter β to indicate the degree of each fungus contribu-tion to the total decomposition rate of the community, describing the multi-fungal decomposition rate model.

2.2 Model building

Based on the above ideas, we comprehensively consider the influencing factors and their correlation with the decomposition rate, setting the corresponding correction coeÿcient, and initially establishing the following model:

$$v = \alpha_1 T + \alpha_2 h + \alpha_3 O + \alpha_4 N + \alpha_5 s + \alpha_6 g + \alpha_7 m + \alpha_8 d$$

2.3 data processing and analysis

After establishing the preliminary model, we gathered data from many major databases and screened out the useful data for this study. Through the reference article [1] given in title, we trace to the source of its experimental data which is of high reliability. Their experiments obtain the wood consumption rate of ten typical kinds of fungi in di˙erent conditions. We first cleaned up the data and filter the data that deviates from normal, to reach the desired data results.

To demonstrate better the relationship between temperature and decomposition rate, we use MATLAB to get ten lines in Figure 2 by a linear fitting. Figure 2(a) shows the variation trend of five fungi named ‘f.fom.n’ , ‘l.carib.s’ , ‘l.crin.s’ , ‘m.trem.s’ and ‘p.flav.s’ . Figure 2(b) describe another five fungi named ‘p.gilv.n’ , ‘p.pend.n’ , ‘ p.rufa.acer.n’ , ‘p.sang.s’ and ‘t.chion.n’ .

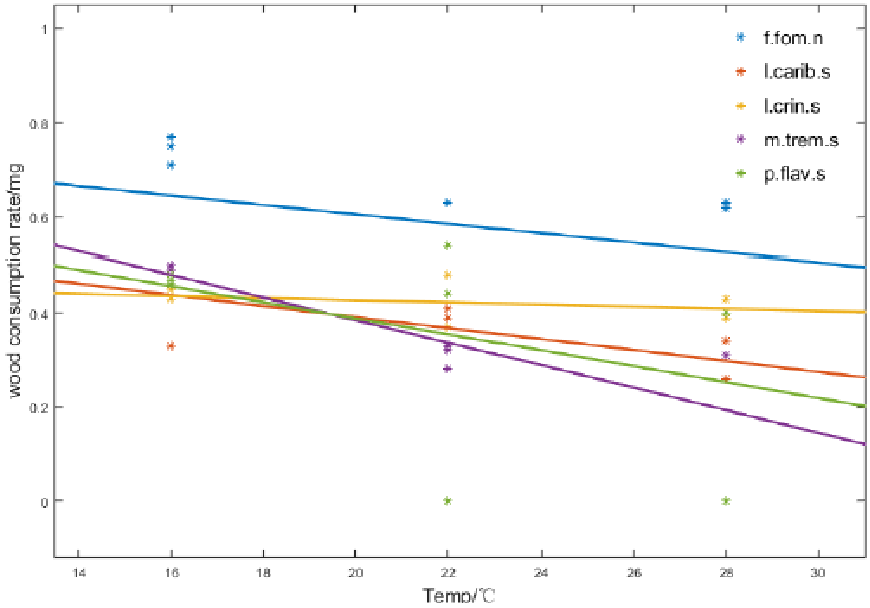

Figure 2 (a)

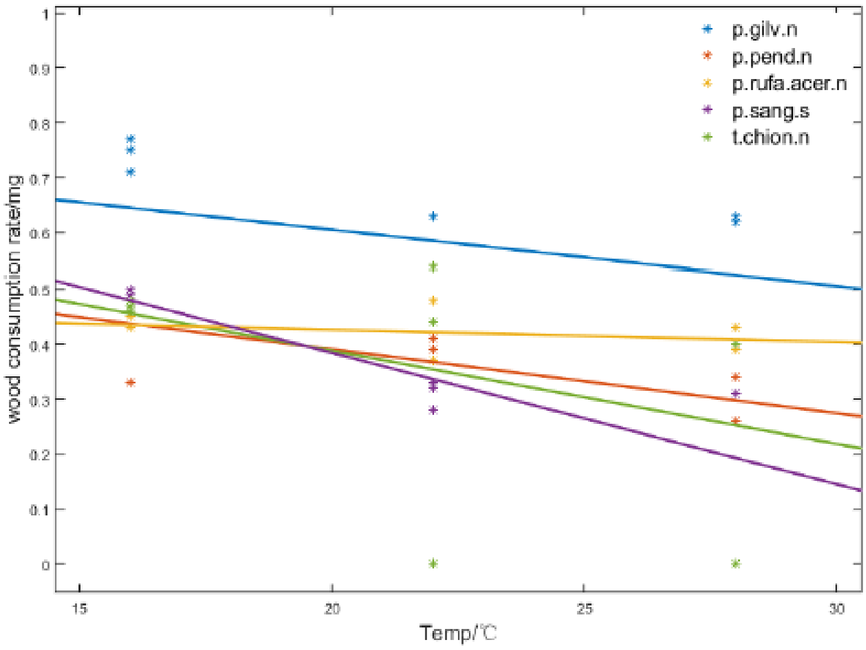

Figure 2 (b)

Figure 2: Use MATLAB to get ten lines

In this figure, each color represents a type of fungi. There are linear correlation between temperature and decomposition rate. It is easy to find that as the temperature rise, some fungi's decomposition rate go up, some go down. This varies with the species of the fungi.

Besides temperature, we also analyze the impact of humidity of environment.

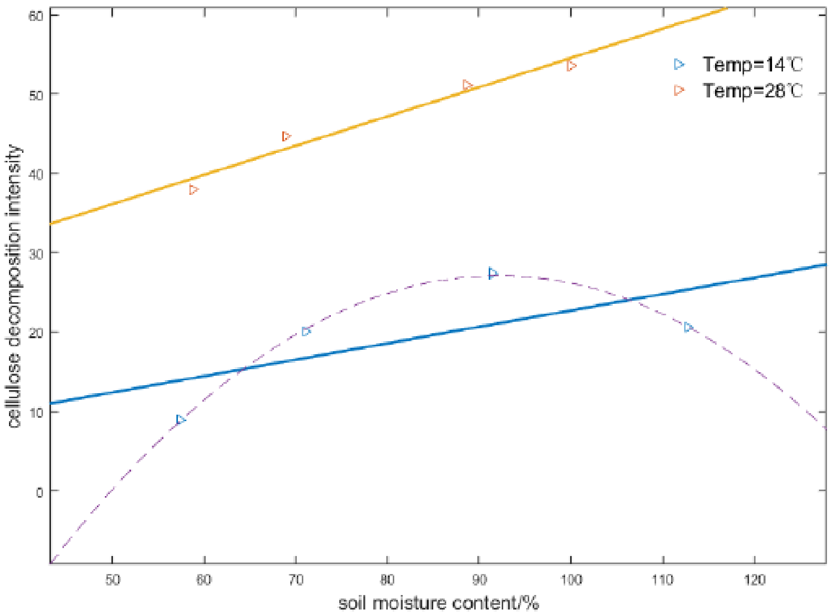

Figure 3: The impact of humidity of environment

As is shown in Figure 3, under the same temperature, the fungi's decomposition rate increase as the soil moisture content raising.

3. Sensitivity Analysis

In the previous modeling process, we combined the average values of ten fungi to determine the influence factor of humidityα2. But in practice, the e˙ect of humidity on di˙erent fungi varies greatly. In order to more accurately describe the e˙ect of humidity on fungi's growth rate, sensitivity analysis of α2 was performed. We change α2 from 0.3 to 0.8, as shown in Figure 4.

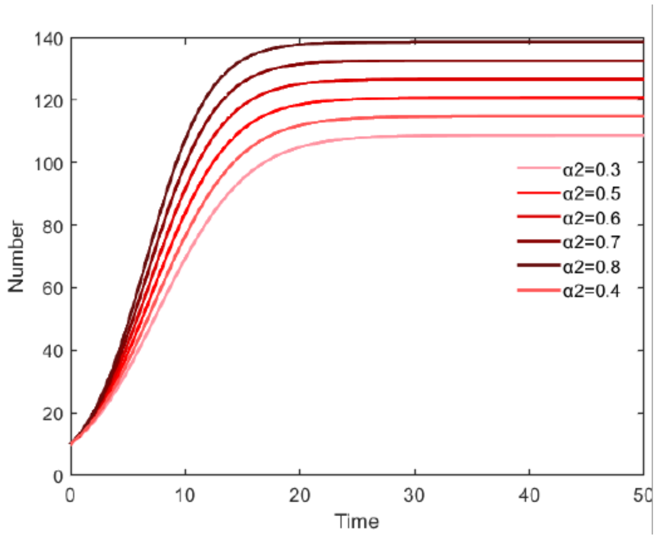

Figure 4: The results for the change of α2 from 0.3 to 0.8

The results showed that when the parameters were changed, the overall trend of the number of fungi did not change. However, when the proportion of the influence of humidity on the population increases, the number of fungi that reach a stable level will also increase. In addition, we also made a sensitivity analysis of the initial number of fungi. By the same principle, we change μi from 10 to 60. The result is shown in Figure 5.

Figure 5 shows that when the initial number of the population changes, the number of fungi that reach a stable level does not change.

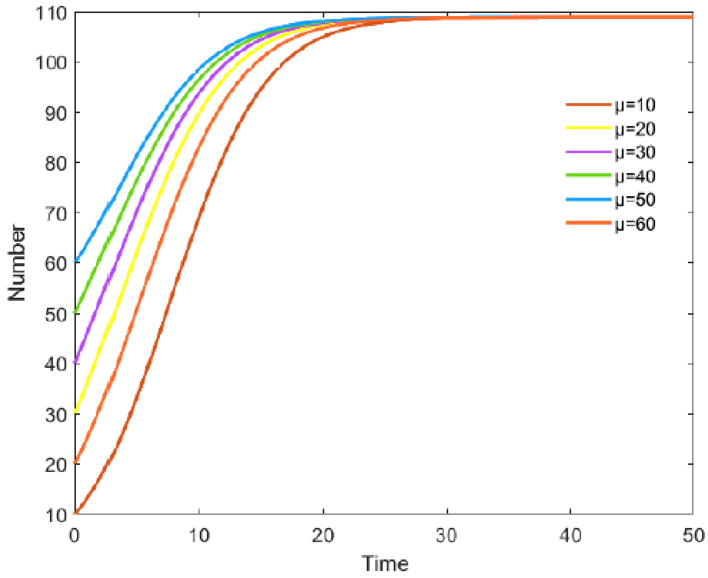

Figure 5: The results for the change of μi from 10 to 60

4. Further Discussion

On the basis of the models and results that have been obtained, and after more in-depth thinking, we have summed up the following ideas that can be improved or further studied:

In the hypothesis, we think that the e˙ect of influencing factors on the community is linear, but this relationship is more complex in nature. Therefore, although a more complex functional relationship will increase the diÿculty of solving the model, it is also more accurate and close to the real nature.

We believe that the interaction intensity between fungal populations is random, but in fact, the e˙ects between di˙erent populations should be generally stable. If there are experimental conditions that can more accurately study the interaction between the two species, thus the model will be improved, of course.

References

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