Claims

1. A train compartment air adjustment and control method based on microorganism, comprising the following steps:

1) testing $PM_{2.5}$ concentration, PM_{10} concentration, CO concentration, NO_2 concentration, SO_2 concentration, O_3 concentration, and the total number of bacterial colonies at an air supply port, an air exhaust port and a seat of a train;

2) establishing, according to the $PM_{2.5}$ concentration, PM_{10} concentration, CO concentration, NO_2 concentration, SO_2 concentration, O_3 concentration, and the total number of bacterial colonies at each test point in a compartment, a mapping relationship between the total number of bacterial colonies *D* and the concentration *d* of air pollutants in each micro environmental unit, wherein the micro environmental unit is the test point;

3) selecting a measured air pollutant concentration data set with a time length of *N* minutes, calculating the total number of bacterial colonies according to the mapping relationship, denoting a time series of the total number of bacterial colonies at the ith seat as X_N^i, denoting a time series of the total number of bacterial colonies at the jth air supply port or air exhaust port as Y_N^j, performing hypothesis test by using Granger causality test to determine whether there is causality between X_N^i and Y_N^j, performing hypothesis test by using Granger causality test and then obtaining a test result set of each seat test point, *m* air supply ports and *n* air exhaust ports;

4) obtaining a nonlinear description model base of all seat test points according to the mapping relationship and the test result set; and

5) inputting ventilation rates of all air supply ports and air exhaust ports of the train to a grey wolf optimizer, calculating fitting results of the total number of bacterial colonies at the air supply ports/air exhaust ports under different ventilation rates, inputting the fitting results to the nonlinear description model base to obtain a fitting result of the total number of bacterial colonies at each seat, and determining the ventilation rates of all the air supply ports and air exhaust ports by using the fitting result of the total number of bacterial colonies at each seat.

2. The train compartment air adjustment and control method based on microorganism

according to claim 1, wherein in step 2), a specific implementation process of establishing a mapping relationship between the total number of bacterial colonies *D* and the concentration *d* of air pollutants in each micro environmental unit comprises:

A, reading a data set of air pollutant concentration and total bacterial colony indexes of the current micro environmental unit in M consecutive historical moments, and dividing the index data set into a training set and a test set;

B, constructing a microorganism-air pollutant model by using a deep belief network, and training the deep belief network by using the air pollutant concentration as input of the deep belief network and the total number of bacterial colonies at the same moment as output of the deep belief network;

C, using the test set as input of the trained deep belief network, and selecting a group of parameters with highest description accuracy on the test set as a microorganism-air pollutant mapping model of the micro environmental unit; and

D, repeating steps A-C until all the micro environmental units are traversed to obtain the mapping relationship between the total number of bacterial colonies and the air pollutants in the total $m + n + p$ test points, where *m*, *n*, and *p* are numbers of test points at the air supply ports, the air exhaust ports, and the seats respectively.

3. The train compartment air adjustment and control method based on microorganism according to claim 1~~ or 2~~, wherein in step 3), the test result set is $\varphi_i = \left\{T_{i,1}^{in}, T_{i,2}^{in}, .., T_{i,m}^{in}, T_{i,1}^{out}, T_{i,2}^{out}, ..., T_{i,n}^{out}\right\}$, where~~ $T_{i,j}^{in}$ is a test result of the air supply port, $T_{i,j}^{in}$~~ $= T_{i,j}^{in/out} = GCT(X_N^i, Y_N^j)$, ~~$T_{i,j}^{out}$ is a test result of the air exhaust port, and $T_{i,j}^{out}$ = $GCT(X_N^i, Y_N^j)$;~~ and values of the test results ~~$T_{i,j}^{in}$ and $T_{i,j}^{out}$~~ $T_{i,j}^{in/out}$ are 0 or 1; and *GCT* () represents Granger causality test.

4. The train compartment air adjustment and control method based on microorganism according to claim ~~3~~1, wherein a specific implementation process of step 4) comprises:

I) reading $PM_{2.5}$ concentration, PM_{10} concentration, CO concentration, NO_2 concentration, SO_2 concentration, and O_3 concentration at the seats, the air supply ports, and the air exhaust ports at P consecutive historical moments, and calculating the total number of bacterial colonies at each test point in the P consecutive historical moments

according to the mapping relationship;

II) reading the total number of bacterial colonies ~~$O_i = \left[S_i^{seat} \right]_t$~~ at the ith seat test point and the total number of bacterial colonies ~~$I_i = \left[S_j^{in/out},\ \text{s.t.}\ T_{i,j}^{in/out} = 1 \right]_t$~~ ~~at the air supply port and the air exhaust port which have causality with the ith seat test point, where S_j^{in} is the total number of bacterial colonies at the air supply port, S_j^{out} is the total number of bacterial colonies at the air exhaust port, $S_j^{in/out}$ is S_j^{in} or S_j^{out}, and $T_{i,j}^{in/out}$ is $T_{i,j}^{in}$ or $T_{i,j}^{out}$~~;

III) using I_i as input of a deep echo state network and O_i as output of the deep echo state network, and learning the corresponding relationship between the total number of bacterial colonies at the seat and the air supply port/air exhaust port at different historical moments; and

IV) repeating steps I) to III) until all the seat test points are traversed to obtain the nonlinear description model base of all the seat test points~~, where the nonlinear description model base is a set of corresponding relationships of the total number of bacterial colonies at all the seat test points and the air supply ports/air exhaust ports~~.

5. The train compartment air adjustment and control method based on microorganism according to one of claims ~~2~~1 4, wherein in step 5), a specific implementation process of calculating fitting results of the total number of bacterial colonies at the air supply ports/air exhaust ports under different ventilation rates comprises:

i) increasing a ventilation rate at equal intervals and measuring the total number of bacterial colonies under the corresponding ventilation rate;

ii) performing least square fitting on the total number of bacterial colonies at the kth air supply port/air exhaust port to obtain a ~~polynomial g(vk)~~polynomialg expression method of the total number of bacterial colonies $\hat{S}_k$ with respect to the ventilation rate v_k; and

iii) repeating steps i) and ii), and traversing all the air supply ports and the air exhaust ports, to obtain a polynomial fitting result $\left\{ \hat{S}_k \middle| k = 1,2,3,...,m+n \right\}$ of the total number of

bacterial colonies at all the air supply ports and the air exhaust ports changing with the ventilation rate, where *m* and *n* are numbers of test points at the air supply ports and the air exhaust ports respectively.

6. The train compartment air adjustment and control method based on microorganism according to claim 5, wherein in step 5), an optimization objective is set to simultaneously minimize the fitting result of the total number of bacterial colonies at each seat, and an optimization function is $\min \ \{\hat{S}_1, \hat{S}_2, ..., \hat{S}_k, ..., \hat{S}_{m+n}\}$ s.t. $\hat{S}_k = g(v_k), l_k \le v_k \le u_k$, where u_k and u_l are an upper limit and a lower limit of the ventilation rate at the kth air supply port/air exhaust port respectively.

7. The train compartment air adjustment and control method based on microorganism according to claim ~~6~~2, wherein in step 5), a non-dominated solution NS^*=arg min *E*, which minimizes an evaluation index $E = \sum_{k=1}^{m+n} \hat{S}_k + Var(\hat{S})$, is selected for determining the ventilation rates NS^* of all the air supply ports and the air exhaust ports, where $\hat{S}_k = g(v_k), l_k \le v_k \le u_k$; $Var(\hat{S})$ is a variance of the total number of bacterial colonies at all the seats in the test set and u_k and l_k are an upper limit and a lower limit of the ventilation rate v_k at the kth air supply port/air exhaust port respectively.

8. A ~~computer apparatus,~~train compartment air adjustment and control system based on microorganism comprising a ~~memory, a processor, and a~~ computer ~~program stored on the memory~~equipment, wherein the ~~processor executes the~~ computer ~~program~~equipment is programmed to ~~implement~~execute the steps of the method according to one of claims 1 to 7.

~~9. A computer readable storage medium, storing a computer program/instruction, wherein when the computer program/instruction is executed by a processor, the steps of the method according to one of claims 1 to 7 are implemented.~~

~~10. A computer program product, comprising a computer program/instruction, wherein when the computer program/instruction is executed by a processor, the steps of the method according to one of claims 1 to 7 are implemented.~~