APPENDIX AVAILABLE ON REQUEST

Research Report 154

Part 2. Association of Daily Mortality with Ambient Air Pollution, and Effect Modification by Extremely High Temperature in Wuhan, China

Zhengmin Qian et al.

Appendix I. Standard Operating Procedure for Ambient Air Pollution Data Collection in Wuhan

---

Correspondence may be addressed to Dr. Zhengmin Qian, Department of Community Health, School of Public Health, Saint Louis University, Salus Center/Room 473, 3545 Lafayette Ave., St. Louis, MO 63104

This document was produced as part of the Public Health and Air Pollution in Asia (PAPA) program. The PAPA program was initiated by the Health Effects Institute in part to support the Clean Air Initiative for Asian Cities (CAI-Asia), a partnership of the Asian Development Bank and the World Bank to inform regional decisions about improving air quality in Asia. Additional funding was obtained from the U.S. Agency for International Development and the William and Flora Hewlett Foundation. The contents of this document have not been reviewed by private party institutions, including those that support the Health Effects Institute; therefore, it may not reflect the views or policies of these parties and no endorsement by them should be inferred.

This document was reviewed by the HEI Health Review Committee but did not undergo the HEI scientific editing and production process.

Wuhan Standard Operating Procedures for Air Monitoring

Air monitoring regulation and quality control

I. Monitoring

1) Equipment operating requirement:

1.1. Wuhan environmental monitoring center air automatic monitoring system uses the US DASIBI-1000 automonitoring system. This equipment has been approved by the US EPA. The operation strictly follows the DaSiBi equipment instruction. (See the equipment instructions for details)

1.2. Central control personnel check the monitoring data every morning, observing flow, temperature, pressure, and other parameters of the monitoring equipment and whether or not these parameters meet the requirements as specified in the equipment instructions.

1.3. This monitoring system has good remote control function and can automatically carry on person-to-machine dialogue. When the reports of the SO_2 and NO_2 monitors fall outside the required range, the monitors will be examined to determine whether this situation is caused by equipment failure. The central control personnel can make corrective remote adjustments according to the equipment instructions.

1.4. When the parameters are outside of the required range, personnel on duty can identify the reason for the failure by remote control and inform their supervisor. The supervisor will send people to the branch monitoring station either to repair the equipment or to replace the faulty equipment parts.

2) Equipment calibration

2.1. SO_2 and NO_2 equipment is calibrated automatically at 2 PM everyday. Also, calibration is done twice every week with 400 ppb span calibration (equipment full range is 500 ppb). If zero calibration is +/- 5 ppb and span calibration is +/- 40 ppb (span +/- 10%), the equipment must be adjusted.

2.2. PM_{10} monitors use the gamma ray method with automatically calibrated film. The equipment automatically carries 5-7 blank samples and the standardized sample measurement for each sample. The average will be regarded as the value of the blank sample as well as the standardized sample. The calculation of the sample will be determined by subtracting out the blank sample. In addition, the system will check whether or not the standardized samples are within the required range. (The standardized range according to the equipment instructions is +/- 10%.) The blank value and standardized values will be shown along with the value measured by the equipment.

2.3. At least one time every half year complete a multiple calibration for the operating SO_2 and NO_2 monitors. (See appendix for method of multiple calibration.)

2.4. During the equipment adjustment, the equipment zero/span and multiple calibration, equipment accuracy and precision must be within the requirement.

2.5. Zero/span check must be done after any replacement of parts. Mechanical parts, electronic parts, optical parts, and magnified electric sensor parts and light source parts are especially subject to multiple calibrations.

2.6. According to the requirement, to insure the quality of equipment, the working status of equipment has to be done with zero/span calibration.

2.7. The steering bottle of helium is provided by the Beijing Helium company. This company is owned by China and the United States together. This company has an ISO9000 certificate. In addition, they have certificates on producing various trace gases. The quality of the trace gas was level 1 according to the U.S. standard. We (Wuhan monitoring system) have not found any problem in using this system.

2.8. The accuracy of multiple gas calibration equipment is +/- 0.6% on the electronic soap film meter. This system is used to check the flow of 0-100 mL/min, and 0-10 L/min.

Appendix: multiple calibration of monitors

- First, make sure that the multiple gas calibration quality is within the requirement when giving the monitoring equipment the full range of trace gas concentrations of 0%, 10%, 30%, 50%, 70% and 90%. Record the response values after all readings are stable. (For the record of multiple calibration, see Appendix A.)

- The standard calibration curve is based on the linear regression method. When the concentration of gas to be measured is *y* and the equipment response value is *x*, the calibration curve can be expressed using the following equation:

$$y = ax + b$$

Where

y is the standardized concentration value (ppm)

x is the equipment response value

a is the slope of the calibration curve

b is the intercept of the calibration curve

the least squares method includes

$X= (\Sigma x)/N$

$Y = (\Sigma y)/N$

$a = [\Sigma xy- (\Sigma x\ \Sigma y)/N]/[\ \Sigma\ x^2-(\Sigma x)^2/N]$

$b = y-ax$

$S_x= [(\Sigma x^2/N-X^2)/(N-1)]^{1/2}$

$S_{y=}[(\Sigma y^2/N-y^2)/(N-1)]^{1/2}$

$r=aS_x/S_y$

where:

X is the average mean of variable x

Y is the average mean of variable y

S_y is the standard deviation of variable y

S_x is the standard deviation of variable x

a is the slope

b is the intercept

r is the correlation coefficient

- Through evaluation of the calibration curve, we can identify the monitor's working status. The intercept of the calibration curve represents the monitor's zero-drift status. The slope represents the monitor's linear index. The correlation coefficient represents the degree of match between the obtained curve with the calibrated points.

3) Equipment maintenance

3.1. Daily maintenance

3.1.1. Pay close attention to the electric supply communication status of the branch station and the surrounding situation. Frequently clear weeds and water. Cut off tree branches which may influence the sampling.

3.1.2. Observe the working status of all equipment. Check equipment flow and other parameters to make sure that all parameters are within the range required by the equipment instructions. Check the clock frequently to make certain that it is correct. If the parameter falls outside of the requirement, adjustments should be done immediately. (See equipment instructions for operation details)

3.1.3. Check the zero calibration value and standardized values; if the value falls outside the required range, immediate adjustment has to be done. (See equipment instructions for operating details.)

3.1.4. Monitor filters must be replaced every week. Based on the degree of environmental pollution, the replacement period can be extended but can be no longer than 30 days. When changing filters, also clean the monitoring netting and recalibrate the zero value. (See equipment instructions for operating details.)

3.1.5. Check the operation status of the PM_{10} monitoring paper strip. If the strip is broken, is off track, is running out of paper, contains any dirt speck, or is not clean on the edge, treatment should be done immediately. (See equipment instructions for operating details.)

3.1.6. Check the agreement of values measured by the monitors and the values shown on the data collecting equipment. If the deviation exceeds the requirement range, adjustment should be made immediately (See equipment instructions for operating details.)

3.1.7. Check the room temperature of the branch station. Every effort should be made to minimize the gradient between the outside and the inside temperatures. The room temperature at the branch station should be 20-30^{o}C. The best temperature is 24-26^{o}C. In the hot summer, the room temperature should be adjusted upward to 26-30^{o} C to be more consistent with the outside air temperature. Otherwise, the high-temperature outside air will condense when it meets with an indoor temperature which is too cool. In the cold winter, the room temperature should be set lower to 20-24^{o}C. During other seasons, the room temperature should be 24-26^{o}C.

3.1.8. Check the sampling main tube and branch tube. Condensation or dirt contamination must be cleaned out immediately. The preferred method of cleaning is using high pressure gas blown through the tube. If the dirt contaminate cannot be cleaned up by high pressure air, soapy water is used instead. After cleaning up the dirt contaminate, water is used to clean the tube, and the tube is then dried off.

3.1.9. Check the pressure of the zero gas source pressure. The pressure of zero gas source should be adjusted to 20psi - 25psi. (See equipment instructions for operating details.)

3.1.10. Check the valid date and the pressure of the steel bottle of trace gas. If past the valid date, the gas must be replaced. The pressure indicated by the high pressure meter should be larger than 0.5 MPa. If the high pressure meter indicates that pressure is less 0.5 MPa the trace gas has to be replaced. The pressure indicated by the low pressure meter should equal to 0.14 MPa. If the low pressure meter indicates that the pressure is more or less than 0.14 MPa, adjustment has to be made.

3.1.11. Prevent dust influence on the cold air circulation of the air conditioner. The filter netting of the air conditioner has to be cleaned out once every month. Maintain the cleanness of the branch station.

3.1.12. Vigilantly complete the records from the inspection tour according to the table of the inspection tour.

3.2. Fixed time maintenance of equipment at the branch station.

3.2.1. Replace the active charcoal and the molecule screening of the zero gas source at intervals not exceeding 6 months.

3.2.2. Replace the filter of the ozone flow of the NOx analyzer equipment at intervals not exceeding 6 months.

3.2.3. Replace the filter of the active charcoal of the gas pump for the NOx analyzer equipment at intervals not exceeding 6 months.

3.2.4. Clean out the PM_{10} sampling system, depending upon the air quality, every 3 - 6 months but not exceeding 6 months.

3.2.5. The equipment at the branch station has to be multiple-flow calibrated once every year.

3.2.6. The equipment at the branch station has to be calibrated every year using the multiple points method.

3.2.7. Make sure that the air conditioning is working normally. Replace the remote control battery in the air conditioning every six months.

3.2.8. Other items not mentioned here: See equipment instructions for maintenance method.

4) Emergency treatment of equipment failure.

4.1. If failure happened at the branch station, personnel should go to the sites immediately and check the cause of the failure.

4.2. Small failures (which do not require replacement of parts) can be dealt with at the sites. One hour is necessary after treatment to make sure that the equipment has recovered to normal working status and that there are no other problems.

4.3. If parts need to be replaced or recovery cannot be made immediately, the equipment should be taken to the central station. At the same time, spare equipment should be set up in order to minimize missing data.

4.4. If the failure happened on the electric supply, all of the equipment should be stopped, and the electric supply department should be informed. After the required repair is done, the stability of the electric supply should be checked. Make sure the voltage is maintained within the required range. The equipment should be started up again gradually, one by one. In addition, personnel should remain for one hour to observe that all of the equipment is working properly.

4.5. If the communication failure happened internally at the monitoring system, then repair and replacement of parts should be done at the monitoring site. If the failure happened at the communication outside, the communication department should be informed as soon as possible.

5) Method of inspection tour to the branch monitoring station

5.1 One person is assigned responsibility at each branch monitoring station.

5.2. That person is responsible for daily maintenance and fixed time maintenance of the monitoring equipment, dealing with small failures or accidents, making sure that the equipment operates normally, and obtaining accuracy monitoring data.

5.3. The responsible person should be vigilant in filling out the automatic monitoring inspection tour records.

5.4. According to the nature of the work, the responsible personnel from several branch stations can work at one monitoring station simultaneously.

5.5. According to the report from the personnel at the central control station, the supervisor can arrange the branch station people to the monitoring sites to deal with the failure and equipment maintenance at any time.

II. Explanation of the air pollution data in Wuhan

The ambient air pollution data in Wuhan is collected using the U.S. Dasibi air quality automatic monitoring system. There are 5 nationally recognized branch monitoring stations in Wuhan, located at Hankow, Hanyang, Wuchang, Qingshen, and Donghu. The monitoring air pollutants are inspirable particles (PM_{10}), SO_2, and NO_2. The statistical methods used to analyze these air pollution data are listed below.

1) The calculation method.

The calculation method is done according to Chinese National standards (GB8170-87). The unit of monitored pollutants is mg/m^3 accurate to the third decimal (0.000). The units can also be expressed as $\mu g/m^3$, depending on the pollutant's concentration. For concentrations too low to be measured, half of the lowest checking limit of the equipment will be used as the measured value.

2) Outliers

2.1. When the measured concentration is too low (e.g. background value), a negative value can be obtained because of the zero drift of the monitor. There is no physical meaning to this value. This negative value can be regarded as a value of "unable to measure."

2.2. For the monitoring station with an automatic calibration system, if equipment zero drift/span drift exceeds the control range during the period of zero/span calibration,

the data from the time it becomes out of control until the equipment is recovered should be regarded as invalid data. The data cannot be used statistically.

2.3. The data during the period of zero calibration/span calibration should be regarded as invalid data. It cannot be used statistically, but a flag should be made on these data and the records stored as evidence.

2.4. When values are missing because of a loss of power, any data received by the central control station during the period of the loss of power should be regarded as invalid data. The period of loss of power should be counted at the start of power outage until complete warm-up of equipment. The data cannot be used statistically.

2.5. Because pollutant concentrations change over time and change slowly, there should be no swift change in pollutant concentration in the results of normal monitoring. Either a swift change or no change indicates that there is an equipment problem. The problem should be identified, and the data between the start of problem to recovery should be regarded as outliers. These data cannot be used statistically.

3) Statistics of monitoring data

3.1. One time value

The central control station will use an average of 15 minutes of pollutant concentrations measured at the branch station as a one-time value. The central control will modify this value and judge whether this value is an outlier using the report software.

3.2. One hour average mean value

At least 75% of the one-time values should be used to calculate the one-hour average mean value. One-hour average mean value is calculated by averaging all the valid one-time values within one hour.

3.3. Daily average mean

For PM_{10} at least 12 valid hourly mean values are needed to calculate the daily mean value (using the calendar as the valid time frame), using all available valid hourly mean values. For SO_2 and NO_2 at least 18 hourly mean values everyday are needed to calculate valid daily mean value (using the calendar as the valid time frame). All of the valid hourly mean values are used to calculate the daily mean. (National Environmental Air Quality Standard GB3095-1996)

3.4. Monthly mean value

The arithmetic mean of all valid daily mean values within the month.

3.5. Seasonal mean value

The arithmetic mean of all valid daily mean values within the season.

3.6. Yearly mean value

The arithmetic mean of all valid daily mean values within the year.

3.7. Urban district daily mean value is calculated using the monthly mean value, the seasonal mean value, and the yearly mean value from 5 branch stations.

The Central Automatic Monitoring Division of Wuhan Environmental Monitoring Center

October 18, 2004.