Analysis on Indoor Air Pollution-a Case Study of Pengxiang Yizhai

Xudong Lyu

1 School of Life Sciences, Tianjin University, Tianjin, Tianjin, TJ 22, China
*Corresponding author’s e-mail: angela@cas-harbour.org

Abstract. This article focused on the indoor air quality and conducted a case study of Pengxiang Yizhai to assess the status quo of the indoor air pollution in China. The experiment is carried out by the electronic detector, the air sample is drawn into the detection chamber through the holes in the pipes to determine the concentrations of the particles. Different concentrations of air pollutants were measured and nearly all of them exceeded the national standard. Meanwhile a public opinion poll was held to collect the opinions of the residents. After identifying indoor pollution sources and illustrating the harmful effects on human health, a couple of countermeasures to address the pollution problem were finally given in this paper.

1. Introduction

Nowadays in China, air population is a heated discussion. Compared to frequently mentioned outdoor particular matter, indoor air pollution is an invisible risk factor. It is true that outdoor particular matter can exert a measurable influence on human health, but indoor air pollution can by no means be overlooked just because indoor air is misunderstood to be better. Dense tenements are ubiquitous in developing countries, especially in metropolis. There may be no better example than students’ dormitories.

Pengxiang Yizhai is an undergraduate dormitory building of Tianjin University (Weijin Road Campus). It is located in the intersection of Huying Road and Jinhun Road, inside the Tianjin University, Weijin Road 92nd, Naikai District, Tianjin. Pengxiang Yizhai is a typical representative of its kind-dense tenements in metropolis. Furthermore, few residents have paid attention to indoor air pollution problems.

The project was started by online literature search and field trips. Basic data and understandings such as the number of residents, local climate and surrounding environment were emphasized. Afterwards, the public opinion poll was performed to collect residents’ perspectives towards indoor air pollution. At the meantime, consulting with the responsible property company, Dongwu Property Ltd, turned out to be more than helpful. Based on numerous materials and in view of actual situation and limited capacity of residents, this article focuses on indoor air pollution, especially indoor particular matter, analyses how indoor air pollution affects human health, both physically and mentally, and lastly, will provide several practical strategies that could be applied to address it properly.

2. Analysis of indoor air pollution

2.1. Air quality situation

2.1.1. General air quality situation
In the initiation phrase, the Dongwu Property Ltd, Logistics Support Department of Tianjin University as well as Tianjin Environmental Protection Agency were involved to obtain relatively authentic circumstances and professional guidance. It is learned that Tianjin used to be a heavily-polluted city owing to the rapid economy development, ignorance of environmental protection and lack of austere governmental supervision. Nevertheless, after the enactment of new policy of environmental protection in 2018, the environmental situations have improved greatly. Apparently, the pollution built up by decades cannot be handled thoroughly and properly in such a short period. As a consequence, the air quality in Tianjin still scarcely meets the China’s Air Quality Standards set in 2012, leaving numerous civilians living in polluted air condition.

During the research, what is unexpected is that common indoor air pollutants are often more sobering compared with outdoor levels. Possible causes are that there are immense neglected indoor sources of air pollutants such as sofa, carpets, beds and plastic objects, and that the effectiveness of the efforts made to conserve energy in buildings, such as weather stripplings, which manage to trap pollutants inside simultaneously.

2.1.2. Indoor air pollution situation
In the data collecting phrase, indexes in consecutive days and a weekday were collected with a household air quality detector. The detector displays the maximums of indexes after warm-up and numerical stationarity. Formaldehyde content, VOCs, PM1, PM2.5 and PM10 are target test items.
Table 1. Indoor Air Pollution Indexes in Consecutive Days (Collected)

|       | Formaldehyde (mg/m³) | Formaldehyde (ppm) | TVOC (mg/m³) | PM1 (μg/m³) | PM2.5 (μg/m³) | PM10 (μg/m³) |
|-------|----------------------|--------------------|--------------|-------------|---------------|--------------|
| 4.28  | 0.182                | 0.126              | 0.994        | 19          | 25            | 29           |
| 4.29  | 0.177                | 0.131              | 1.062        | 19          | 25            | 29           |
| 4.30  | 0.248                | 0.160              | 1.447        | 11          | 15            | 16           |
| 5.1   | 0.226                | 0.168              | 1.351        | 9           | 13            | 15           |
| 5.2   | 0.249                | 0.185              | 1.488        | 16          | 22            | 25           |
| 5.3   | 0.260                | 0.178              | 1.469        | 9           | 10            | 15           |
| 5.4   | 0.287                | 0.188              | 1.546        | 12          | 17            | 19           |
| Average| 0.233                | 0.162              | 1.337        | 13.6        | 18.1          | 21.1         |

According to the standards set by Ministry of Ecological Environment of the People's Republic of China (GB 3095-2012), the air quality in Pengxiang Yizhai rarely meets with acceptable standards. Take formaldehyde for example, the standards give 0.10 mg/m³, which is terribly surpassed by the average data, 0.233 mg/m³. And 0.60 mg/m³ is the standard for TVOC, which is outstripped too. Unfortunately, there is no clear standard with regard to PM.

Table 2. Indoor Air Pollution Indexes in a certain weekday (Collected)

|       | Formaldehyde (mg/m³) | Formaldehyde (ppm) | TVOC (mg/m³) | PM1 (μg/m³) | PM2.5 (μg/m³) | PM10 (μg/m³) |
|-------|----------------------|--------------------|--------------|-------------|---------------|--------------|
| 7:00  | 0.260                | 0.192              | 1.494        | 22          | 29            | 34           |
| 9:00  | 0.263                | 0.195              | 1.572        | 26          | 35            | 40           |
| 11:00 | 0.265                | 0.197              | 1.585        | 25          | 34            | 39           |
| 13:00 | 0.246                | 0.183              | 1.471        | 12          | 16            | 18           |
| 15:00 | 0.255                | 0.189              | 1.528        | 9           | 13            | 15           |
| 17:00 | 0.298                | 0.221              | 1.787        | 8           | 11            | 12           |
| 19:00 | 0.246                | 0.183              | 1.474        | 7           | 10            | 11           |
| 21:00 | 0.238                | 0.177              | 1.428        | 10          | 14            | 16           |
| 23:00 | 0.234                | 0.174              | 1.417        | 9           | 10            | 15           |
| Average| 0.256                | 0.190              | 1.528        | 14.2        | 19.1          | 22.2         |

From the dynamic changes of indexes on Friday, May 3rd 2019, it can be drawn that nearly all indexes see a decline during the daytime. The reason to choose this specific day is that it is not the weekend when people spend longer time indoors than they usually do. The possible reasons are that reduced human activities lead to less disturbance and emission, and ventilation contributes to downturn.

2.2. Public opinion poll

One of the most efficient ways to define the issues that worth time and effort is to listen to direct stakeholders, who in this case, are undergraduates living in Pengxiang Yizhai. Views of the masses are thought highly of and the public opinion poll was carried out consequently. Data analysis shows:

About 60% of residents are unsatisfied with current air quality, more than 30% of interviewees express that they do not care about the living environment in particular, while the rest 70% say they reluctantly compromise with the status quo. From the survey data, 81% of interviewees indicate that some actions must be taken to improve air quality, at least indoors. 56% say they are willing to make changes even if it means sacrificing their own convenience. Unfortunately, nobody has made any kinds of efforts. Nearly all of them say it is more than challenging to better air quality individually so that they have not taken an action.
3. Analysis of indoor air pollution

3.1. Effects of indoor air pollution

Indoor air quality plays a significant role in human health, both physically and mentally. Indoor air pollution can cause bronchitis and airway obstruction, contributing to the cancer. Inhaling dirty air involves breathing in microbes and particular matters simultaneously. There is a growing tendency for people to worry about particular matters on account of its damage to important organs, especially lungs, as well as its ability to develop diseases like thrombosis. It should be underlined that the physiological structure of the human body determines that there is no filtering or blocking ability for PM2.5\(^1\). If the content of PM2.5 increase by 10μg/m\(^3\), the mortality on that day will increase by 1.5%, 3.3% for intractable pneumonia patients and 2.1% for ischemic heart disease patients\(^2\).

PM2.5 is a terrific carrier for heavy metal, among them, As, Cr, Cd and Ni are carcinogens. Heavy metal may not show their influences instantly, but in the long term, they are undoubtedly deadly threat. This project uses the exposure model recommended by the US Environmental Protection Agency to better understand the potential effects of PM2.5 on human health\(^3\). The conclusions are that heavy metal in the air can interfere with the intake of necessary mineral, which is closely associated with function of enzymes, thus affecting the degradation progress of toxic substances. Besides, heavy metal deposited on the walls of blood vessels can lead to the lack of elasticity of the vessel walls, putting increasing risk of narrowing of the blood vessels, especially in heart and brain. To make it worse, heavy metal can inhibit the absorption of hormones, causing hormone imbalance through negative feedback regulation.

What is unexpected is that air pollution can also influence mental health. A study carried out by University of Washington showed that compared with the residents whose living environment had an average PM2.5-year concentration of 5 micrograms per cubic meter, the residents whose average PM2.5-year concentration reached 21 micrograms per cubic meter had 17% higher psychological distress\(^4\). The possible explanation is that the polluted air cannot guarantee that human cells consume enough oxygen to function normally. Undoubtedly the effects upon physical health can never be neglected.

3.2. Sources of indoor air pollution

Before the discussion of solutions, the sources of air pollutant need to be found out for the sake of better understanding and comprehensive consideration. Potential sources are as follows.

(1) Pollutants from outdoors. On account of the need of ventilation, indoor air system is linked to outdoor air surroundings. Considering the fact that the noticeable role the convection plays is widely acknowledged by the public, this article mainly focuses on the uncommon sources. For example, Radon gas seeping up naturally from soils and rocks underneath the building, and pollens carried by insects into the building, especially in spring, both of them can barely possible to hold back.

(2) Pollutants generated indoors. A considerable number of furniture are to blame for their contribution to indoor dust mites. Not frequently cleaned carpet is the first to bear the brunt. Additionally, taking the comfort and safety of residents into consideration, many managers apply pesticide inside the building, which few people know. Some daily supplies such as cigarettes and perfumes also release substantial particles into the air, for example, aldehydes, nitrides and olefins, which can stimulate the respiratory tract.

(3) Cooking. This factor is not popular in dormitory, but more than familiar to ordinary residential building. Owing to the special Chinese dietary habit, the usage of frying pan is general. Cooking methods such as frying, smoking and braising can release tremendous pollutants into the air. To name but a few, cracking products of oils—polycyclic aromatic hydrocarbons are semi volatile\(^5\). To make it worse, many rural communities in China still use coal to cook, whose products pose threaten to chronic bronchitis.
3.3. Practical countermeasures

After the discussion of several aspects of PM2.5 above, this part will offer advisable counterparts to solve, at least improve, the conundrum: changing ventilation and purification mode and raising awareness of indoor air pollution prevention.

As for the proposed strategies, to replace ventilation and purification mode is the most urgent task. The traditional way of ventilation is to realize air conviction just by windows and air conditioners. New proposal targets to arm windows with absorption devices as on many Japanese highways to absorb pollutant matters, which has proven to be surprisingly effective[6]. Meanwhile, air conditioners with purification are favored. The expenses of both of the strategies are affordable compared with university funding, while the former makes less interruption to students’ life during construction.

In addition, given the lack of awareness on indoor air pollution, compulsory education to every student is expected. To make it better, it is even better to hold regular rating activities on the basis that Chinese students value their grades and credits very much. The target goals of the above two proposals are groups, yet every individual can make a contribution. The simplest stuffs for every individual to get started are sweeping the dormitory floors more frequently and removing the dust from objects before ventilation. At the same time, those behaviors are cultivating students’ habits and awareness of indoor air pollution.

4. Conclusion

The indoor air quality of residential building is closely related to human health, nonetheless, it used to be neglected by many. Because of late start and lack of experience, researches on air pollution are relatively deficient in China, especially indoors.

This project takes an undergraduate building as an example, analyses its indoor air pollution situation, values the effects on human health, infers the resources of air pollutants and provides several practical counterparts. The heavy metal inside particular matter are never supposed to be belittled in the long run. Moreover, simple attempts such as to replace ventilation and purification mode can be amazingly beneficial.

References
[1] Pan, X. (2005) The influence of indoor air quality on human health. J. Bulletin of National Natural Science Foundation of China, 4:205-208.
[2] Zhao, H., Shao, L., Shi, Z. (2003) Indoor Air PM2.5 Research Status and Development Trend. J. Environ Health, 20:310-312.
[3] Wang, J., Wang, F., Han, M., Jia, C. (2018) University Campus Indoor PM2.5 Heavy Metal Pollution Characteristics and Its Health Risk Assessment. J. Journal of Southeast University, (Natural Science Edition) 40:955-960.
[4] Li, X. Be careful! (2007) Air pollution also "pollute" mental health, Xinhua Net. [Online] Available:http://www.xinhuanet.com/world/2017-11/08/c_129735122.htm[Accessed on Aug. 16, 2019]
[5] Qian, H., Dai, H. (2007) Indoor Air Pollution and Its Adverse Health effects. J. Environ Occup Med, 24:426-430.
[6] Yuan, W. J., Han, M. R., Wang, H., (2019) Pollution and Control of Unorganized Emission from Gasifier Station. Glass, doi 1003-198702-0049-04.