Journal of Cleaner Production 112 (2016) 1658–1666

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Mitigating construction dust pollution: state of the art and the way forward

Zezhou Wu [a], Xiaoling Zhang [b,*], Min Wu [c]

[a] Department of Building and Real Estate, The Hong Kong Polytechnic University, Kowloon, Hong Kong
[b] Department of Public Policy, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong
[c] School of Architecture and Built Environment, Faculty of Engineering and Built Environment, The University of New Castle, Australia

ARTICLE INFO

Article history:
Received 27 March 2014
Received in revised form
23 December 2014
Accepted 8 January 2015
Available online 17 January 2015

Keywords:
Construction dust
Air pollution
Mitigation
China

ABSTRACT

Along with China's modern industrialization, challenges on smog crisis are raising dramatically in the past decade. The sources of municipal smog are multiple and complex, one of which is construction dust emission due to the rapid urbanization. In literature, there are studies focusing on the end-pipe treatment of construction dust; however, very little research has been conducted from the perspective of dust mitigation in developing countries. To fill in this research gap, this paper investigates the current situation of construction dust prevention and control in China, with the aim of providing insights for mitigating dust pollution caused by the construction industry. Through a combination of the content analysis, on-site observation, questionnaire survey and interviews with experienced professionals, a total of 11 related regulations are thoroughly reviewed, and the main sources of construction dust production are identified. A case study is further presented to demonstrate the prevailing dust control measures on site. Recommendations are proposed in order to increase the awareness of related stakeholders, including formulation of targeted regulations, establishment of an appropriate charging scheme, development of a feasible monitoring system, and enhancement of training and dissemination.

1. Introduction

Air pollution has become a global crucial environmental problem, especially for the developing countries with rapid economic development. In China, the situation of air pollution is extremely severe (Jiang et al., 2013; Shi et al., 2014). According to the “urban outdoor air pollution database” established by the World Health Organization (WHO), the annual average PM10 (i.e. particulate matter with diameter of 10 μm or less) density of China is 98 $\mu g/m^3$ in 2009, while the world's average value is 71 $\mu g/m^3$ (WHO, 2011). Since 2013, it has been reported that the area of hazardous dense haze reached 1.4 million km^2 and the daily life of more than 800 million people were influenced (Finance, 2013). The increasing energy demand and transportation is considered to result in more serious air pollution in China (Liu et al., 2013). The adverse impact of air pollution is extensive, especially for the public health. A number of serious diseases, such as respiratory diseases, cardiovascular and cerebrovascular diseases, and even lung cancer can be caused by air pollution (Chen et al., 2013). Thus, concerns on the air pollution issues have been raised in different industrial sectors.

In mega cities of China, the particulate pollution is very severe (Chan and Yao, 2008). Though it has been investigated that the largest sources for particulate pollution include coal combustion, motor vehicle emission, and industrial dust (Xu et al., 2013), the particulate pollution in the construction industry should be given equal attention to. Regarding to the particulate pollution in construction industry, Zhang et al. (2013) claimed that the particulate matter is a main source of air emissions during a building's lifecycle. More specifically, Yang et al. (2005) and Song et al. (2006) stated that the calcium element in PM2.5 mainly originated from construction activities. According to Zhao et al. (2007), the average monthly contribution of construction dust to the overall PM10 pollution was around 10% in Beijing. Many construction procedures, such as drilling and grinding, can produce high level of particulates that can be inhaled into lung, and consequently lead to physical diseases (e.g., pneumoconiosis) and even social contradiction (ChinaLabourBulletin, 2009; Liang et al., 2003). As there is an increasing trend of the number of construction and demolition

* Corresponding author.
E-mail addresses: zezhou.wu@connect.polyu.hk (Z. Wu), xiaoling.zhang@cityu.edu.hk (X. Zhang), Manfred.Wu@newcastle.edu.au (M. Wu).

http://dx.doi.org/10.1016/j.jclepro.2015.01.015
0959-6526/

activities, it is predicted that construction dust pollution will become more serious in the future. Therefore, it is of necessity and significance to investigate the measures that can mitigate construction dust pollution.

However, the existing research on mitigating construction dust pollution is not adequate so far; only a few studies can be found concerning construction dust. The earliest study was conducted by Tharr and Lofgren (1993). In their research, case studies were employed to investigate the situation of silica exposure to concrete workers and masons. Similarly, Thorpe et al. (1999) evaluated three systems for mitigating dust pollution of cut-off saws through laboratory tests. In the same year, Chang et al. (1999) measured the TSP (i.e. total suspended particulates, refers to the particulate matters with diameters less than 100 micrometers) emission rate of road construction activities. Afterwards, Nlj et al. (2003) conducted an exposure study as well as a questionnaire survey to investigate the effectiveness of dust control measures for reducing quartz dust exposure, concluding that respiratory protection is the most widely used protection measure in construction industry. In China, Huang et al. (2007) investigated the generation characteristics of construction dust at different construction phases by monitoring dust fall, indicating that the dust pollution in earthwork phase is more severe than structure and decoration phases, and the pollution at spring is more severe than the other seasons. The most recent research on construction dust was conducted by Fan et al. (2012). They designed an experimental study to test the effectiveness of a dust control tool named “DustBubble”. The results showed that this tool could reduce the dust exposure significantly; however, the evidence on reducing respirable quartz exposure was weak.

Through the chronological literature review, it can be found that existing studies mainly focus on the end-pipe treatment which utilizes technological measures to deal with construction dust. Very little of the research has been conducted from the perspective of dust mitigation, e.g., how to use managerial instruments or measures to mitigate construction dust. To fill in this research gap and provide insights for mitigating dust pollution in the construction industry, this study investigates the current situation of construction dust mitigation in China. It aims to take an early attempt in investigating the management countermeasures of construction dust mitigation. Three research objectives are as follows.

- To generalize the development of construction dust regulations in China.
- To investigate the main sources and corresponding countermeasures of dust pollution at jobsite.
- To provide recommendations for mitigating construction dust pollution at municipal level.

The rest of this paper is organized as follows: the methodology used in this study is introduced in Section 2. Then, the research findings, including relevant regulations retrieval, on-site dust generation sources and countermeasures, and municipal policy recommendations are discussed in Section 3. Finally, conclusions which highlight the main contributions and future research directions are presented in Section 4.

2. Methodology

The research methodology used in this study is a combination of content analysis, on-site observation, interviews with experienced professionals, questionnaire survey, and case study.

Content analysis was employed to investigate the development of regulations for mitigating construction dust pollution in China. Related clauses in the identified regulations were retrieved manually to analyze the historical. Furthermore, on-site observation was conducted, aiming to explore the sources of construction dust directly. The observation was conducted in Chongqing – a municipality which is experiencing rapid urbanization. Three construction sites were selected, including two projects at construction stage and one project at demolition stage. Regular site visits were carried out from 28 October 2013 to 27 November 2013, lasting for one month. In addition, interviews were also conducted to experienced professionals to verify the observation findings and to solicit their valuable comments. This procedure is very essential because the observation duration may not so adequate for discovering all the inconspicuous sources, meanwhile, the observed findings can be verified. A total of 17 interviewees were interviewed, including 10 contractors, 5 developers and 2 government officers. All of them had more than five years' working experiences. Table 1 shows the profile of the interviewees.

Four questions were asked during the interviews, including not only their perceptions of construction dust pollution, but also the practical measures that they have employed in real-life projects. The specific questions are listed as follows.

1) Do you think the on-site construction dust emission is a significant problem that needs to be addressed?
2) What are the main sources that bring construction dust in your project?
3) What countermeasures have been adopted to prevent dust pollution in your project?
4) If you regard the current dust mitigation situation is not satisfactory, what managerial strategies do you suggest for promoting dust mitigation?

After the interview, it was found that all of the respondents agreed that the on-site construction dust pollution is a common environmental problem that needs to be addressed and the current situation is not satisfactory. Potential sources that result in construction dust production were verified as well.

Table 1
Profile of the interviewees.

Category	Interviewee ID	Job category	Education	Experience (year)
Contractor	C1	Project manager	Associate degree (Bachelor)	11
	C2	Project manager	Bachelor	8
	C3	Project manager	Bachelor	7
	C4	Construction worker	High school	13
	C5	Construction worker	High school	11
	C6	Construction worker	High school	8
	C7	Quantity surveyor	Associate degree (Bachelor)	10
	C8	Quantity surveyor	Bachelor	6
	C9	Safety inspection	High school	9
	C10	Safety inspection	Associate degree (Bachelor)	6
Developer	D1	Project manager	Associate degree (Bachelor)	11
	D2	Project manager	Bachelor	8
	D3	Project manager	Master	7
	D4	Site supervision	Associate degree (Bachelor)	9
	D5	Site supervision	Bachelor	7
Government officer	G1	Construction supervision	Bachelor	7
	G2	Environment supervision	Master	5