(Revised 07/09)

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NSFC/RGC Joint Research Scheme
Joint Completion Report

(Please attach a copy of the completion report submitted to the NSFC by the Mainland researcher)

Part A: The Project and Investigator(s)

1. Project Title Health Risk Assessment of Toxic Trace Elements and Polycyclic Aromatic Hydrocarbons (PAHs) Via Indoor Dust from Coal-burning Households in Rural China

中國農村燃煤家庭室內大氣顆粒物中有毒元素與多環芳烴的健康影響

2. Investigator(s) and Academic Department/Units Involved

	Hong Kong Team	Mainland Team
Name of Principal Investigator *(with title)*	Prof. WONG Ming Hung (黃銘洪)	Dr. LIU Wenxin (劉文新)
Post	Research Chair Professor of Environmental Science	Associate Professor
Unit / Department / Institution	Department of Science and Environmental Studies, The Hong Kong Institute of Education.	College of Urban and Environmental Sciences, Peking University
Co-investigator(s) *(with title)*	Dr. WU Fuyong Dr. WU Shenchun Prof. LIU Wing Keung Dr. LEUNG Clement Kai Man	Dr. FU Xiaofang Dr. YU Yanxin Mr. LIU Yu Ms. MENG Bingjun

3. Project Duration

	Original	Revised	Date of RGC/ Institution Approval *(must be quoted)*
Project Start date	01 January 2012		
Project Completion date	31 December 2014		

Duration *(in month)*	36		

Part B: The Completion Report

5. Project Objectives

5.1 Objectives as per original application

1. To determine the level and mass distribution of PM based on dust particle size from coal-burning households in rural China;
2. To quantify the concentrations of toxic trace elements (As, Cr, Ni, Pb, F, Hg) and PAHs, Nitro-PAHs and OH-PAHs in indoor air, PM and indoor dusts collected from living rooms, bedrooms and kitchens in coal-burning households in rural China;
3. To evaluate the health risk of the toxic trace elements and PAHs exposure of local residents via indoor dust;
4. To study the toxic effects of indoor dust and PM on human airway cell lines (human macrophage and bronchial epithelial cells) (inhalation exposure), hepatoma cell lines (ingestion exposure) and keratinocyte cell lines (dermal contact); and
5. To understand the mutagenicity of PM and indoor dust from coal-burning households in rural China.

5.2 Revised Objectives

Date of approval from the RGC: _____

Reasons for the change: _____

_____

1.
2.
3. ....

6. Research Outcome

Major findings and research outcome
(maximum 1 page; please make reference to Part C where necessary)

This study indicated that in Baofeng and Fangcheng, the mean concentrations of $PM_{2.5}$ and PM_{10} were substantially higher in winter than in autumn at all measurement points (many of the differences were statistically significant at $p<0.05$). This indicated that winter heating in the study area caused seasonal variation of indoor air pollution. Among the collected samples, 92.9% $PM_{2.5}$ samples and 87.5% PM_{10} samples exceeded the 24-h health based guidelines for PM2.5 (65 μg m^{-3}) recommended by USA (USEPA, 1997) and PM_{10} (150 μg m^{-3}) recommended by China (GB/T, 18883–2002), respectively. During winter, the highest mean concentrations of $PM_{2.5}$ and PM_{10} (368.5 and 588.7 μg m^{-3}) were recorded in sitting rooms in Baofeng, which were 5.7 and 3.9 times of corresponding health based guidelines for $PM_{2.5}$ and PM_{10}, respectively. These implied that levels of household $PM_{2.5}$ and PM_{10} in rural Henan Province, especially during winter, posed a significant threat to human health (Wu et al., 2015a).

Samples of $PM_{2.5}$, PM_{10} were collected in rural households (Henan Province), households using four different types of domestic energy (crop residues, coal, liquid pertroleum gas (LPG) and electricity) for cooking and heating. The concentrations of As, Pb, Zn, Cd, Cu, Ni and Mn associated with $PM_{2.5}$ and PM_{10} varied among households using four different types of domestic energy, and between the two seasons. Mean concentrations of $PM_{2.5}$ and PM_{10} in kitchens in winter were 59.2–140.4% and 30.5–145.1% higher than those in autumn, respectively. Using coal resulted in severe increase of indoor air pollutants, including PM and associated metal (loid)s, compared with those using crop residues, electricity and gas. The concentrations of $PM_{2.5}$ and PM_{10} taken in by rural residents would be roughly reduced by 13.5–22.2% and 8.9–37.7% when using electricity, leading to a significant improvement in indoor air quality (Wu et al., 2015a).

In addition, high concentrations of $PM_{2.5}$-bound and PM_{10}-bound PAHs were detected in the rural households using the four different types of domestic energy in Henan Province. The most severe contamination occurred in kitchens in winter, where the daily mean concentrations of $PM_{2.5}$-bound PAHs were up to 762.5 ± 931.2 ng m^{-3}, indicating that there was serious health risk of inhalation exposure to PAHs in rural households of Henan Province. The present results also show that particulate-bound PAHs in rural households exhibited a large variability between the two seasons and among four types of domestic energy used. Significantly higher levels of particulate-bound PAHs were recorded in winter than in autumn.

The households using LPG for cooking gave rise to higher concentrations of PAHs in the kitchens than using crop residues or electricity. In addition, using coal in the sitting rooms generated higher concentrations of particulate-bound PAHs than using the other three types of domestic energy, during winter. The most severe contamination occurred in kitchens using LPG in winter, where the daily mean concentrations of $PM_{2.5}$-bound PAHs were up to 762.5 ± 931.2 ng m^{-3}, indicating the situation was serious. However, using electricity would significantly improve indoor air quality by reducing $PM_{2.5}$-bound and PM_{10}-bound PAHs (Wu et al., 2015b).

Furthermore, daily mean concentrations of BaP in $PM_{2.5}$ or PM_{10} were in excess of Chinese Air Quality Standards (1.0 ng m^{-3}) for indoor air (GB/T, 1883–2002) and the highest concentrations of BaP in $PM_{2.5}$ were up to 39.2 ng m^{-3} recorded in the sitting rooms using coal in winter, imposing serious potential cancer health risks of rural indoor air to inhabitants of Henan Province (Wu et al., 2015b).

Potential for further development of the research and the proposed course of action *(maximum half a page)*

This study reported results of a pilot research on indoor air quality, based on concentrations of metal(loid)s (As, Pb, Zn, Cd, Cu, Ni and Mn) and PAHs, associated with 4 different types of domestic energy (crop residues, coal, liquid pertroleum gas (LPG) and electricity) used in 2 rural areas (Baofeng and Fangcheng) of Henan Province. In order to reveal a fuller picture, the indoor air pollution due to the use of different types of domestic energy (crop residues, coal, liquid pertroleum gas (LPG) and electricity) in China, a more comprehensive study should be conducted, by studying more rural areas in different provinces. In addition, this study used total pollutant concentrations in samples to estimate potential health risks exerted may overestimate the actual health risks posted to human beings. Further studies related to human health risks could focus the bioaccessibility of pollutants contained in air samples, based on *in vitro* digestion models.

7. The Layman's Summary

(describe in layman's language the nature, significance and value of the research project, in no more than 200 words)

This study provides new information on indoor air pollution, resulting from using 4 domestic energy (crop residues, coal, liquid pertroleum gas (LPG) and electricity) for heating and cooking, in rural areas of Henan in China. Results showed that using electricity for heating and cooking in the studied villages can greatly reduce potential health risks exerted on local residents. This finding may help policy makers to improve indoor air quality in rural areas in Henan.

Part C: Research Output

8. Peer-reviewed journal publication(s) arising directly from this research project

(Please attach a copy of each publication and/or the letter of acceptance if not yet submitted in the previous progress report(s). All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.))

The Latest Status of Publications				Author(s)	Title and Journal/Book	Submitted to RGC	Attached to this report	Acknowledged the support of this Joint Research Scheme
Year of publication	Year of Acceptance *(For paper accepted but not yet published)*	Under Review	Under Preparation *(optional)*	***(bold** the authors belonging to the project teams and denote the corresponding author with an asterisk*)*	*(with the volume, pages and other necessary publishing details specified)*	*(indicate the year ending of the relevant progress report)*	*(Yes or No)*	*(Yes or No)*

2015a				**Wu FY***, Wang W, Man YB, Chan CY, Liu WX, Tao S, **Wong MH***	Levels of PM2.5/PM10 and associated metal(loid)s in rural households of Henan Province, China. Sci Total Environ. 512-513: 194-200		Yes	Yes
2015b				**Wu FY***, Liu XP, Wang W, Man YB, Chan CY, Liu WX, Tao S, **Wong MH***	Characterization of particulate-boun d PAHs in rural households using different types of domestic energy in Henan Province, China. Sci Total Environ. 536: 840-846		Yes	Yes
2015				Huang MJ*, Kang Y, Wang W, Chan CY, Wang XM, **Wong MH***	Potential cytotoxicity of water-soluble fraction of dust and particulate matters and relation to metal(loid)s based on three human cell lines. Chemosphere. 135: 61-66		Yes	Yes
2013a				Wang W, **Wu FY**, Huang MJ, Kang Y, Cheung KC, **Wong MH***	Size fraction effect on phthalate esters accumulation, bioaccessibility and in vitro cytotoxicity of indoor/outdoor dust, and risk assessment of human exposure. J Hazard Mater. 15: 261:753-762		Yes	Yes

2013b				Wang W, **Wu FY**, Zheng JS, Cheung KC, **Wong MH***	Risk assessments of PAHs and Hg exposure via settled house dust and street dust, linking with their correlations in human hair. J Hazard Mater. 15: 263:627-637		Yes	Yes
2013c				Wang W, Huang MJ, **Wu FY**, Kang Y, Wang HS, Cheung KC, **Wong MH***	Risk assessment of bioaccessible organochlorine pesticides exposure via indoor and outdoor dust. Atmos Environ. 77: 525-533	2013	Yes	Yes
2013d				Wang W, Huang MJ, Zheng JS Cheung KC , **Wong MH***	Exposure assessment and distribution of polychlorinated biphenyls (PCBs) contained in indoor and outdoor dusts and the impacts of particle size and bioaccessibility. Sci Total Environ. 463-464: 1201-1209	2013	Yes	Yes

2013				Man YB, Chow KL, Kang Y, **Wong MH***	Mutagenicity and genotoxicity of Hong Kong soils contaminated by polycyclic aromatic hydrocarbons and dioxins/furans. Mutat Res Genet Toxicol Environ Mutagen. 752: 47-56	2013	Yes	Yes

9. Recognized International conference(s) in which paper(s) related to this research project was/were delivered *(Please attach a copy of each delivered paper)*

Month/Year/ Place	Title	Conference Name	Submitted to RGC *(indicate the year ending of the relevant progress report)*	Attached to this report *(Yes or No)*	Acknowledged the support of this Joint Research Scheme *(Yes or No)*

10. Student(s) trained *(Please attach a copy of the title page of the thesis.)*

Name	Degree registered for	Date of registration	Date of thesis submission/ graduation
WANG Wei	Ph.D.	01 Nov 2009	01 MAR 2013
HUANG Minjuan	Ph.D.	16 Oct 2009	18 July 2013

11. Other impact *(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, etc.)*

We have collaborated with Dr. John Chuen-yu Chan (Associate Professor, Associate Dean Faculty of Science and Engineering, University of Nottingham Ningbo China) for investigating the level and mass distribution of PM10 and PM2.5 from coal-burning households in rural China.