ANNEXURE -IX

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI- 110002

PROFORMA FOR SUBMISSION OF INFORMATION AT THE TIME OF SENDING THE FINAL REPORT OF THE WORK DONE ON THE PROJECT

1. **TITLE OF THE PROJECT**: CHARACTERIZATION OF FINE PARTICULATES IN INDOOR MICROENVIRONMENT
2. **NAME AND ADRESS OF THE PRINCIPAL INVESTIGATOR**: Prof. AJAY TANEJA, Department of Chemistry, Dr. Bhimrao Ambedkar University, Khandari Campus, Agra, U.P.- 282002
3. **NAME AND ADRESS OF THE INSTITUTION:** Dr. Bhimrao Ambedkar University, Khandari Campus, Agra, U.P.- 282002 India
4. **U.G.C. APPROVAL LETTER NO. AND DATE**: File No. 43-209/ 2014 (SR) (MRP-MAJOR-CHEM-2013-25775) dated 23/July/2015 & 28/August/2017
5. **DATE OF IMPLEMENTATION**: 01/07/2015
6. **TENURE OF THE PROJECT**: 3 Years from 01/07/2015 to 30/06/2018
7. **TOTAL GRANT ALLOCATED**: **Rs. 12,70,830/-**
8. **TOTAL GRANT RECEIVED**: **Rs. 11,84,407+Rs. 38404 (Interest earned)**
9. **FINAL EXPENDITURE**: Rs. **12,21,254.**
10. **TITLE OF THE PROJECT**: CHARACTERIZATION OF FINE PARTICULATES IN INDOOR MICROENVIRONMENT

11. **OBJECTIVES OF THE PROJECT:**
    1. To provide quantitative information on the mass concentration of fine in typical microenvironments (domestic homes classified on the basis of location & income, business shops, hospitals & offices)
    2. To characterize temporal variability in particle composition and size distribution in different indoor microenvironments providing overview of their formation, chemical composition, morphology and surface functionality
    3. To highlight conventional and emerging sources of these particles
    4. To correlate and evaluate the obtained information based on modern analytical instruments like SEM, EDS, AAS etc.

5. To address the particle size effect in elemental bioavailability and therefore the potential risk of exposure and future research needs.

12. WHETHER OBJECTIVES WERE ACHIEVED (GIVE REASONS):

Major objectives like providing quantitative information on mass concentration of fine particles, their size distribution and chemical composition during all seasons with elemental and particle size effect on bio-availability in residential homes was **successfully achieved**. Added information (eg. effect of outdoor environment on indoor particulate matter (PM) pollution status and the quantitative information on health toxicity on residents) regardless of the previously outlined objectives was additionally extracted to gain a better view on the occurrence of fine particles in indoor environment. Objectives like analyzing surface functionality and providing quantitative information on PM levels in shops, hospitals and offices were dropped in view of insufficient funds required for this purpose.

13. ACHIEVEMENTS FROM THE PROJECT:

As there is a strive to establish sound indoor air quality globally, limited data is available upon the general understanding of indoor air quality (IAQ) of residential homes. The study conducted in the project underline and confirms the presence of finer particulates in residential homes whereby people spend around 75-80% of their human time considering to be safely guarded from outdoor pollution. The study conducted in the project is the first one to report the size segregated particulate trend in total and bio-available metal forms and gives a better understanding of particle size, formation and related toxicity. It furthermore gives an insight into the characteristics of ultrafine particles that are still underway in Indian context.

14. **SUMMARY OF THE FINDINGS (IN 500 WORDS):**

During the study period, annual average PM_{10}& $PM_{2.5}$ concentrations were 287.16±22.43 and 196.51±12.58 and 256.41±64.35 and 223.51±66.16 $\mu g/m^3$ for indoors and outdoors respectively. On comparison, results were approximately 4-6 times higher than NAAQS (CPCB) and 13-15 times higher than WHO standards. This indicate that air quality at residential sites of Agra city is extensively affected by PM pollution in indoor environment of urban and rural homes while roadside homes (newly built with proper infrastructure) had better indoor PM quality. For

outdoors, trend obtained was roadside>urban>rural. Seasonal variation indicated trend: winters >summers> monsoons. Fine particles were known to dominate (62-80%) of PM_{10} concentration in which q-UF particles occupied a significant portion (24-35%) of fine PM mass. Low linear relationship obtained between coarse and fine particles were attributed to their different origin, behavior and removal mechanism; while greater correlation between q-Acc & q-UF mode described their inter-formation. Higher inter particle mode correlation in winters and low in monsoons can be traced to factors *s.a.* stable atmospheric conditions and efficient gravitational settlement pertaining in winters and monsoons respectively. Higher contribution of coarse mode to TSP during summers was observed; whereas for winters and monsoons, q-Acc and q-UF range seemed to dominate. As per analyzing the aggregate relation between pollution-income, LIG of urban homes recorded 25-32% higher fine PM concentration than MIG and HIG. Temporal variation revealed that morning (7.00-11.00) and evening hours (5.00-8.00) recorded 78.6% higher PM2.5 concentration than noon hours (1.00-4.00). Identifying the metal concentration, Ca, Fe, Al, Mg, K - Group I elements (major) and Zn, Co, Ba, Cd, Cu, Mn, Cr, Pb, Ni in Group II (minor) elements. Interestingly, the sum of total metal concentration was observed higher in summers than winters unlike PM concentration that recorded higher concentration in winters. In view of size-segregated trend $PM_{1.0\text{-}0.5}$ recorded highest metal mass loading in ambient air whereas for indoors, heterogeneous variation w.r.t. particle size fraction was noted indicating strong indoor sources with consistently varying concentration. Differential distribution pattern of PM indicated a uni-modality with preference to q-Acc mode ($PM_{0.5\text{-}0.25}$ in indoor & $PM_{1.0\text{-}0.5}$ in outdoor). For summers and winters, bimodal pattern with secondary peak in coarse mode was identified.

In view of elemental bioavailability, Ni recorded highest BI (22.4%) followed by Mg (19.4%). Particle size effect on elemental bioavailability was assessed whereby metals in q-UF and q-Acc were more bioavailable (27.1%) than coarser range (14.53%). The bio-available concentration of toxic metals (s.a. Cu, Cr, Pb, Zn) exhibited a modal shift towards smaller particle size fraction; attributed to rise in particle SA/Vol ratio with decrease in diameter. According to seasonal trend of BI, monsoon season can be considered comparatively safer with low shares of critical elements w.r.t bio-availability whereas highest BI of toxic metals obtained during summers. The application of SEM-EDS technique aid in understanding the differences in morphology, elemental composition of PM in different sizes. Morphology results by SEM confirmed soot,

alumino silicate, tar balls, and irregular shape mineral particles of geological origin as the most commonly found particles.

15. CONTRIBUTION TO THE SOCIETY

The comprehensive assessment of indoor PM in urban, rural and roadside homes with different particle size fraction including accumulation and ultrafine modes and their relationship to different outdoor sources with analyzed toxicity of total and bioavailable metal concentration in human body would significantly contribute to the present understanding of people exposure in homes (that were previously considered to be safe) to the society. The obtained information through measurements can be a leading step to work for consistency between emission standards and to develop a better understanding of particle size, source and related toxicity. Moreover, in view of void indoor standards in Indian context, such robust study can surely aid the regulatory agencies and policy makers for implementation of guidelines and environmental strategies vital for establishing cost effective pollution control policy. The outcomes of this study may offer opportunity in development of improved particle monitoring programme in residential areas and may aid too in establishing relatively small international elemental modality dataset that could be incorporated in the exposure and risk assessment of atmospheric particles.

16. **WHETHER ANY Ph.D. ENROLLED OR PRODUCED OUT OF THE PROJECT:**

Yes, two Ph.D. students are working on the topics related to this project. Three M.Phil.'s has been awarded on the topics related to project proposal

17**. NO. OF PUBLICATIONS OUT OF THE PROJECT:**

5 publications and one book chapter (Offprints attached)

(a) HimanshiRohra, Rahul Tiwari, Puja Khare& Ajay Taneja, Indoor-Outdoor Association of particulate matter and bounded elemental composition within coarse, quasi-accumulation and quasi-ultrafine ranges in residential areas of northern India, *Science of the Total Environment*, 631-632: 1383-97 (**2018**) **[IF=5.1]**

(b) Himanshi Rohra, Rahul Tiwari, Neha Khandelwal & Ajay Taneja, Mass distribution and health risk assessment of size segregated articulate in different microenvironments of Agra, India- A case study, *Urban Climate*, 24: 139-152 (**2018**) **[IF=1.3]**

© Himanshi Rohra & Ajay Taneja, Indoor Air Quality scenario in India- An outline of household fuel combustion, *Atmospheric Environment*, 129: 243-255 (**2016**) **[IF-3.841]**

(d) Rahat Parveen, Renuka Saini & Ajay Taneja, Chemical characterization and health risk assessment of soil and airborne particulates metals and metalloids in populated semiarid region, Agra, India, *Environ Geochem Health*, DOI 10.1007/s10653-016-9822-4 (**2016**) **[IF-2.08]**

(e) Poorti Varsheny, Renuka Saini & Ajay Taneja, Trace element concentration in fine particulate matter (PM2.5) and their bioavailability in different microenvironments in Agra, India: a case study, *Environ Geochem Health*, 38: 593-605 (**2016**) **[IF-2.08]**

(f) Atar S. Pipal, Himanshi Rohra, Ajay Taneja & P.G. Satsangi, Particulate matter and its consequences in ambient air: The current scenario, Advances in Environmental Research, Vol 50. Edited by Justin A. Daniels. ISBN 978-1-63485-477-1, *Nova Science Publishers*, New York, 1-27 (**2016**)

PRINCIPAL INVESTIGATOR **REGISTRAR**