CARBONACEOUS PARTICULATE DISTRIBUTION IN INDIAN KITCHENS

R. Baghel[1], N. K. Jaiswal[1], K. S. Patel[1], H. Saathoff[2], T. Leisner[2]

[1]School of Studies in Chemistry, Pt. Ravishankar Shukla University, Raipur, India

[2]Institute for Meteorology and Climate Research (IMK), KIT, Karlsruhe, Germany

Email – rbaghel9@gmail.com

Summary - Indoor particulate matter (PM) air pollution is being several folds more dangerous than the outdoor particulate air pollution in developing countries like India due to widespread use of solid fuels (i.e. wood, charcoal, dung, crop residues, etc.) for purposes i.e. cooking, heating, etc. The Indian population suffers a high health burden from lung diseases, and respiratory disease is the primary cause of death in rural India. In fact, little is known about human exposure to indoor PM constituents in India. Therefore, in the present work, the distribution, concentration and emission fluxes of BC and OC in the Kitchen environment are described.

Introduction - The biomasses, agricultural residues and charcoal are the primary source of domestic energy in developing countries (Barnes, 1994). Nearly 400 million (40% total population) people of India live in urban areas and rely on different energy sources for cooking, water heating and lighting in household. The incomplete combustion of fossil fuels such as coal, diesel and gasoline, as well as biomass burning is a precursor for the OC and EC (Engling et al., 2010). The BC is one of the unique pollutants that have a large direct negative impact on human health, indoor and outdoor air quality, temperature, cloudiness, precipitation, mountain glaciers, sea ice, and snow packs. The commercial cooking is a surprisingly large source of a range of air pollutants that could pose risks to human health and the environment in India.

Methodology - The Partisol Model 2300 (Thermo Sci., USA) air sampler was used for collection of the particulate material over 47-mm quartz filter paper in the kitchens. The organic carbon (OC) and black carbon (BC) contents was analyzed by the thermal method. The samples were collected during November, 2008. The particulate matters (PM) during the burning processes lie in the fine and ultrafine modes.

The emission flux was evaluated by burning solid fuel in a chamber (0.7x0.7x0.7 m^3) equipped with the exhaust fan and the portable sampler. The smoke was collected for the burning period. The relevant blank was prepared for the correction.

Results and Discussion - The concentration of BC and OC during burning of the LPG, gasoline, diesel, kerosene, coal, cow dung(CD) and biomass(BM) in the Kitchen environments ranged (n=38) from 13 – 3068 and 63 – 17786 µg m^{-3} with mean value of 1383±309 and 6146±1553 µg m^{-3}, respectively. The fraction of BC and OC ranged (n=38) from 1.1 – 53% and 2.3 – 72% with mean value of 13±3% and 47±6%, respectively. Among them, the PM of kerosene and diesel was contained with the highest BC fraction, **Fig.1**. However, the PM of coal, CD and BM contained with highest OC fraction. The emission fluxes of BC and OC for the CD, coal and BM were evaluated. Among them, CD and coal emitted at least 2-folds higher amount of TC (TC=BC+OC) **Fig.2**.

Conclusion – The indoor environment is contaminated with higher fraction of carbonaceous particulates in fine mode being several folds more dangerous than in the outdoor environment. The elevated levels of OC and EC are emitted during burning of fuels i.e. diesel, kerosene, coal, CD and BM. However, BM is a less dangerous fuel than diesel, kerosene, coal or CD.

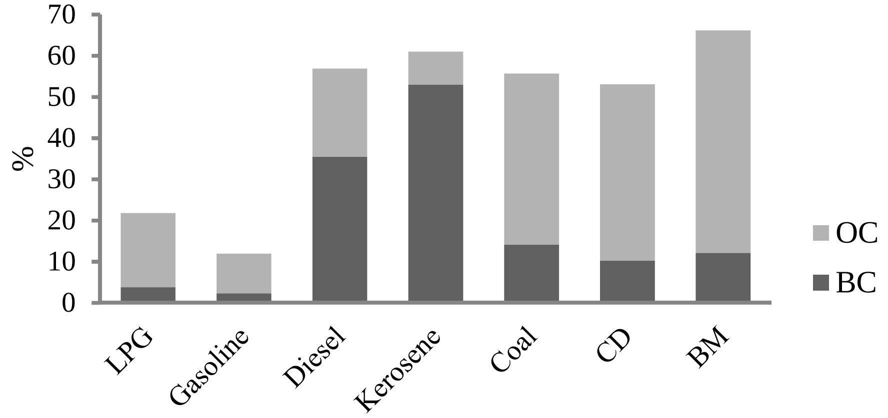

Figure 1. Mean BC and OC fraction in the PM of various fuels during burning process

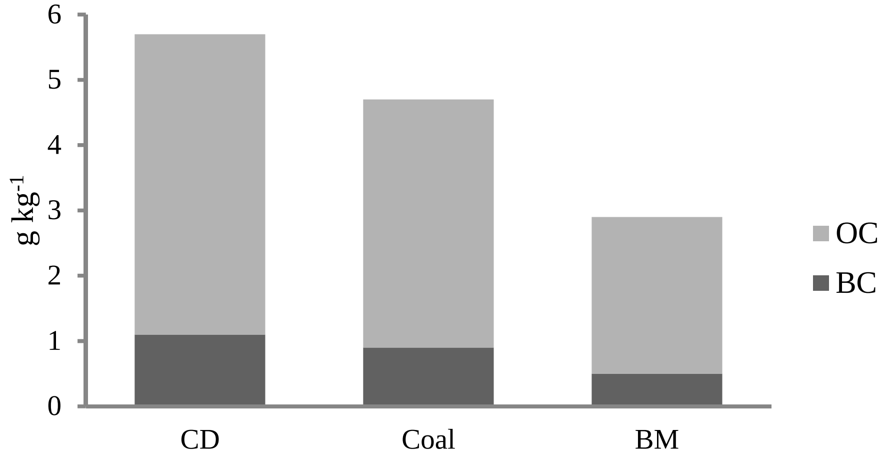

Figure 2. Emission flux of BC and OC

References –

Barnes D.F., Openshaw K., Smith K.R. and van der Plas R., (1994) *what makes people cook with improved biomass stoves? A comparative International review of stove programs*, The World Bank: Washington, DC.

Engling G., Zhang Y.-N., Chan C.-Y., Sang X.-F., Lin M., Ho K.-F., Li Y.-S., Lin C.-Y. and Lee J. J., (2010) Characterization and sources of aerosol particles over the southeastern Tibetan Plateau during the Southeast Asia biomass-burning season, Tellus.

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Rameshwari Baghel,

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School of Studies in Chemistry,

Pt. Ravishankar Shukla University

Raipur, Chhattisgarh, India

MOTIVATION

- Solid fuels i.e. coal, biomass, etc. are widely used as a energy source in rural India.
- Indoor air is several folds more polluted than ambient air.
- Combustion particulates are mostly in fine and ultrafine modes.
- Indian women's are generally suffering with respiratory diseases.
- There is little known about human exposure to indoor PM constituents in India.

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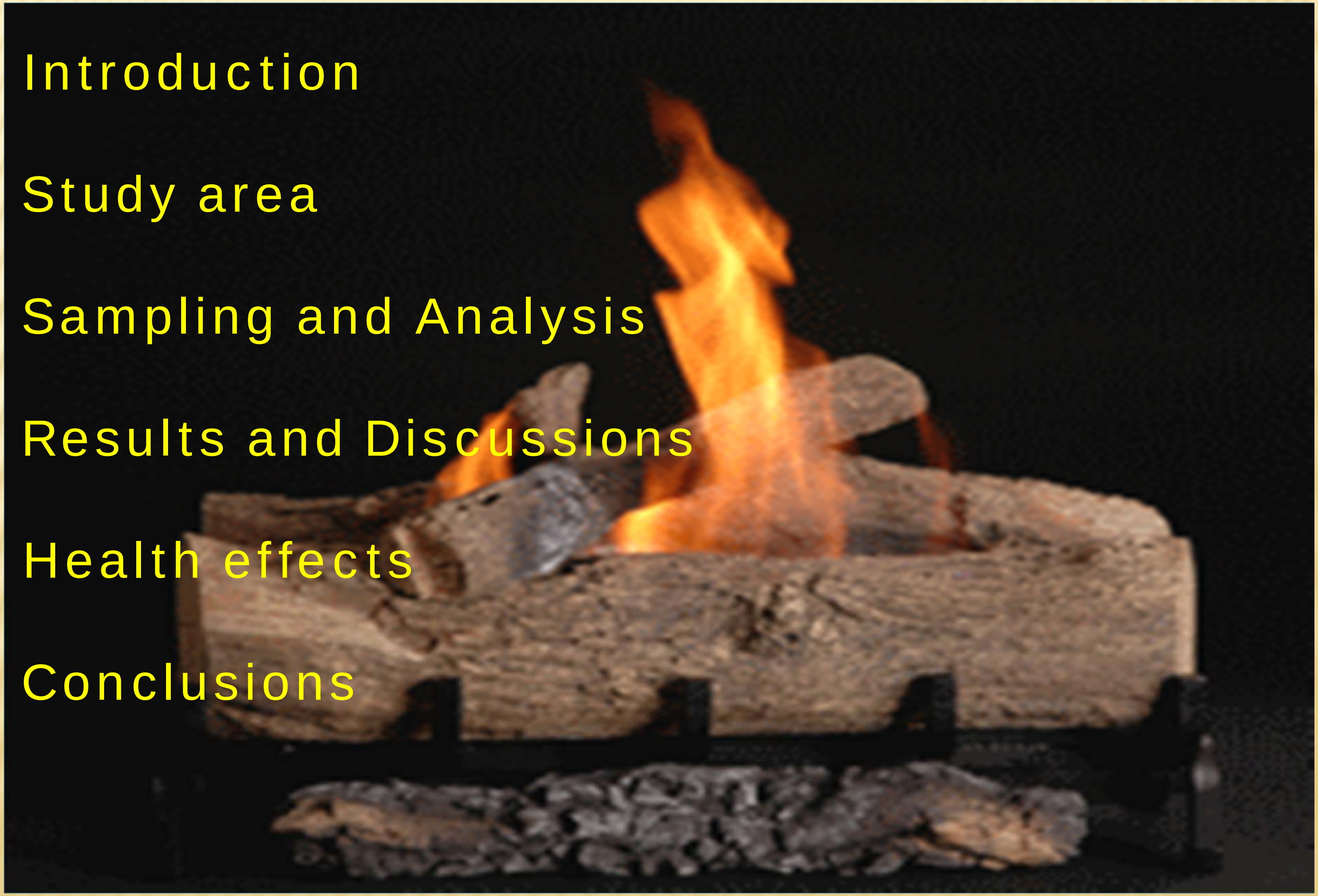


INTRODUCTION

- The biomasses, agricultural residues and charcoal are the primary source of domestic energy in developing countries.

- Two main activities, cooking and heating account for 90 and 50% of rural and urban household energy consumption, respectively .

- Almost one half of the world's population still relies on solid fuels (i.e. biomass and coal) for their everyday cooking and heating.

Kitchen
Poor and low income family

- **The residential burning contributes the greatest part of the total carbonaceous emissions because of poor combustion condition and lack of emission controls.**
- **The indoor exposure to air pollutants may cause the human health and environmental damage in India.**
- **The indoor smoke is a complex mixture of particulate matters (PM) including organic carbon (OC), black carbon(BC), silica, elements, various salts, etc.**
- **The BC is one of the unique pollutants that have a large direct negative impact on human health, indoor and outdoor air quality, temperature, cloudiness, precipitation, etc.**

Distribution of energy consumption		
S. No.	Fuel source	Consumption %
1	Electricity, Coal, Kerosene, LPG and Solar energy	60.0
2	Wood	27.0
3	Agricultural residues	1.7
4	Cow and buffalo dung	4.0
5	Coal	7.3

WHO REPORT


Deaths from indoor smoke from solid fuels
IAP deaths/million
0 - 10
10 - 50
50 - 100
100 - 200
200 - 300
300 - 400
No Data

STUDY AREA

Kerosene Stove

Kitchen using

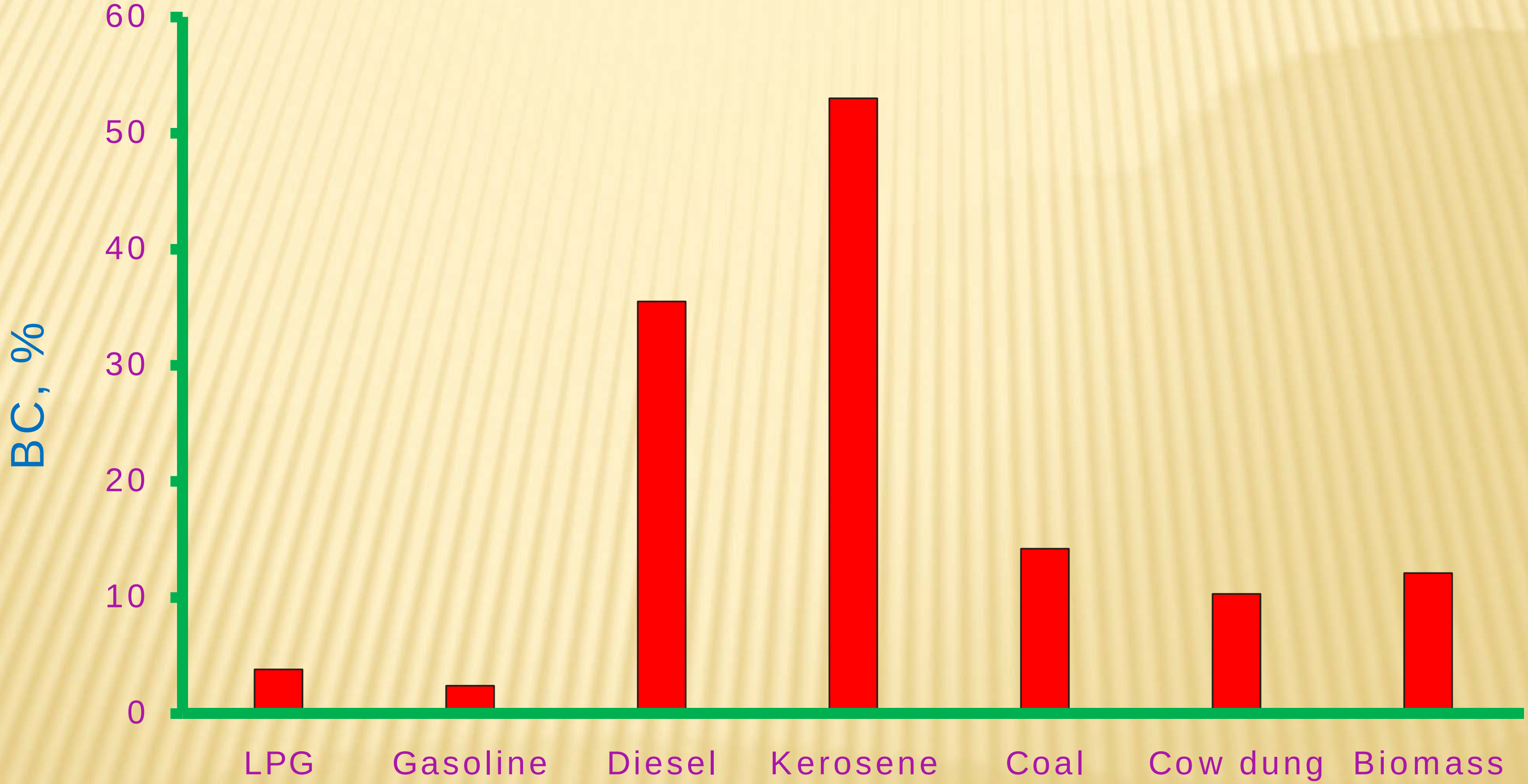
- LPG
- Gasoline
- Diesel
- Kerosene
- Coal
- Cow dung
- Biomass

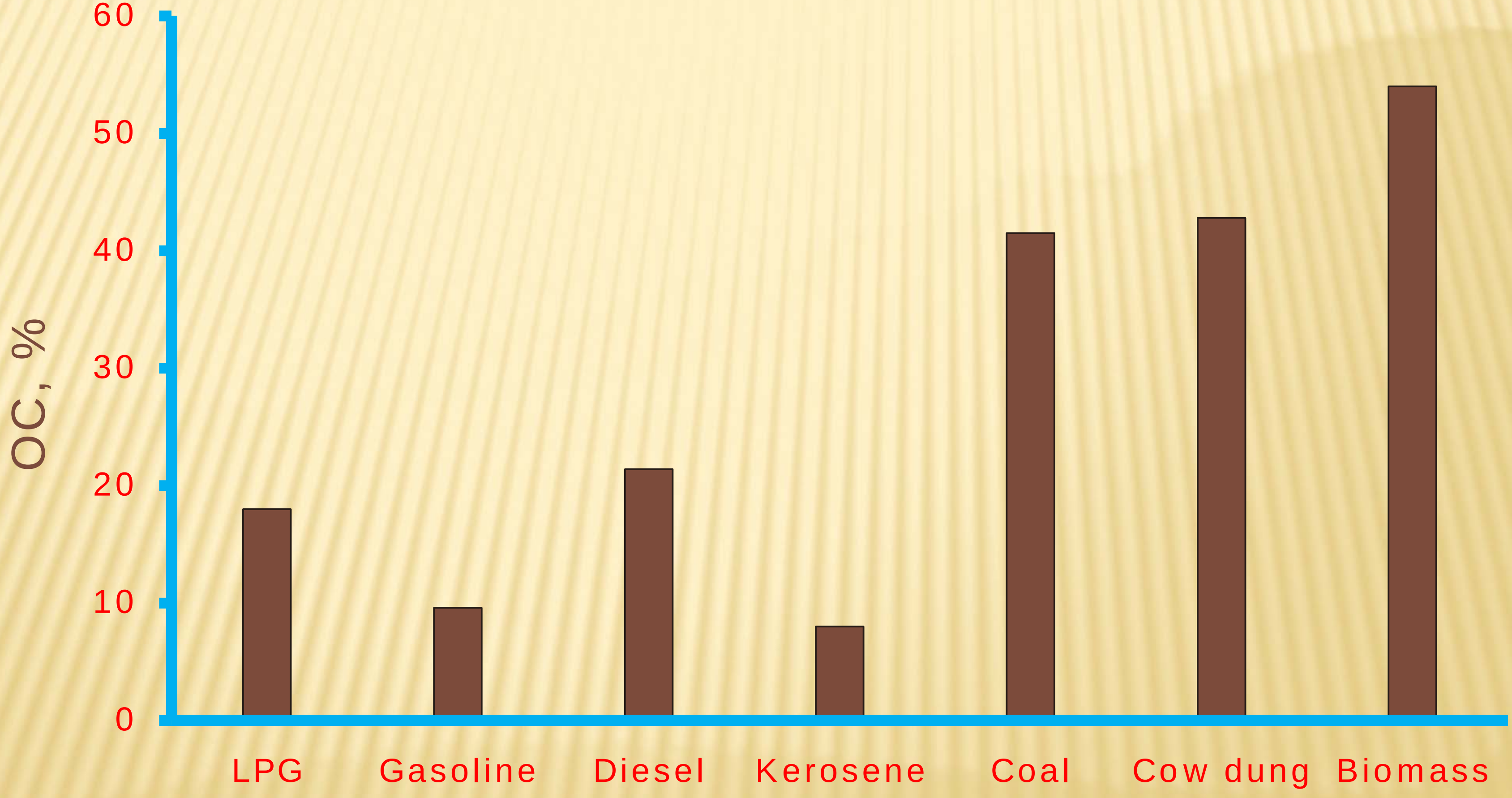
SAMPLING AND ANALYSIS

- Sampler - Partisol Model 2300 (Thermo Sci., USA) air sampler
  Filter - 47-mm quartz filter paper
  Flow rate of sampler– 10-L min^{-1}
- One sample blank was used to correct the blank value.
- The filter was prior heated up to 600 ^{o}C for 6 hrs to lower their carbon blank value, and placed in clean polyethylene petri dishes.
- The weighted filters were housed in the sampler and run for the duration of burning process.
- Then, the loaded filters were heated up to 50 ^{o}C for 6 hrs to remove the moisture contents and finally weighted to record the particulate contents.
- Carbon analyzer was used for the analysis of BC &OC.

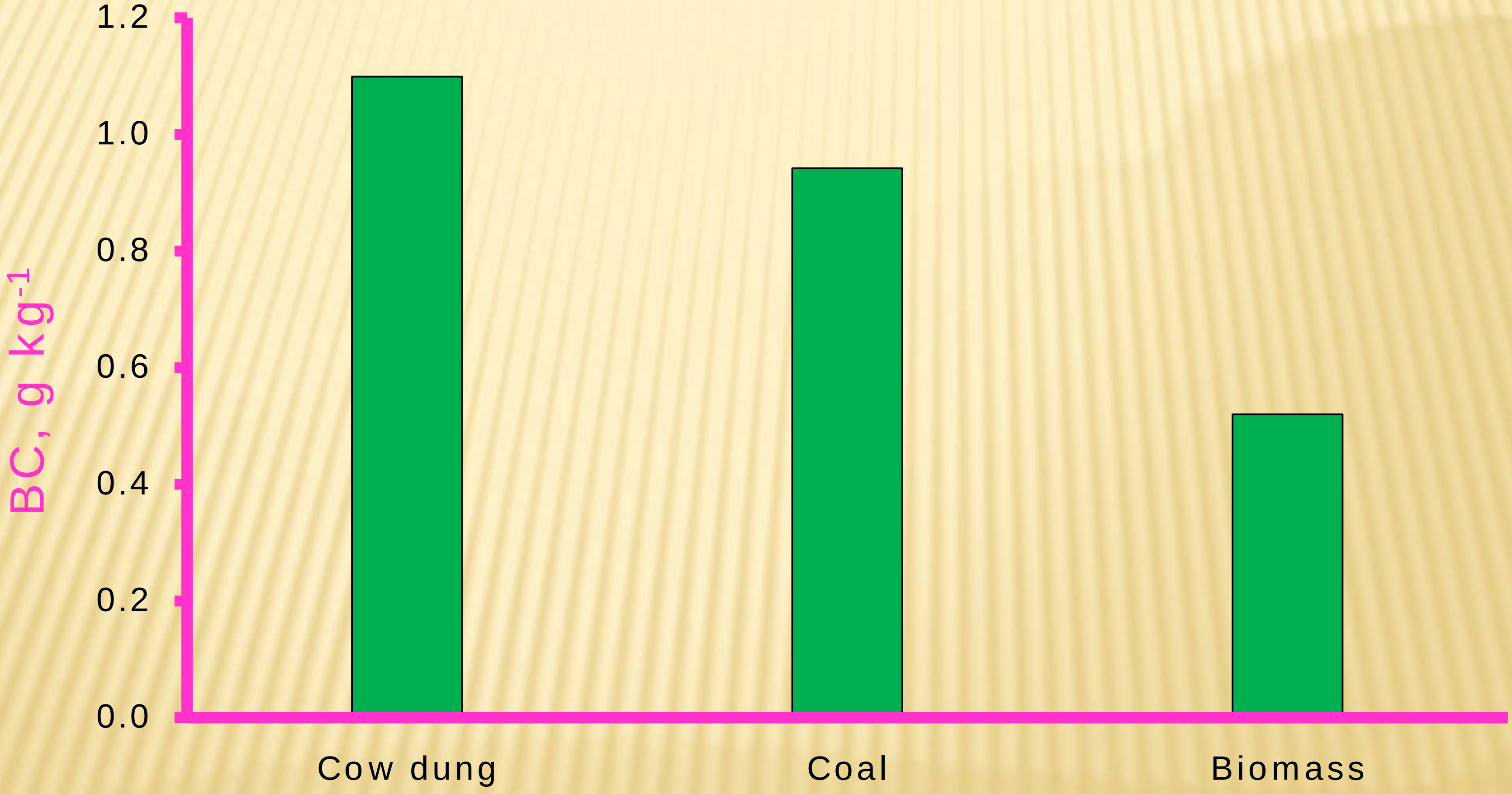
Partisol Model 2300 Air Sampler (Thermo Sci. USA)

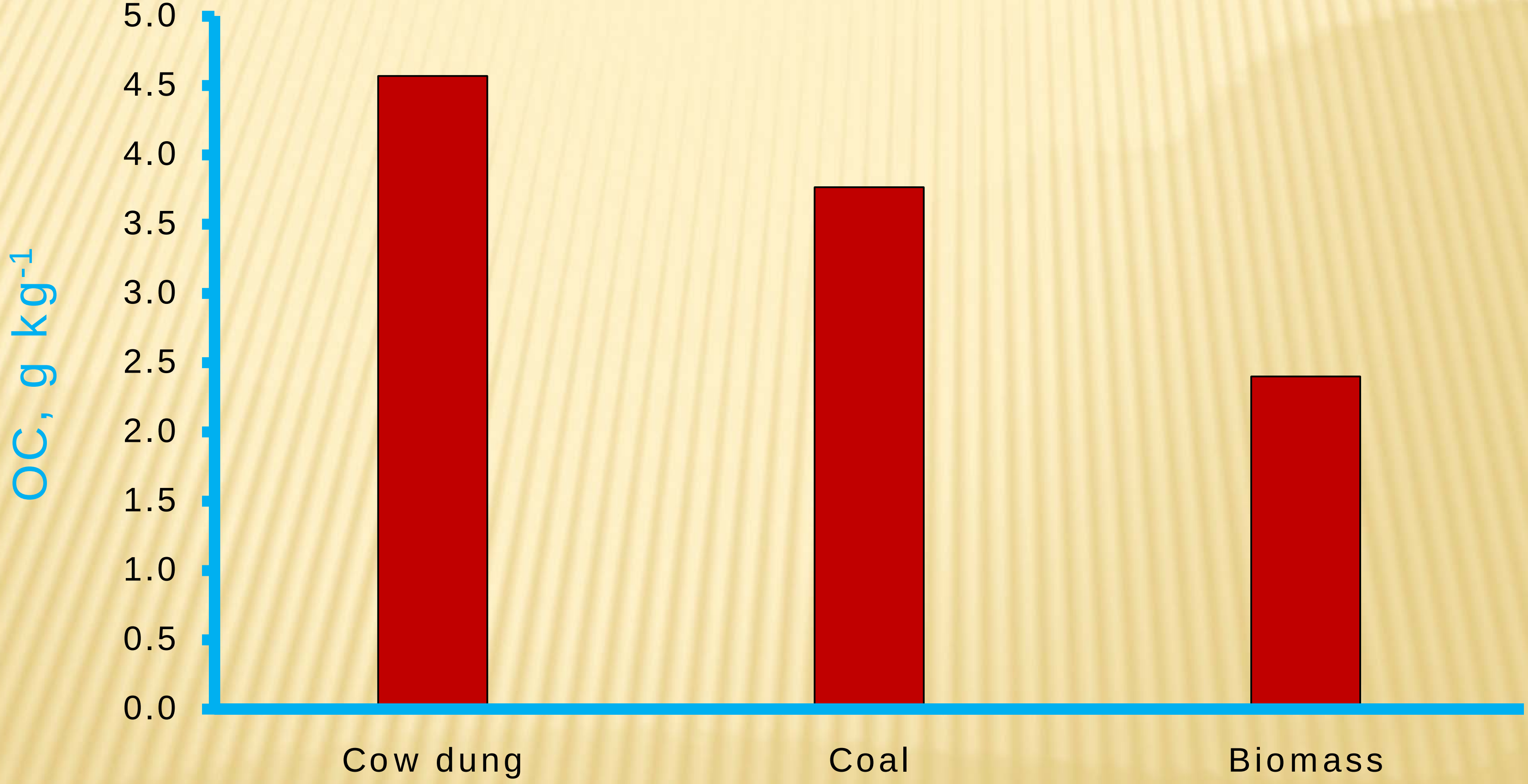
RESULTS AND DISCUSSIONS

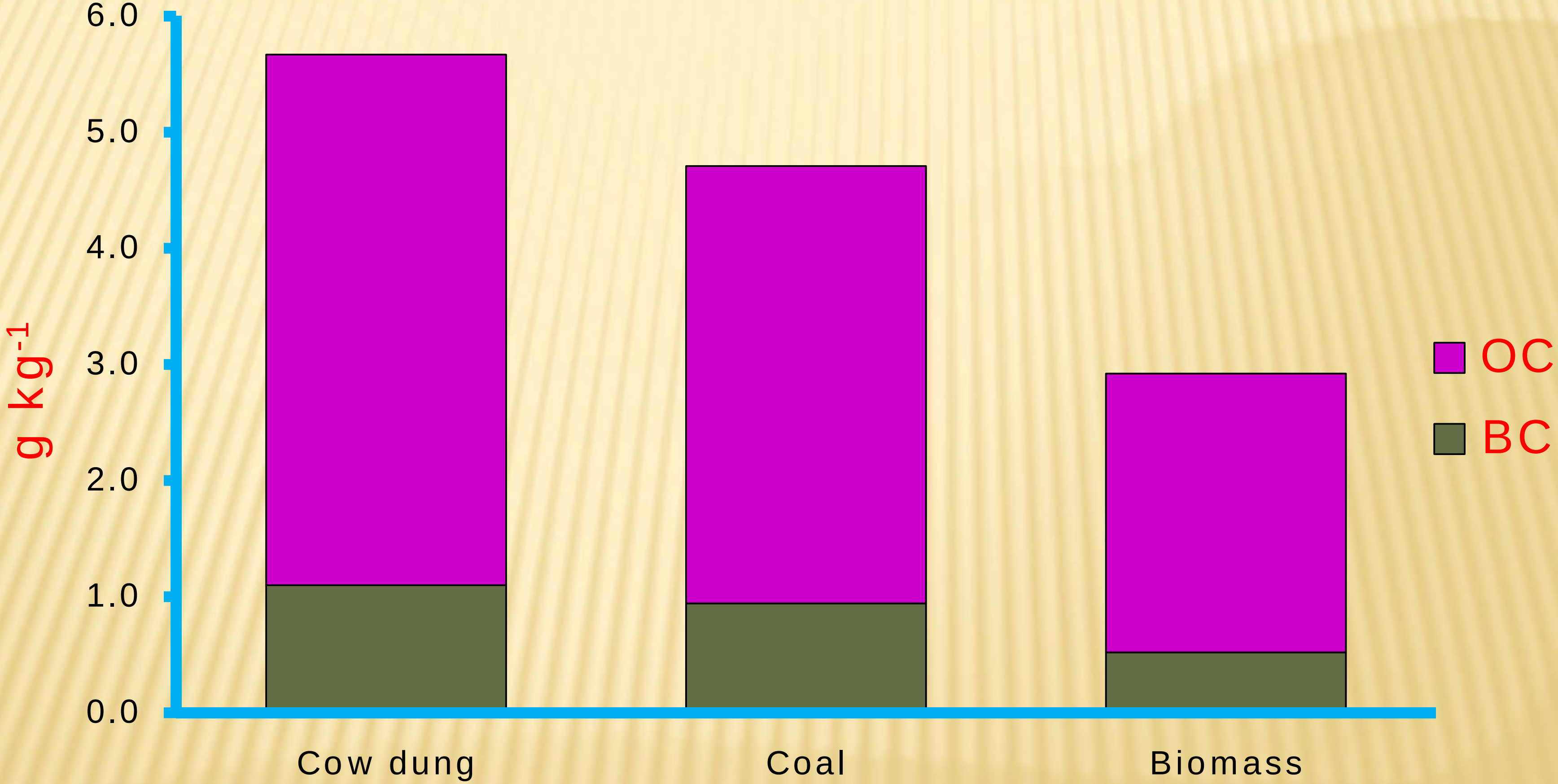


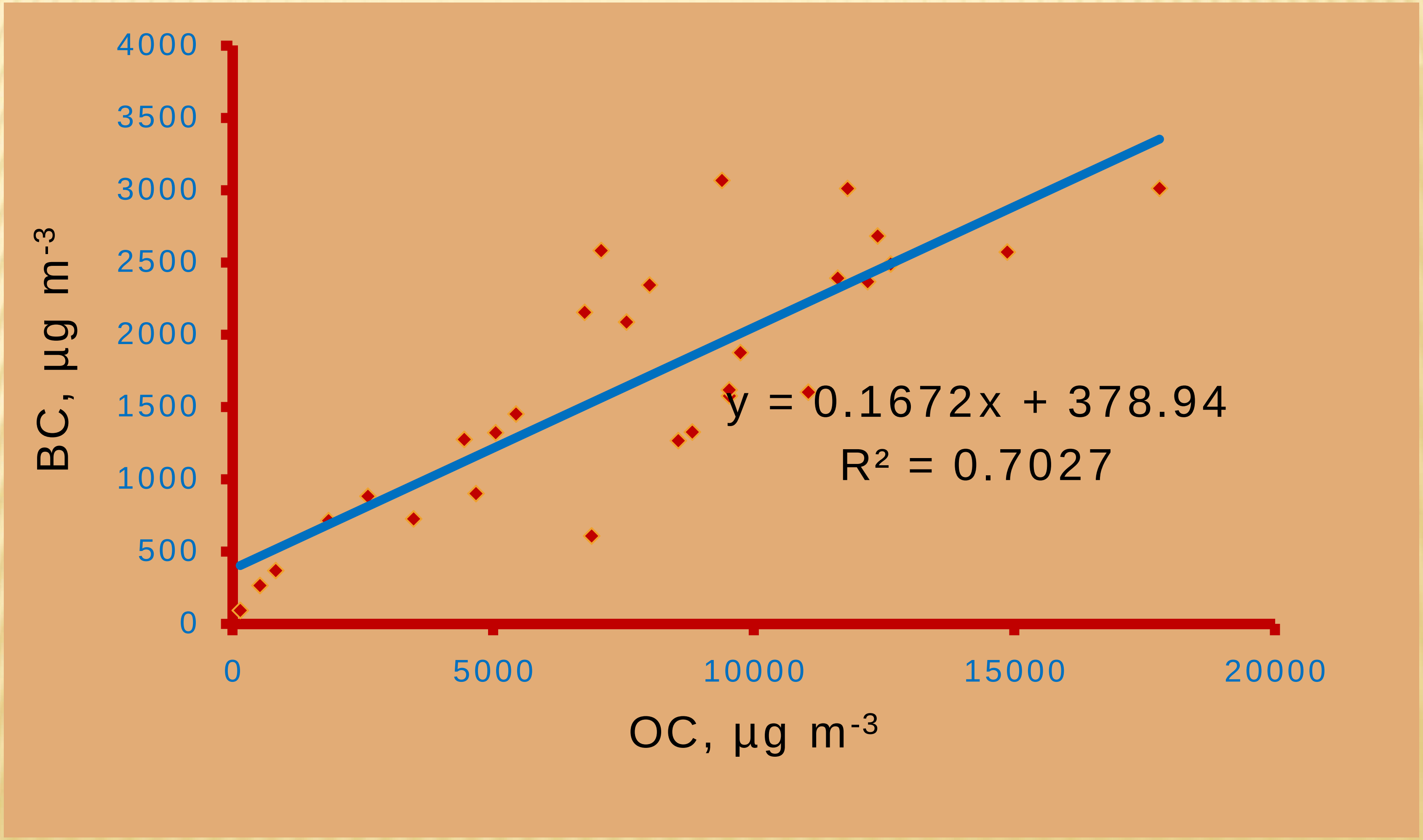

OC, %
60
50
40
30
20
10
0
LPG
Gasoline
Diesel
Kerosene
Coal
Cow dung
Biomass

EMISSION FLUXES




OC, g kg-1
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Cow dung
Coal
Biomass


6.0
5.0
4.0
3.0
2.0
1.0
0.0
g kg-1
Cow dung
Coal
Biomass
OC
BC


4000
3500
3000
2500
2000
1500
1000
500
0
BC, µg m-3
0
5000
10000
15000
20000
OC, µg m-3
y = 0.1672x + 378.94
R² = 0.7027

HEALTH EFFECTS

- Acute respiratory symptoms are related to high levels of indoor air pollution and killing almost 1 million children under five every year in developing countries.

- Exposure to these smokes has also been linked to several health effects (i.e. chronic bronchitis in women and acute respiratory infections in children) especially for women who cook with these fuels and in young children.

- Both, the organic and elemental carbon components are observed associated with changes in brachial artery diameter in young healthy adults.

CONCLUSIONS

- The indoor environment is contaminated with higher fraction of carbonaceous particulates in fine mode being several folds more dangerous than in the outdoor environment.
- The PM of kerosene and diesel was contained with the highest BC fraction. However, the PM of coal, CD and BM contained with higher OC fraction.
- The emission fluxes of BC and OC for CD and coal emitted at least 2-folds higher amount of TC (TC=BC+OC) than Biomass.
- The elevated levels of BC and OC are emitted during burning of fuels i.e. Diesel, kerosene, coal, CD and BM. However, BM is a less harmful fuel than diesel, kerosene, coal and CD.
- Good ventilation and improved cooking stoves can reduce exposure to smoke.

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Thanks