Aim of the study

- To compare genotoxic potential and oxidative DNA damage by organic compounds bound to particulate emissions from various boilers.
- To assess the effect of boiler’s technology, fuel and operation output.

Background

- Combustion of various solid fuels in different types of small boilers is a widely used form of heating of family houses.
- However, these types of combustion processes emit large quantities of harmful gaseous and PM emissions.
- Epidemiological studies show that PM created in small heating appliances contains carcinogens and mutagens and thus may have undesirable and harmful impacts on human health.
- The quality of combustion is affected by the combustion technology, user operation, and fuel used, all of which affect the formation of emissions.

Conclusions

- Mass of particulate emissions from boilers highly correlates with PM2.5, the correlation with benzo(a)pyrene level is lower suggesting the contribution of other PM components to the total genotoxicity.
- For all fuels, the highest genotoxicity was observed for over-fire and down-draft boilers compared to gasification and automatic boilers.
- Reduced output exhibited more emissions and higher toxicity than nominal output.
- In over-fire boiler are emissions from coal substantially higher and more genotoxic than from biomass.
- Modern boilers (gasification and automatic) produced much lower emissions and exhibited much lower genotoxicity and DNA oxidative damage than old technology boilers per GJ of power.

Results

Genotoxic potential – DNA adducts

- Highest levels of DNA adducts were induced by emissions by organic compounds emitted by over-fire boiler while automatic boiler exhibited ~100-fold lower genotoxic potential (Figure 1).
- The differences between <9 and >99 samples suggest substantial contribution of genotoxic PAHs to the total adduct levels.
- Reduced output is connected with higher genotoxicity.

Genotoxic potential – oxidative DNA damage

- Highest levels of 8-oxo-dG were induced by emissions by organic compounds emitted by over-fire boiler while automatic boiler exhibited ~5-fold lower toxicity (Figure 2).
- The differences between <9 and >99 samples suggest substantial contribution of genotoxic PAHs to the total adduct levels.
- Reduced output is connected with higher oxidative DNA damage.

PM size distribution and chemical analysis

- The size distribution of PM emissions strongly suggests that most of PM is sized between 0.3–1 μm for all types of boilers (Figure 3).
- PM mass is much higher for old technologies of boilers than for new technologies. The same applies for PAH content normalized per GJ of power (Figure 3).

Correlation of genotoxicity with PM and BaP

- Genotoxic potential as detected by DNA adduct formation correlates with PM mass (Figure 4A).
- The correlation with BaP level is lower suggesting the significant contribution of other PM components to the total genotoxicity (Figure 4B).

Methodology

- Four types of small domestic boilers representing both old structural design (over-fire and down-draft boilers) and also up-to-date combustion devices (gasification and automatic boilers) shown in Figure 5 were compared in specialized testing laboratory (Figure 6).

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