Particle and gas phase distribution of toxic metals during biomass combustion

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Combustion of biomass releases several pollutants: particle, NOx, SOx, metals etc., of health and environmental concerns (Williams et al., 2012). Since fine particulates are associated with increased mortality, cardiovascular diseases and impact on climate, it is necessary to control such emission. CAROLA- electrostatic precipitator (ESP) was developed at Karlsruhe Institute of Technology, Germany to control fine particles from biomass combustion in small scale units (Bologa et al., 2012). Biomass contains trace concentration of metals which are released into the environment during combustion. Particle bound metals usually are removed in dry type particle removal system, however, gas form are not. So knowing the distribution of metals has an important implication in its removal within the pollution control devices and fate in the environment. In this paper, particle and gas phase distribution of selected toxic heavy metals (Cd, Cr, Pb and Hg) from biomass combustion and their behavior is presented. Flue gas was sampled simultaneously at the inlet and outlet of CAROLA- ESP according to US EPA method 29. Particulate and gaseous samples were collected to measure selected heavy metals emission concentration and distribution in flue gas, temperature ranging from 160 to 203 ^{0}C. Heavy metals concentrations were determined using Inductively Coupled Plasma Mass Spectroscopy.

In combustion flue gas, particle concentration ranged 55.5 to 173.9 mg/Nm^3 and 13.0 to 23.9 mg/Nm^3 at the inlet and outlet of CAROLA- ESP, respectively. Particle removal efficiency of CAROLA- ESP ranged 64 to 86%. Heavy metals were more enriched in fly ash than bottom ash. This is in agreement with the earlier studies (e.g. Narodoslawsky and Obernberger, 1996).

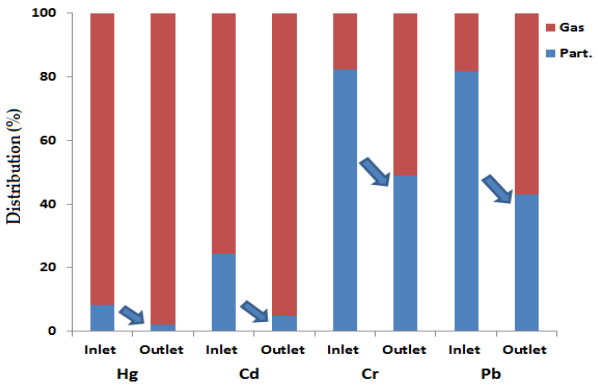

Figure 1. Metals distribution into particle and gas phase in flue gas at the inlet and outlet of CAROLA-ESP.

Metals concentrations in flue gas at the inlet CAROLA- ESP were 0.45 µg/Nm^3 (Cd), 0.63 µg/Nm^3 (Hg), 1.69 µg/Nm^3 (Cr) and 3.75 µg/Nm^3 (Pb). Similarly, metals concentration in flue gas at outlet CAROLA- ESP were 0.22 µg/Nm^3 (Cd), 0.52 µg/Nm^3 (Hg), 0.61 µg/Nm^3 (Cr) and 1.13 µg/Nm^3 (Pb). This corresponds to metals removal in CAROLA- ESP from 16.9 to 69.9%. Metals distribution into particle and gas phase in flue gas is presented in Figure 1. Cr and Pb were mainly distributed in particulate form. On the other hand, Hg and Cd were distributed mainly in gas form. Passing through the CAROLA- ESP 78.3 to 90.4% of particulate bound metals were removed. So at the outlet, gaseous form metals were dominant.

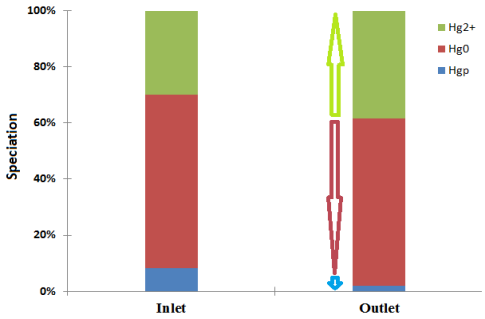

Figure 2. Hg speciation variation in flue gas at the inlet and outlet of CAROLA- ESP.

At the inlet of CAROLA- ESP, 92% Hg was speciated into gaseous form and 8% as Hg_p (Figure 2). Passing through the CAROLA- ESP, particulate bound Hg was significantly removed (78.5%), however, overall removal of Hg was low (16.9%). Hg^0 decreased and Hg^{2+} increased due to possible interaction with oxidants in flue gas, mainly HCl. Metal distribution into gas and particle form during combustion is a complex phenomenon primarily dependent on initial metals concentration in fuel, availability of oxygen and chloride, combustion temperature, flue gas residence time etc. More data in controlled conditions are required to explain the distribution of metals during biomass combustion and efficiently control them.

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