Fine particles, ultra-fine and nano particles in emission of a municipal solid waste incineration plant

Tirler W [1], Angelucci G [2], Bedin K [2], Verdi L [3]

[1]Eco-Research, Via Negrelli, 13, 39100 Bolzano, Italy
[2] Ufficio Gestione Rifiuti, Via Amba Alagi, 35 39100 Bolzano, Italy
[3] Laboratorio di Chimica Fisica, Via Amba Alagi, 5 39100 Bolzano, Italy

Abstract
Ultra-fine particles (UFPs) and nano particles (NPs), are similar in size (<100 nm) and possess many similar characteristics. UFPs, like NPs, have an enormous specific surface area and can also carry large amounts of adsorbed pollutants. The comparability of NPs and UFPs suggests that the human health effects are similar. Municipal solid waste incineration (MSWI), can like all other combustion processes be a potential source of fine particles and ultra-fine particles. A continuous dioxin sampling system installed on a stack of a MSWI plant was coupled directly to aerosol spectrometers for the determination of fine particle and UFPs. Fine particles were measured by the physical principle of orthogonal light scattering. For the detection of ultra-fine and nano particles a condensation particle counter coupled with a Vienna-type differential mobility analyser was used. The measurement results suggest that the waste incineration plant of Bolzano is not a notable source of fine, ultra-fine and nano particles.

Introduction
The advent of nanotechnology is considered to be the biggest engineering innovation since the industrial revolution.[1] Using engineered nano materials in industrial and medical applications allows the realisation of new products with unprecedented features. The technological progress during the industrial revolution enhanced quality of life but also resulted in a human health burden.[2] As in the case of asbestos with its decades of long latency, there are many legitimate concerns about the unknown human heath consequences of nano materials. [3] Nano particles (NPs) which are commonly defined as engineered structures with a diameter of less than 100 nm, are materials produced by chemical and /or physical processes having specific properties not displayed in their macro-scale counterparts. The term ultra-fine particles (UFPs) traditionally has been used to describe airborne particles with diameter of less than 100 nm that have not been intentionally produced but are the incidental products of processes involving industrial, combustion, welding, automobile, diesel, soil and volcanic activities. [4] UFPs and NPs, anthropogenic as well as engineered, are similar in size (<100 nm) and possesses many similar characteristics. UFPs, like NPs, have an enormous specific surface area and can also carry large amounts of adsorbed pollutants. The comparability of engineered NPs and UFPs suggests that the human health effects are likely to be similar. Municipal waste incineration can like all other combustion processes be a potential source of fine particles and ultra-fine particles. Also NPs can be emitted by MSWI if waste containing engineered NPs is burned with household waste and if the flue gas cleaning system of the plant is not effective in removing these particles. For this reasons waste incineration should not only be considered critical as a potential source of PCDD/F but also for the risk of fine particles, UFPs and even NPs emissions.[5]

Materials and Methods
The flue gas cleaning of the Bolzano incineration plant is performed by a fabric filter and a two stage wet scrubber, in line with a final selective catalytic reduction (SCR) unit for NOx and trace organics (PCDD/F) removal. To measure these emissions of particles with an aerosol spectrometers directly on the stack is usually not possible. Stack gas can contain many compounds and also a relatively high amount of water. So condensation can happen when the gas is cooled down during sampling. Condensation will trap most of the particles and false the obtained results. Condensation of liquid will also damage the measurement devices. So dilution is necessary in the case of MSWI plants. In our case we utilized a modified continuous dioxin sampling system from Monitoring Systems (Kottingbrunn, Austria). The sampler works by the dilution method described in EN-1948 Part 1. The sampling equipment permits to dilute flue gas within a wide range until 1:10 maintaining still automatic isokinetic sampling. Representative sampling is important in order to minimize sampling

artefacts. Particle formation, chemical composition and size distribution are highly dependent on the conditions surrounding the aerosol. Particle loss is known to occur through inertial impaction, thermophoresis, diffusion and electrostatic deposition on charged surfaces. In our experiment we diluted the hot stack gas (160°C) with pre-cleaned air with a ration of 1:7. The continuous dioxin sampling system was coupled directly to aerosol spectrometers for the determination of fine particle and UFPs. The instrument used to detect fine dust was an aerosol spectrometer made by Grimm (Ainring, Germany) model 1.108). The dilution of the flue gas avoids condensation within the aerosol spectrometer. The particles are measured by the physical principle of orthogonal light scattering. Here particles are illuminated by a laser light and the scattered signal from the particles passing through the laser beam is collected at approximately 90° by a mirror and transferred to a recipient diode. Each signal of the diode is fed, after a corresponding reinforcement, to a pulse height analyser then classified according to size and transmitted in different size channels. These counts are converted each minute to a mass distribution from which the different PM values derive. The instrument makes it possible to determine the number of particles as well as the particle mass. The aerosol spectrometer classifies the particles size in 15 different size channels from 0,25 up to 20 µm. The obtained size distribution spectrum permits qualitative consideration about the origin of particulate matter (PM). Sampling for ultra-fine particles was performed in the same way as for fine particles. For the detection of ultra-fine particles a condensation particle counter from Grimm (Ainring, Germany) model CPC 5403 was used, coupled with a Vienna-type Differential Mobility Analyser (DMA) 55706 operating within a range from 5.5 and 350 nm. The classification of the nano particle size is realized due to their electrical mobility.

Results and discussion

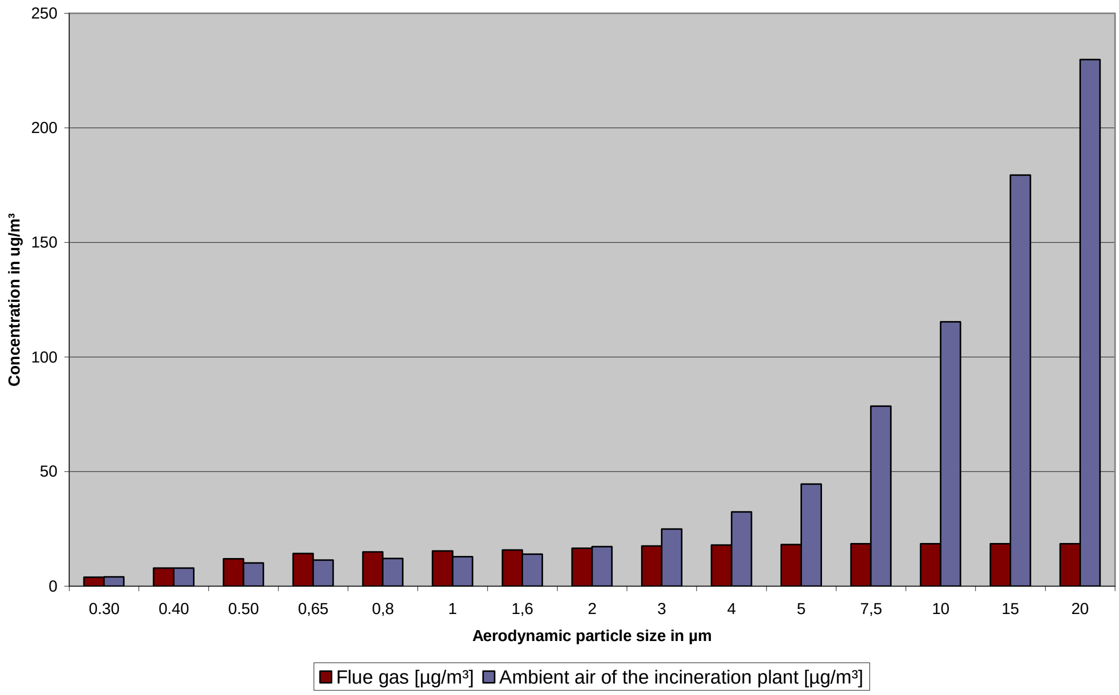

Figure 1: Fine particles in the flue gas and in the ambient air of the incineration plant

The measurement results reported in Figure 1 show very low concentration levels of fine dust in the flue gas. The flue gas cleaning system of the plant seems to be efficient in removing this particles. The levels are lower than in the air outside of the plant. Close to the plant we have a heavily trafficked high way. For this reason we find relatively high concentrations of fine dust outside the incineration plant.

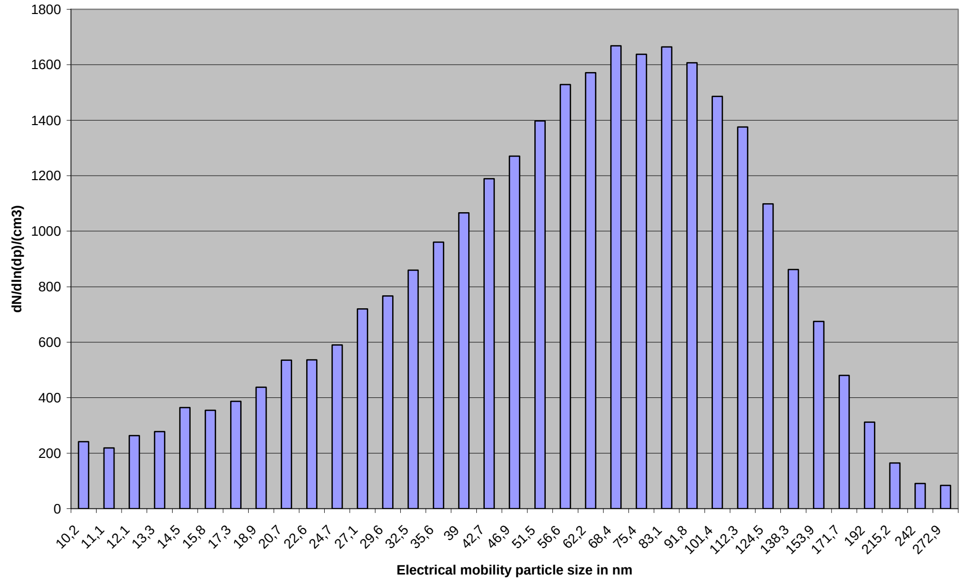

Figure 2: Ultra fine particles in the flue gas

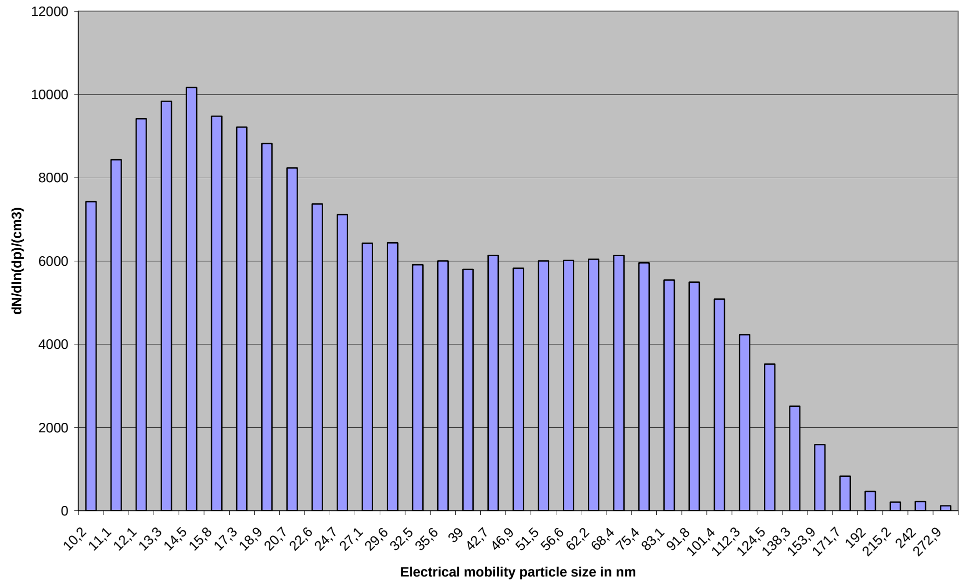

Figure 3: Ultra fine particles in the ambient air of the incineration plant

Also in the case of ultra fine particles and nano particles the flue gas concentration levels (see Figure 2) measured were lower than the levels in the outside air of the plant (see Figure 3). The road traffic influence of the highway in close proximity to the plant is responsible for the relative high concentration found in the air. The measurement campaign was completed with measurements taken at the air quality monitoring stations in Bolzano. Data concerning the number of particles were correlated with data taken from the air quality monitoring stations of Bolzano in order to better observe this phenomenon. The correlation concerned the following parameters: Benzene, Tuolene, CO, NO_2, NO, NO_x, SO_2, PM10, PM2.5, solar radiation, and number of vehicles. There was a good correlation as far as the parameters directly linked to vehicle traffic (Benzene, Tuolene, CO, NO_2, NO, NO_x and number of vehicles) were concerned.

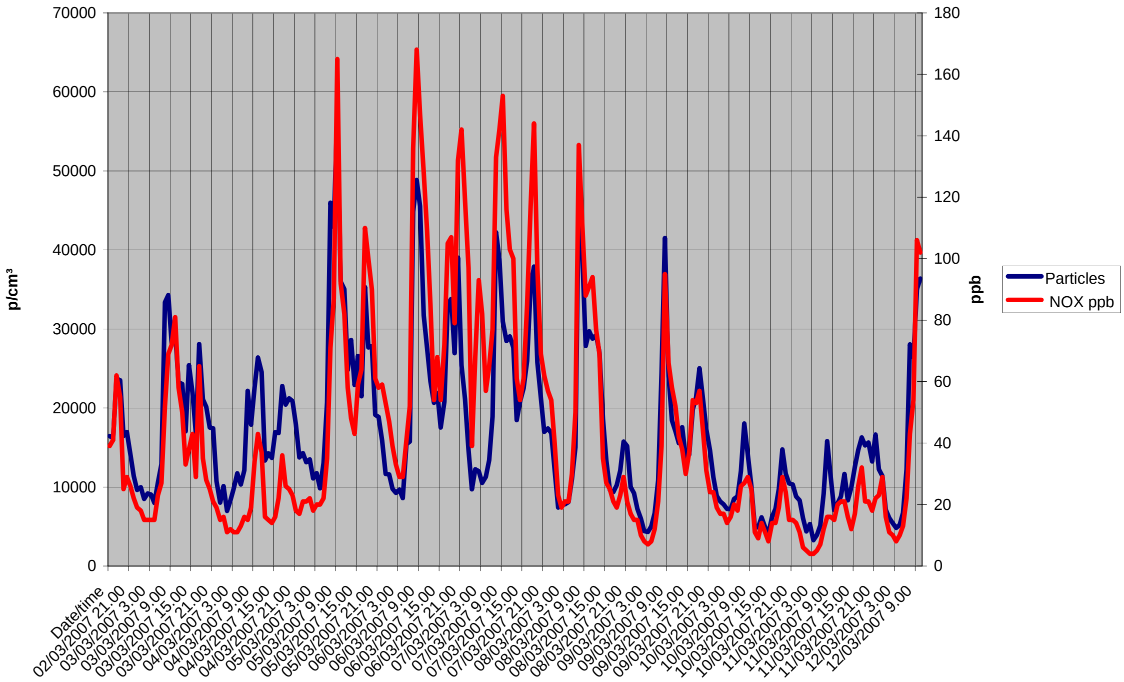

Figure 4: Time trend for ultra-fine particles (from 10 nm to 300nm) and NO_x in the ambient air in Bolzano

To conclude, it can be stated that the ultra-fine dust measurements for Bolzano can be directly correlated with traffic; NO_x, a typical traffic related pollutant, correlates with the particles present in the air (see Figure 4). No significant single source point for ultra fine particles was found for the period considered. The waste incineration plant of Bolzano is not a notable source of fine and ultra-fine particles. On the other hand, it was found that the amount of contaminants in the ambient air of Bolzano can be correlated to domestic heating and road traffic.

References:

1. Gwinn MR, Vallyathan V. *Environmental Science& Technology* 2006; 114: 1818.
2. Warheit DB. *materialstoday* 2004; February:32
3. Brunner TJ, Wick P, Manser P, Spohn P, Grass RN, Limbach LK, Bruinink A, Stark WJ. *Environmental Science& Technology* 2006; 40: 4374
4. Lin CC, Chen SJ, Huang KL. *Environmental Science& Technology* 2005; 39: 8113.
5. Gatti AM. *Biomaterials* 2004; 25:385