e-ISSN: 2458-8156

Journal Homepage: http://dergipark.gov.tr/ejens

EJENS

European Journal of Engineering and Natural Sciences

CODEN: EJENS

DergiPark AKADEMİK

Indoor Particle Size Distribution and Ionic Content of Particles in the Laboratory of ISTAC Composting Facility

Arslan Saral[1]*, S. Levent Kuzu[1], Şenol Yıldız[2]

[1]*Yildiz Technical University, Department of Environmental Engineering, 34220, Esenler/İstanbul, Turkey.*

[2]*ISTAÇ AŞ, Paşa Mah., Piyalepaşa Bulvarı, No:74, Şişli/İstanbul, Turkey.*

**Corresponding Author email: saral@yildiz.edu.tr*

Publication Info

Paper received:
29 May 2016

Revised received:
15 October 2016

Accepted:
01 March 2017

Abstract

Particulate matter can be generated through several processes. Formation processes determines the size distribution of the particles. The size distribution gives us important data about the fate of the particles. Composition of the particulate matter includes forensic about their actual sources. The aim of this study is to determine the impact of composting process to laboratory indoor air quality in close proximity to composting process. For this purpose, sampling was conducted at two different points; one of them wass inside the laboratory, whereas the other one was in the composting facility. A low volume cascade impactor was used to collect particulate matter according to their sizes. The impactor was operated for one week at each sampling point. Particles of 10 µm was dominant in the composting facility. The dominant particle size was 5.8 µm inside the laboratory. Particles were ultrasonically extracted in deionized water in order to determine ion concentrations. Ions were quantified in Dionex ICS-3000 ion chromatograph. Ca+2, NH4+ and SO4-2 were investigated. NH4+ and SO4-2 had highest share in the finest size fraction at both laboratory and plant. Particles of 3.3 µm were enriched with Ca+2. Biological decomposition products were effective in the ionic composition of the fine particles, whereas mechanically generated dusts formed the coarse particle fraction.

Key words

Particle size distribution, ionic content, active sampling

1. INTRODUCTION

Particles in ambient air is among the major pollutants. They referred in three maim groups, which are nuclei mode, accumulation mode, and coarse mode [1]. Nuclei mode are occurred from primary formed gasses, latter they are accumulated to form accumulation mode particles. Accumulation mode particles are usually regarded to be at the proximity of 1 µm aerodymamic size. The size with the highest size is referred as coarse mode. Particle sizes bigger than 2.5 µm are considered as coarse mode. The coarse mode particles are generated through mechanical formation. This formation can either be from industrial activities or from abrasion effect of the wind. Combustion and biological activities generate fine particles (particle diameter less than 2.5 µm). The data of particle size distribution is essential to know further insights of the particle sources. In many cases atmospheric particles exhibits bi-modal size distribution [2]. Apart from biological activities, biological sources could yield coarse particles [3].

Particles carry forensic from their actual sources. The chemical compositions of the particles can be used to distinguish their actual sources. There are several studies, in which the researchers investigated both particle distribution and its composition for source estimations [4]-[6]. In those references studies authors have made comments about the possible sources of the origins of the particles. Additionally, chemical composition data of the particles gives an idea of their probable effects.

Composition of the size segregated particles serves critical data about their sources. In this study, it was aimed to determine the sources of indoor particle, related to their sizes.

2. MATERIALS AND METHODS

2.1. Sampling

Sampling was conducted inside the laboratory of ISTAC AS composting facility. An additional sampling point was in the composting plant in order to differentiate the sources. There was one more plant nearby, which is producing brick. Map of the study area is shown in Figure 1.

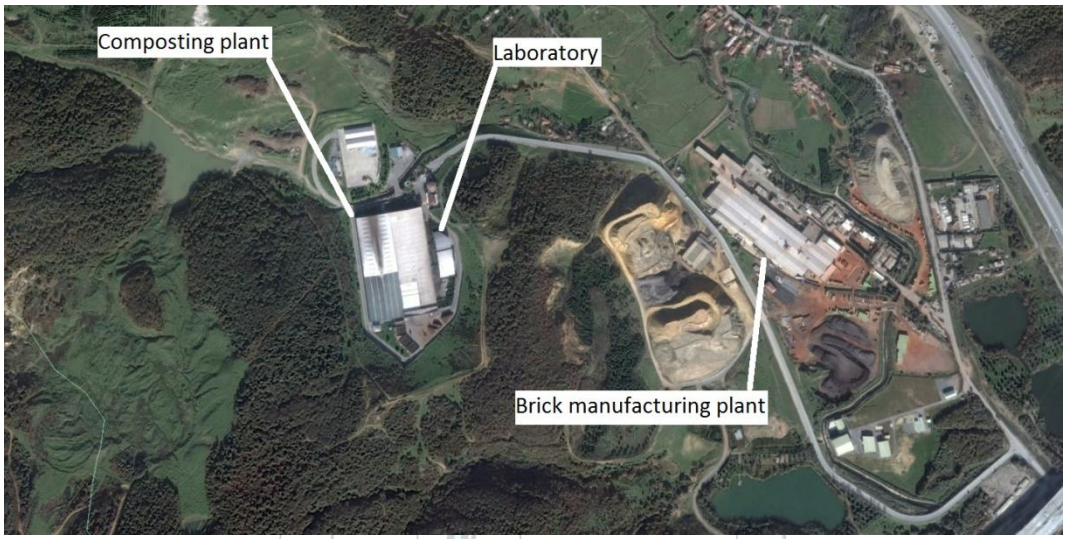


Figure 1. Study area

2.2. Sampling equipment

A low volume cascade impactor (LVCI) was used in the study to make the size segregation of the particles. LVCI was an eight-stage impactor, operated at 28.3 L/min air flow. The sampling at each point took one week in order to collect enough particle for the analyses of ions. This flowrate yielded the cut-off diameters given in Table 1.

Table 1. LVCI cut-off diameters

Stage no	Cut-off diameter (µm)
1	10
2	9
3	5.8
4	4.7
5	3.3
6	2.1
7	1.1
8	0.65

Stages of each diameter were weighed before and after the sampling in order to quantify particle mass at each stage. Further processing was applied for the determination of ions related to particles.

2.3. Sample preparation and quantification

Ionic species on the particles were eluted with deionized water [4]. 50 ml of water was used to collect all of the ions on the particles. The conductivity of the deionized water was 18.2 M.ohm.cm^{-1}. Prepared water samples were taken to vials for quantification in an ion chromatograph. The quantification results gives the concentrations in liquid medium in mg.L^{-1}. This concentration was multiplied with 50 mL to find the mass of ions at each stage.

3. RESULTS AND DISCUSSION

Particle sampling was performed inside the laboratory and plant environments with the LVCI. Particle size distribution data was gathered and source profile was investigated with the achieved particulate matter size data. The modal size distribution inside the laboratory was shown in Figure 2.

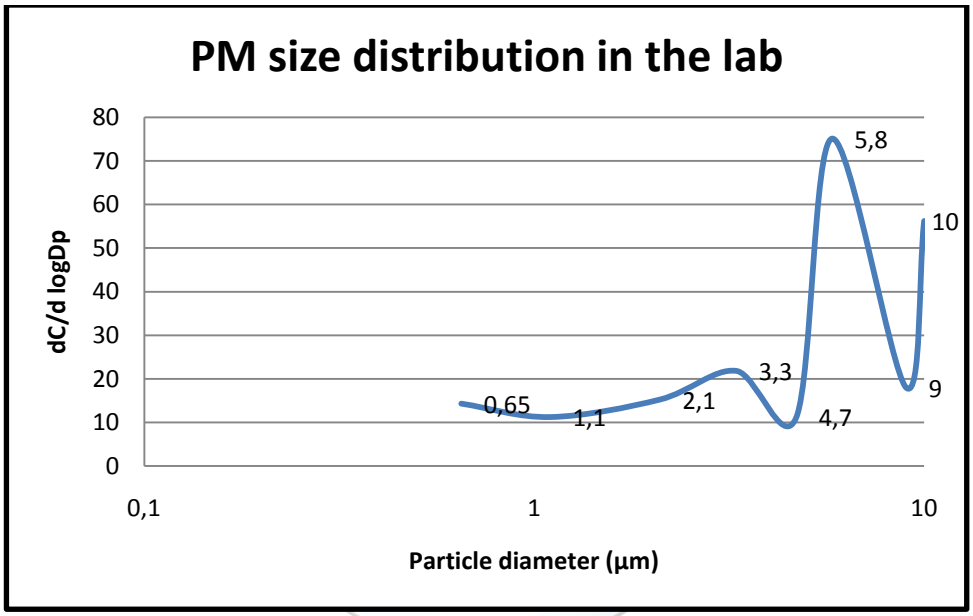


Figure 2. Particle size distribution inside the laboratory

Two peaks were observed. one of them wa at 5.8 µm, whereas the other one was at 3.3 µm. There was not an elevated trend below 1 µm particle size. It was thought that particles having diameter less than 1 µm is released from the plant. However, an additional sampling was required in order to verify this claim inside the plant. The particle size distribution inside the plant was shown in Figure 3.

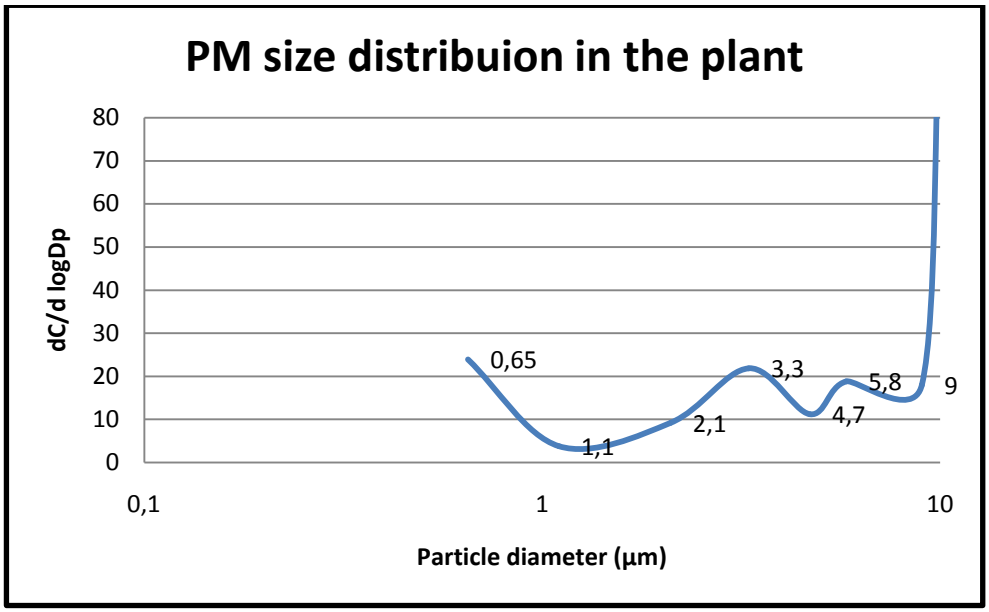


Figure 3. Particle size distribution inside the plant

In this case, there is an important increase below 1 µm particle size. This was the expected case in accordance with the nature of the process in the composting plant. Either of the samplings were shown in Figure 4 in order to make a comparison.

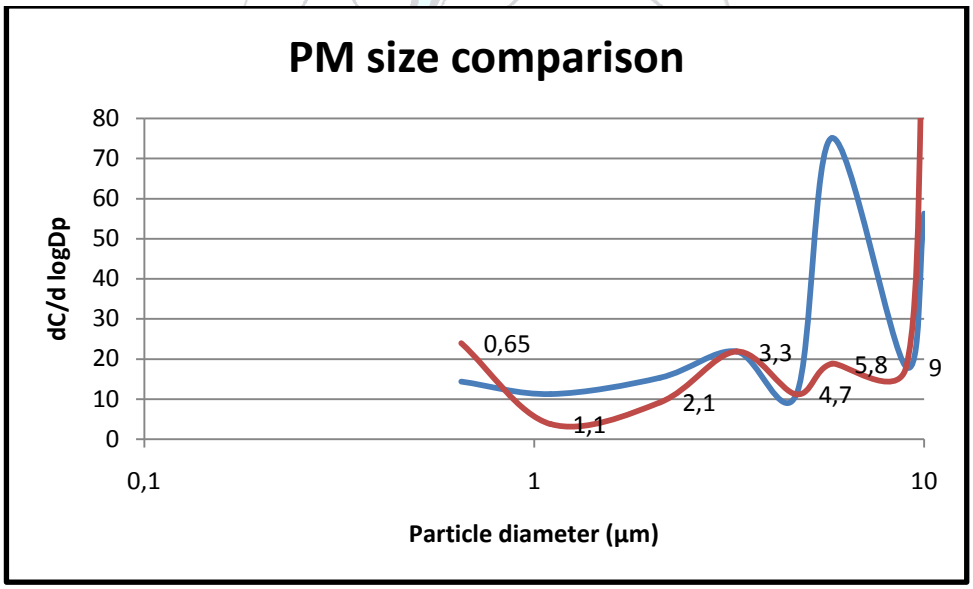
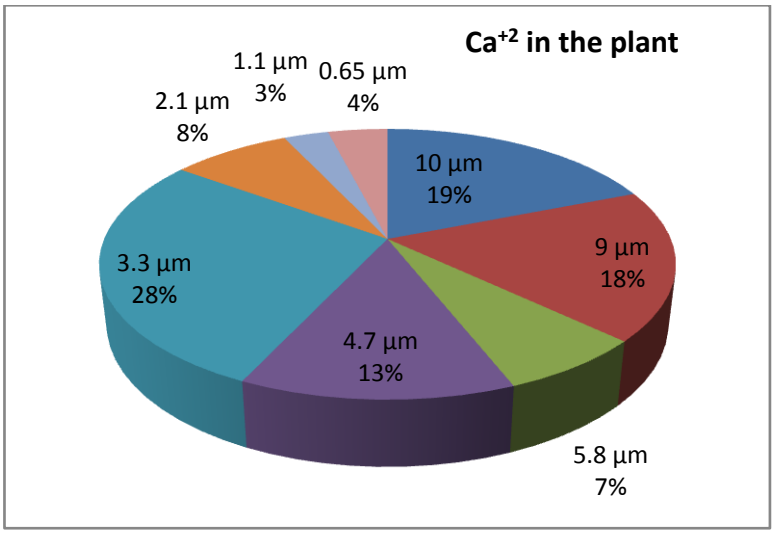


Figure 4. Comparison of particle size distribution in the plant and the laboratory

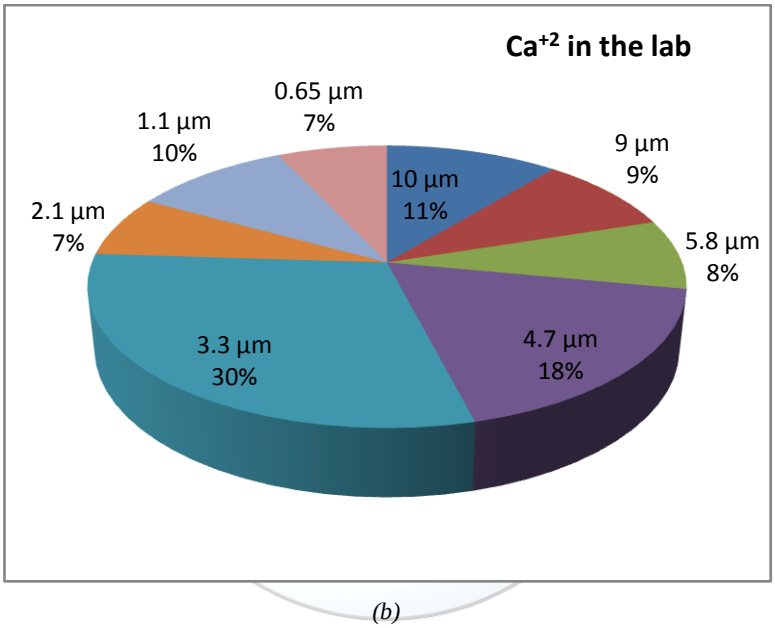
The line with blue color shows the distribution inside the laboratory, whereas the line with red color shows the distribution inside the plant. It is observed that major and minor peaks were observed at the same stages in both of the cases. However, their dominancy were different from each other. This fact tells us that same source or sources affect the two sampling points. Further comments can be made according to compositional results.

Air conditioning system is present to supply air to laboratory. The air moving to the system is pre-filtered. However it is seen that particles of 5.8 µm was from the major fractions inside the lab. It can be inferred that this filtration system is not working properly to remove the coarse particles. Coarse particles are usually originated from naturally blown dusts. In order to clarify this point, Ca^{+2} ions were investigated.

The distribution of Ca^{+2} ions at each stage is given in Figure 5.



(a)



(b)

Figure 5. (a) Ca^{+2} distribution among different stages in plant (b) Ca^{+2} distribution among different stages in lab

Sodium, potassium, and magnesium ions were also quantified along with calcium ions. However there was no difference among the distribution of these species. So that, it was decided not to include them in the paper. Calcium was included as a representer to the major ionic group. Coarse particles were dominated with these ions. The previous comment during the particle size distribution, is verified according to these results.

Organic matter originated compounds such as sulfate and ammonium was enriched in the fine particle mode at both plant and the laboratory. Ammonium was solely in the fine fraction inside the plant, where dense biological activity occurs. Particles less than 0.65 µm had contribution over 80%. Distribution of the ammonium and sulfate ions among the particle sizes are shown in Figure 6.

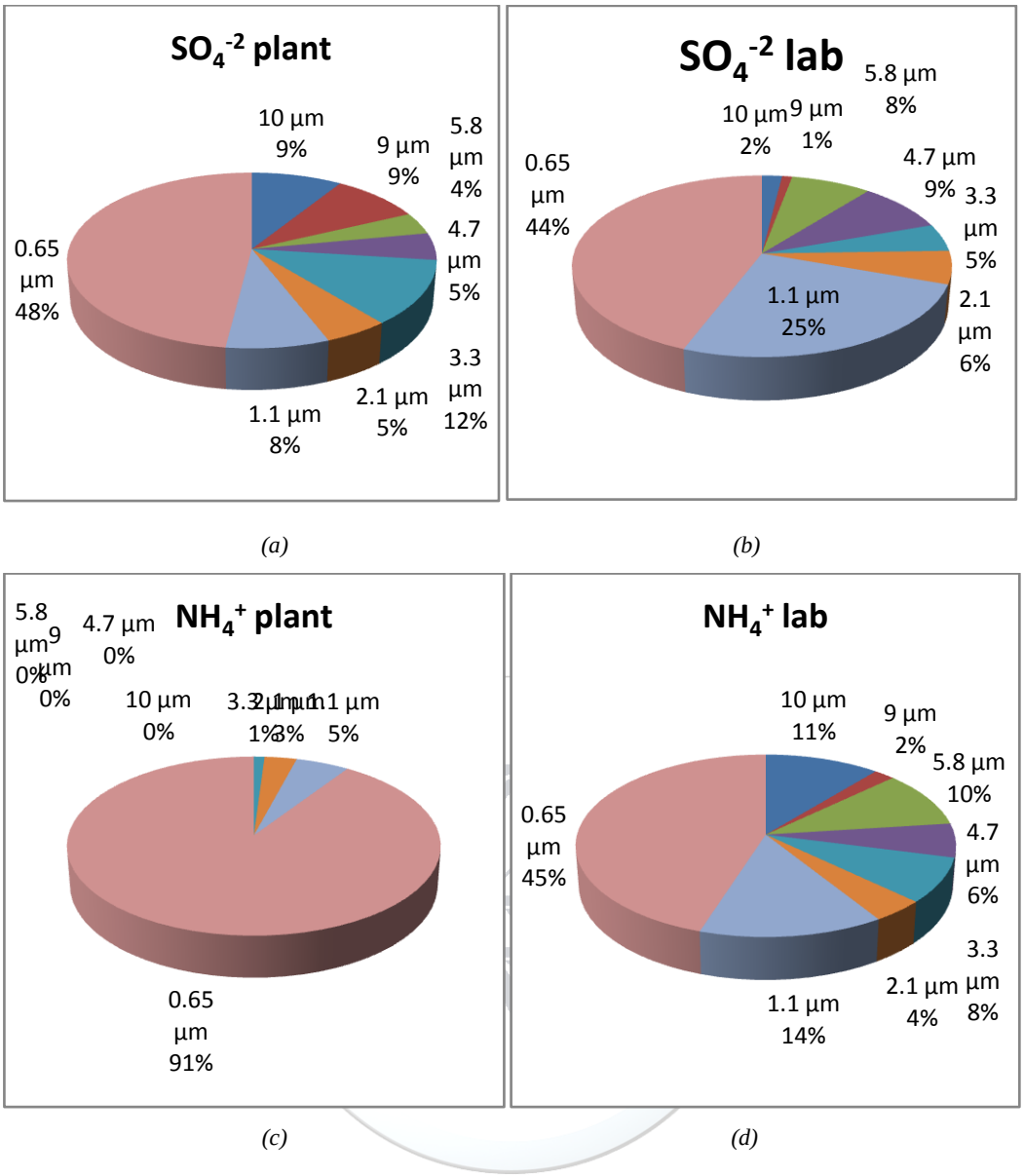


Figure 6. (a) SO_4^{-2} PM distribution in the plant (b) SO_4^{-2} PM distribution in the lab (c) NH_4^+ PM distribution in the plant d) NH_4^+ PM distribution in the plant

Accumulation particles, which are equal to or less than 1 µm, are occurred through the condensation of primary gasses and humidity in the air boost their formation. Sulfate ion can further lead to acidic aerosol forms. This can cause damage on laboratory devices. According to above results, it is inferred that air conditioning is not efficiently supplied.

4. CONCLUSIONS

In this study, air sampling was conducted at two locations; inside the laboratory and composting plant. Sampling was realized by LVCI. Particle size distributions in both of the sites were revealed. Particles of 3.3 µm mass median particle diameter were mostly enriched by calcium ion. This shows the contribution from resuspension of mineral dusts. The nearby brick factory could cause this contribution. Ammonium and sulfate ions were highly enriched in fine particles at both laboratory and composting plant. However, ammonia had much more contribution from the plant itself. Almost entire ammonium ions were below 1 µm. Sulfate content of indoor particles can lead to corrosion of laboratory devices. Some suggestions are listed below in order to improve the quality of indoor air inside the laboratory.

- HEPA filters should be used to improve the filtration capacity at the inlet of the fan system. Additional carbon fitler could reduce the organic content of the air and breakthrough tests should be performed to determine the capacity of carbon filters.

- Air fed to the conditioning system should be taken from the North or East of the laboratory in order to prevent direct contamination from composting process.
- Positive pressure should be present. So that, leaks from the outside air can be prevented.
- Sufficient circulation should be present with higher air fan power.
- Dehummidification of the indoor air is essential.
- Recirculation (close circuit system) should be present in the air conditioning system.

ACKNOWLEDGMENT

The authors would like to acknowledge ISTAC AS for their technical support during the sampling stage.

REFERENCES

[1]. K. T. Whitby, W. E. Clark, V.A. Marple, G.M. Sverdrup, G. J. Sem, K. Willeke, B. Y. H. Liu, D.Y.H. Pui, " Characterization of California aerosols—I. Size distributions of freeway aerosol", *Atmos Environ*., vol. 9, pp. 463–482, 1975

[2]. L. Morawska, S. Thomas, M. Jamriska, G. Johnson, "The modality of particle size distributions of environmental aerosols", *Atmos Environ*, vol. 33, pp. 4401–4411, 1999

[3]. J. H. Seinfeld and S. N. Pandis, *Atmospheric Chemistry and Physics: from air pollution to climate change*, 2nd ed., Berlin, USA: Wiley, 2006.

[4]. S. L. Kuzu, A. Saral, S. Demir, G. Summak, G. Demir, "A detailed investigation of ambient aerosol compositions and size distribution in an urban atmosphere", *Environ Sci Pol Res*, vol. 20, pp. 2556-2568, 2013

[5]. Ü. Alver Şahin, K. Scherbakova, B. Onat, "Size distribution and seasonal variation of airborne particulate matter in five areas in Istanbul, Turkey", *Environ Sci Pol Res*, vol. 19, pp. 1198-1209, 2012

[6]. B. Onat, Ü. Alver Şahin, C. Bayat, "Assessment of particulate matter in the urban atmosphere: size distribıtion, metal composition and source characterization using principal component analysis", *J. Environ Mon*., vol.14, pp. 1400-1409, 2012