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Odorous Volatile Organic Compounds Determined Inside the ISTAC Landfilling Facility and Places at Close Vicinity by Passive Air Sampling Method

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*

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Abstract

Volatile organic compounds (VOCs) attract the attention of the authorities due to their detrimental effects on environmental and human health. People are exposed to odor problems, which live in close vicinity of the emission sources. This is the most obvious effect of these emissions. In order to manage and control the emissions, released compounds at least should be monitored at source and receptor points. So that, source contributions can be evaluated. Landfilling is the most frequent method used in Turkey to manage and dispose the solid wastes. Although, engineering methods during and after the landfilling process minimizes the undesired effects of the wastes in the environment, odorous compounds released to the atmosphere still remains as a serious problem. Especially, people living in the surrounding residential areas are the most vulnerable ones. Sampling was conducted in the European side of Istanbul. Sampling points were selected to be inside the landfilling facility and residential areas where are reported to be exposed to odor from landfilling activity. Passive sampling method was used in this study. Sample tubes were placed in the area at least for ten days. Then, these tubes were brought to laboratory for further processing and quantification. VOC species were detected and quantified by GC-MS. Total VOC concentrations were ranged between 50 and 850 ppm. The VOC species with the highest concentrations were m&p xylene, 1,2,4-trimethybenzene, 1,4-diethylbenzene, n-decane, n-undecane. Concentrations observed in summer were considerably higher than in winter. The highest concentrations were observed in active landfilling lot, leachate waste water collection tank and composting facility.

Key words

VOC, passive sampling, landfill gas, passive sampling

1. INTRODUCTION

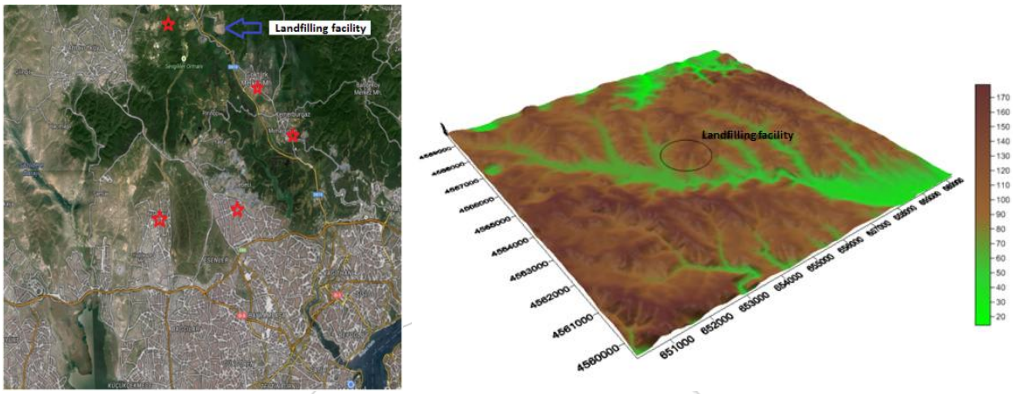
Investigation of volatile organic compounds (VOCs) are of scientific interest nowadays due to their toxic, carcinogen, and their odor effects [1],[2]. Long time exposure to benzene, toluene, xylene, and chlorinated compounds could yield health problems on landfilling operators [3]. Odor is occurred when insufficient oxygen is present during the decomposition of solid wastes [4]. There are some studis on the composition of landfilling gasses. In Turkey, characterization study was conducted in Izmir Harmandali landfilling area [5]. Diverse types of VOCs were identified in that study. The identified VOCs were monoaromatics, halogenated compounds, aldehydes, esters, ketones, sulfur/nitrogen containing compounds, volatile fatty acids. The main problem of these organic types are their annoying odor in urban areas [6].

The main goal of this study is to determine the VOC levels inside the landfilling facility area and in the residential zones close to the landfilling area, where people living in those areas are usually get annoyed. Finally, spatial distribution of VOCs were determined.

2. MATERIALS AND METHODS

2.1. Study Area

Landfilling facility in the European side of Istanbul is located in Kemerburgaz-Odayeri. This location is to the north of residential area of Istanbul. The prevailing wind direction in Istanbul is north-easterly. For that reason, the sampling points, apart from waste processing facilities, were selected to be the residential sites to the south of the facility. Sampling points are shown in Figure 1.



(a) *(b)*

Figure 1. (a) Map of the study area (b) Geographical properties of the study area (elevation in meters)

The red stars are the residential sites distributed in the sampling train. Geographic properties and meteorological conditions have big importance on the dispersion of the pollutants released from landfilling activities. The map showing the geographical properties of the study area in 10 km x 10km dimensions.

Meteorological data were gathered from Davis Vantage Pro-2 weather station present in Odayeri landfilling facility.

2.2. Sampling Method

The sampling was not in a single point. On the contrary, there were many sampling points distributed within a large area. So that, passive sampling method was selected. It is easy to handle passive sampling and a common method when there is large number of sampling points [7]. Sampling pump is not used so operation is cheaper than active sampling [8].

Passive sampling tubes were filled with 100 mg Carbopack-B adsorbent material and closed with fine mesh at both edges of the tube. Dept of the mesh was 1.5 cm from the edge. These tubes were delivered to the sampling location inside a falcon tubes. They were closed with telfon lids when sampling was finished and returned to the laboratory again in the falcon tubes. Sampling dates are given in Table 1.

Table 1. Sampling dates

Sampling no	Start date	Finish date
1	03.12.2014	17.12.2014
2	15.01.2015	04.02.2015
3	03.03.2015	19.03.2015
4	20.04.2015	05.05.2015
5	02.06.2015	17.06.2015

6	31.07.2015	21.08.2015
7	17.09.2015	15.09.2015
8	26.10.2015	06.11.2015
9	26.11.2015	11.12.2015

Some photos taken from the field studies are shown in Figure 2. Blank samples were taken along with the original samples in order to make quality assurance/quality control tests.

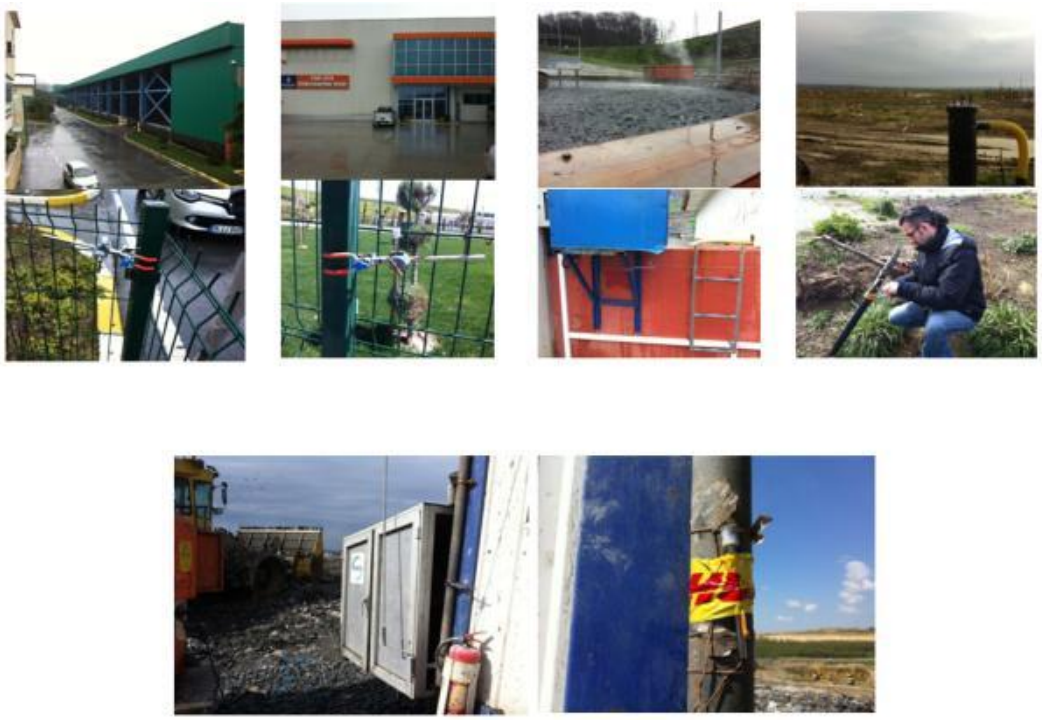


Figure 2.Pictures from field sampling studies

2.3. Sample Preparation

VOCs were adsorbed to adsorbent material at the sampling points. Their desorption was made by solvent extraction. Methanol was selected as the solvent. Chemical desorption process was realized inside the falcon tubes. Meshes of the tubes were removed and adsorbent material were poured in the falcon tubes. 2 ml of methanol was included inside the falcon tube. Then, falcon tubes were placed inside an ultrasonic bath and samples were ultrasonically extracted for 30 minutes. At the outset of each extraction, surrogate standards were included to find the recovery. After that, samples were placed into vials for gas chromatography (GC) analysis.

2.4. Gas Chromatography Analysis

Analyses were performed by Perkin-Elmer GC-MS system. The column was HP-5MS (30 m, 0.25 um, 0.25 id). Sample injection volume was 1 ml. Splitless injection was selected. Carrier gas was ultra pure helium, having pressure of 20 psi. Injector port temperature was kept at 240 ^{o}C. The oven was held 5 min at 35 ^{o}C, then temperature was raised to 110 ^{o}C at a rate of 5 ^{o}C/min. The oven was held at 110 ^{o}C for 2 min. After that, oven temperature was raised to 200 ^{o}C, at a rate of 40 ^{o}C/min. Finally, temperature was increased to 220 ^{o}C and waited there for 2 min. Total run time was 26.25 min.

In order to quantify the compounds 18 masses were investigated at two channels, which were 42, 43, 55, 57, 67 ,69, 71, 78, 83, 84, 85, 91, 92, 93, 98, 104, 105, 119. Forty different VOCs were targeted with these masses. However, 17 VOCs were regularly quantified. These species were: m-xylene, p-xylene, styrene, propylbenzene, n-decane, isopropylbenzene, alpha-

pinene, beta-pinene, propylbenzene, 3,4-ethyltoluene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, 1,2,3-trimethylbenzene, 2-ethyltoluene, 1,3-diethylbenzene, n-undecane.

2.5. Gas Chromatography Analysis

Blank samples were analyzed as with regular samples. Limit of detection (LOD) was calculated according to blank samples. LOD was calculated as : mean blank sample concentration plus three times of the standard deviation of the blank samples. o-xylene were used as the surrogate standard. Its average recovery efficiency was 53±11%

2.6. Calculation of the Concentrations

Concentration of VOCs were determined in liquid phase. Total air flowrate need to be known in order to find atmospheric concentrations. As the sampling was passive type, it is not accurately possible to find actual flowrate. VOCs accumulated inside the adsorbent by diffusion. Equation 1 and equation 2 are used to calculate ambient air concentrations.

$$Uptake\ rate = \frac{D\left(\frac{cm^2}{sec}\right)xA(cm^2)}{L(cm)} \quad (1)$$

$$Atmospheric\ concentration\ (ppm) = \frac{M_a(mg)}{upta\ ke\ rate\left(\frac{ng}{ppm\ \ x\ min}\right)x\ t\ (\text{min})} \quad (2)$$

where, D is the diffusion coefficient for each VOC type, A is the cross sectional area of the sampling tube, L is the distance between the mesh and the edge of the tube, Ma is the molecular weight of the VOC in concern, and t is the sampling time.

3. RESULTS AND DISCUSSION

The result of each sampling period was shown with the spatial distribution and wind rose acquired for each sampling period. The time spent in the field for sampling no 7 was prolonged and consequently they reached to saturation. The values results for sampling no 7 was not reported for that reason. Spatial distribution of sampling no 1 is given in Figure 3.

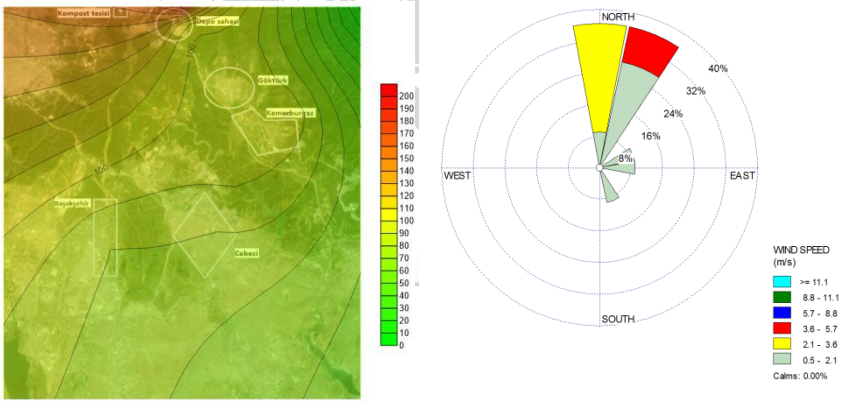


Figure 3.Sampling results of sampling no 1

Prevailing wind direction was N-NE. Wind speed was mostly below 3.6 m/sec. The highest concentration was 200 ppm. The location of the highest concentration was landfilling area. The three highest concentrations in residential areas were 90 ppm, 80 ppm, and 70 ppm for Kemerburgaz, Başakşehir, and Cebeci, respectively.

Spatial distribution of sampling no 2 is given in Figure 4.

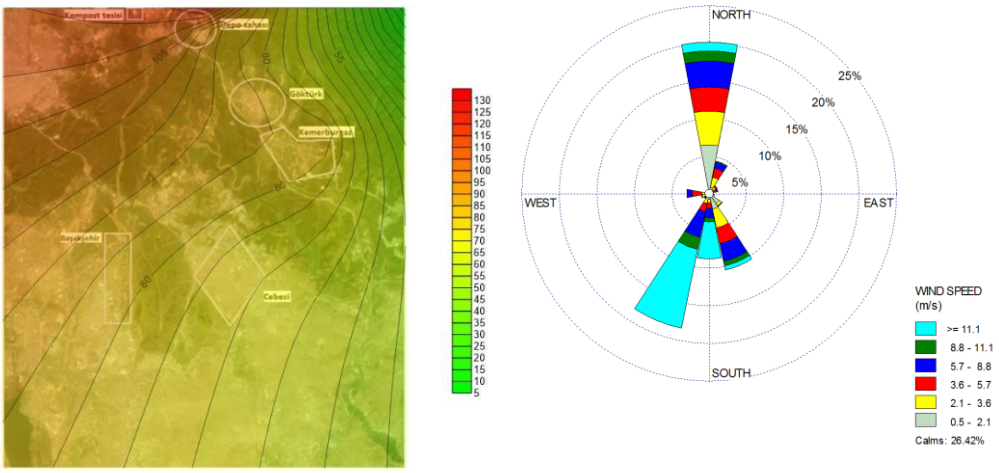


Figure 4. Sampling results of sampling no 2

Prevailing wind direction was N-SW. Wind speed was mostly above 11.1 m/sec. The wind speed was less than 0.5 m/sec during 26% of the whole sampling time. The highest concentration was 130 ppm. The location of the highest concentration was landfilling area. The three highest concentrations in residential areas were 80 ppm, for Kemerburgaz, Başakşehir, and Cebeci. It was 60 ppm in Cebeci.

Spatial distribution of sampling no 3 is given in Figure 5.

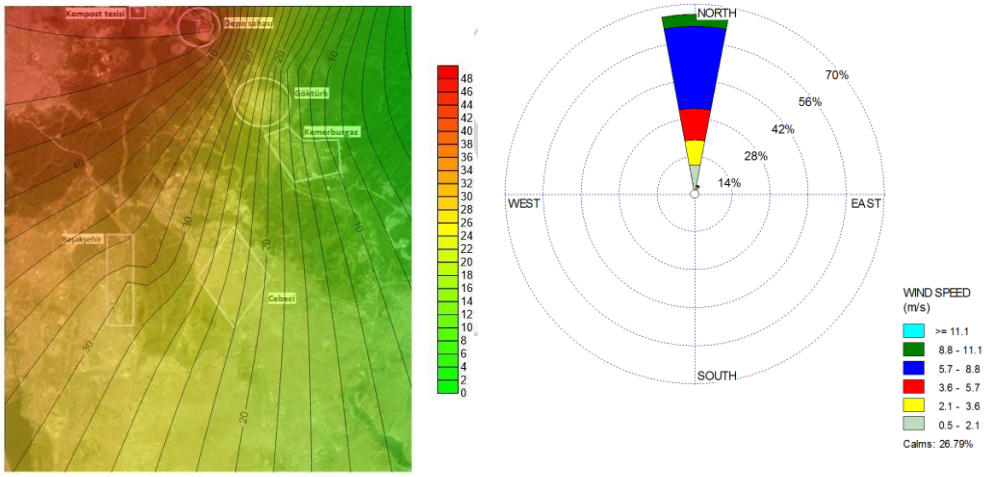


Figure 5. Sampling results of sampling no 3

Prevailing wind direction was N. Wind speed was mostly between 5.7-8.8 m/sec. The wind speed was less than 0.5 m/sec during 27% of the whole sampling time. The highest concentration was 50 ppm. The location of the highest concentration was landfilling area. The two highest concentrations in residential areas were 50 ppm for Başakşehir, and Cebeci.

Spatial distribution of sampling no 4 is given in Figure 6.

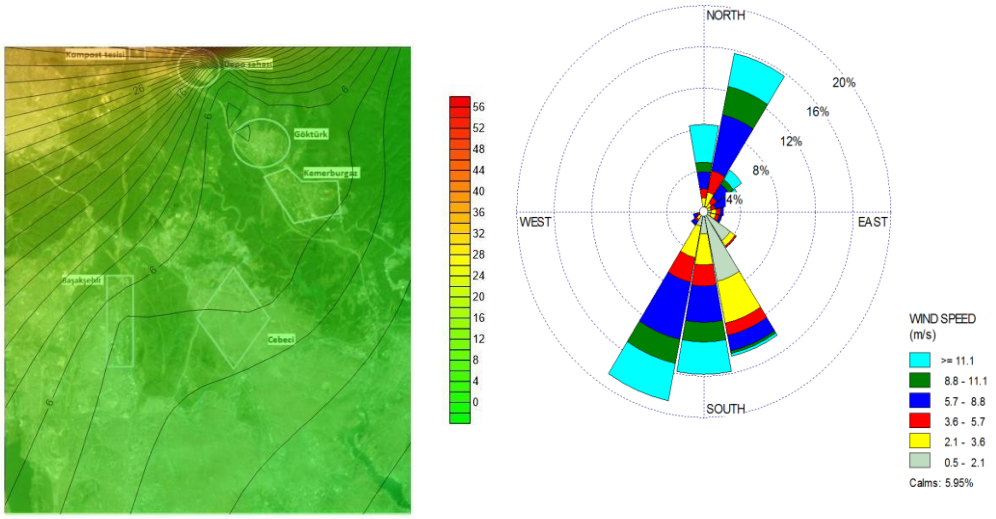


Figure 6. Sampling results of sampling no 4

Prevailing wind direction was S-SSW-NNE. Wind speed was mostly between 5.7-8.8 m/sec. The wind speed was less than 0.5 m/sec during 6% of the whole sampling time. The highest concentration was 56 ppm. The location of the highest concentration was landfilling area. The highest concentrations in residential areas were 5 ppm Göktürk, Kemerburgaz, Başakşehir, and Cebeci.

Spatial distribution of sampling no 5 is given in Figure 7.

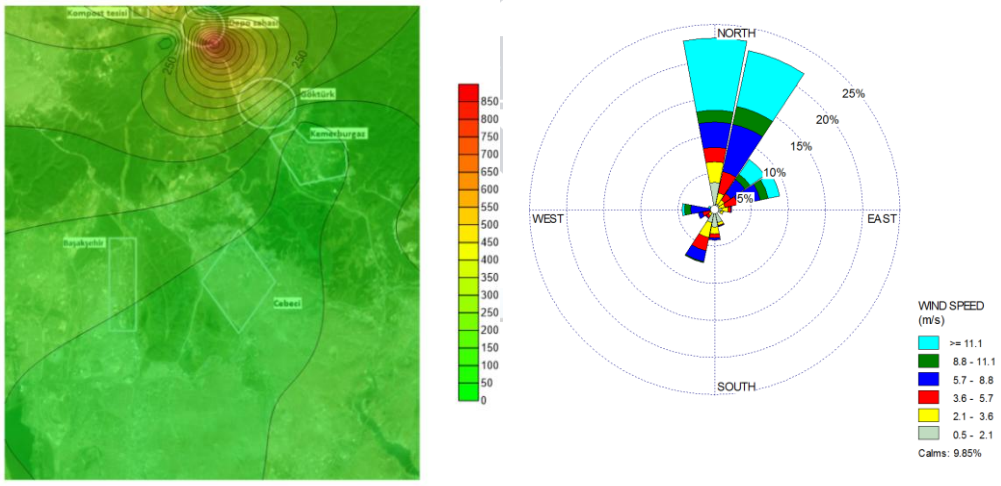


Figure 7. Sampling results of sampling no 5

Prevailing wind direction was N. Wind speed was mostly above 11.1 m/sec. The wind speed was less than 0.5 m/sec during 10% of the whole sampling time. The highest concentration was 850 ppm. The location of the highest concentration was landfilling area. Half of this concentration was observed from the composting facility. The highest concentrations in residential areas were between 50 and 100 ppm at Kemerburgaz, Başakşehir, and Cebeci'.

Spatial distribution of sampling no 6 is given in Figure 8.

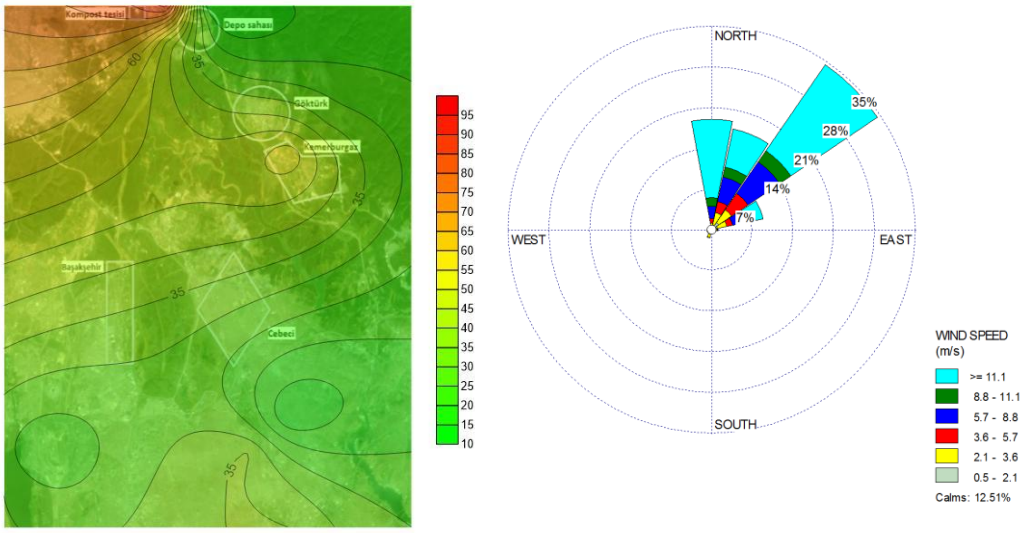


Figure 8. Sampling results of sampling no 6

Prevailing wind direction was N. Wind speed was mostly above 11.1 m/sec. The wind speed was less than 0.5 m/sec during 12% of the whole sampling time. The highest concentration was 100 ppm. The location of the highest concentration was the composting facility. VOC concentration was 60 ppm at the landfilling site. The highest concentration in residential areas was observed in Kemerburgaz as 45 ppm. The concentration was 35 ppm at between 50 and 100 ppm at Göktürk, Başakşehir, and Cebeci.

Spatial distribution of sampling no 8 is given in Figure 9.

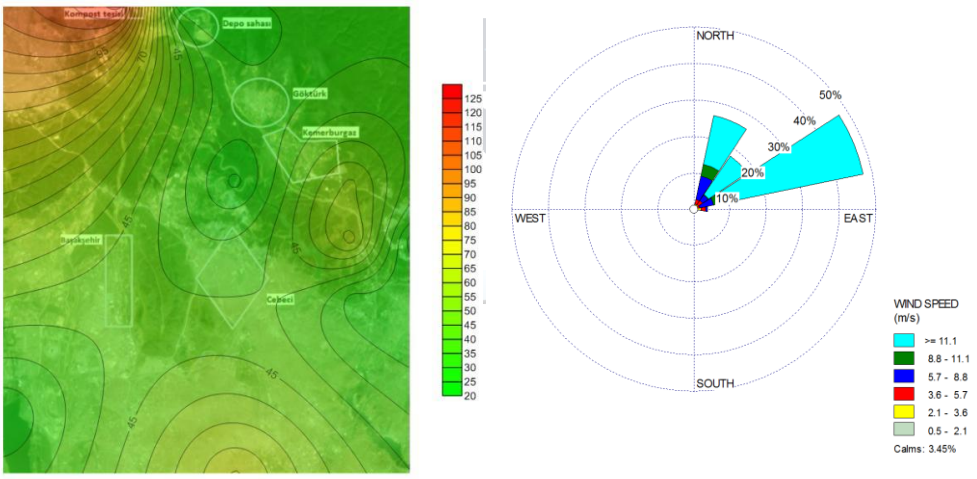


Figure 9. Sampling results of sampling no 8

Prevailing wind direction was N. Wind speed was mostly above 11.1 m/sec. The wind speed was less than 0.5 m/sec during 3% of the whole sampling time. The highest concentration was 130 ppm. The location of the highest concentration was the composting facility. VOC concentration was 45 ppm at the landfilling site. The highest concentrations in residential areas were between 35 and 50 ppm in Kemerburgaz.

Spatial distribution of sampling no 9 is given in Figure 10.

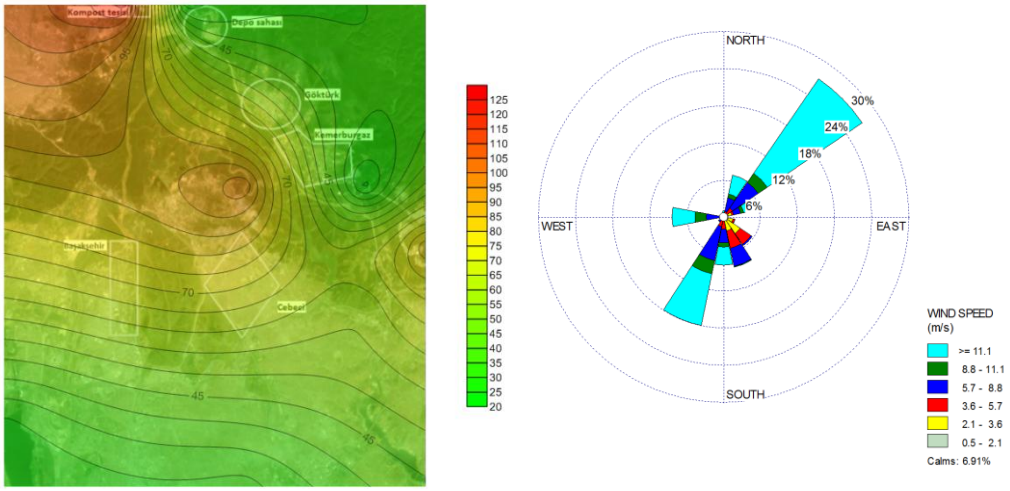


Figure 10. Sampling results of sampling no 9

Prevailing wind direction was N. Wind speed was mostly above 11.1 m/sec. The wind speed was less than 0.5 m/sec during 26% of the whole sampling time. The highest concentration was 300 ppm. The location of the highest concentration was the composting facility. The concentrations were at the same levels for the remaining places.

4. CONCLUSIONS

In this study, VOC concentrations at the waste management facilities were measured and to see their effect on residential sites, sampling was conducted at some specific residential areas. The highest concentrations were encountered mostly in landfilling area. The highest concentration was 850 ppm However, the variability was very high. Usually half of the VOC concentrations were present in residential areas. The main sources were landfilling, composting, and leachate collection tank. It is suggested to control the emissions from these sources. Daily soil can be laid in order to prevent volatilization of VOCs from landfill and operation can be made within small scale lots. Top of the leachate collection tank could be closed and emissions can be treated in a further step. The emissions of composting facility is treated by a biofilter. However, the treatment process is not working efficiently. It is suggested to revise and modify this system to control the VOCs.

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REFERENCES

[1]. A. Saral, S. Demir, and Ş. Yıldız, “Assessment of odorous UOBs released from a main MSW landfill site in Istanbul-Turkey via a modelling approach”, *J Haz Mat*, vol 168, pp 338-345, 2009.
[2]. M. A. Parra, D. Elustondo, R. Bermejo, and J. M. Santamaria, " Exposure to volatile organic compounds (UOB) in public buses of Pamplona, Northern Spain ", *Sci Tot Environ*, vol 404, pp 18-25, 2008.
[3]. S. C. Zou, S. C. Lee, C. Y. Chan, K. F. Ho, X. M. Wang, L. Y. Chan, and Z. X. Zhang, "Characterization of ambient volatile organic compounds at a landfill site in Guangzhou, South China", *Chemosphere*, vol. 51, pp. 1015-1022, 2003.
[4]. Q. Liu, M. Li, R. Chen, Z. Li, G. Qian, T. An, and J. Fu, "Biofiltration treatment of odors from municipal solid waste treatment plants", *Waste Management*, vol. 29, pp. 2051-2058, 2009.
[5]. F. Dinçer, M. Odabaşı and A. Muezzinoğlu, "Chemical characterization of odorous gases at a landfill site by gas chromatography-mass spectrometry", *J Chrom A*, vol 1122, pp. 222-229, 2006.
[6]. A. Muezzinoglu, "A study of volatile organic sulfur emissions causing urban odors", *Chemosphere*, vol. 51, pp. 245-252, 2003.
[7]. F. Karaca, "Istanbul'un tarihi yarımadasında yüzey yayılım profilinin araştırılması", *Hava Kirliliği Araştırmaları Dergisi*, vol. 1, pp. 53-65, 2012.
[8]. E. Woolfenden, "Sorbent-based sampling methods for volatile and semi-volatile organic compounds in air Part 1: Sorbent-based air monitoring options", *J Chrom A*, vol. 1217, pp. 2674-2684, 2010.