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Volatile Organic Compound Analysis in Istanbul

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Abstract

One of the major problems of megacities is air pollution. Therefore, investigations of air quality are increasing and supported by many institutions in recent years. Air pollution in Istanbul contains many components that originate from a wide range of industrial, heating, motor vehicle, and natural emissions sources. VOC, originating mainly from automobile exhaust, secondhand smoke and building materials, are one of these compounds containing some thousands of chemicals. In spite of the risks to human health, relatively little is known about the levels of VOC in Istanbul. In this study, ambient air quality measurements of 27 VOCs including hydrocarbons, halogenated hydrocarbons and carbonyls were conducted in Kağıthane (Golden Horn) region in Istanbul during the winter season of 2012 in order to develop the necessary scientific framework for the subsequent developments. Kağıthane creek valley is the source part of the Golden Horn and one of the most polluted locations in Istanbul due to its topographical form and pollutant sources in the region. In this valley, horizontal and vertical atmospheric motions are very weak. The target compounds most commonly found were ethene (ethylene), 3-methylpentane, trans-2-butene, cyclohexane, isopentane (FID), propane (FID) and Ethyn (FID).

Study Area and Data

One of the megacities in the world with more than 13 million inhabitants according to the 2011 figures, Istanbul, in terms of industrial, commercial, cultural and tourism is the heart of Turkey. It has a cosmopolite topography that includes a lot of valley and hill. The city (41ºN; 29 ºE) is located between Asia and Europe with a total area of 5.714 km^2. Kagithane region's population is about 414,000 according to 2010 figures. About 24% of the total residents use coal as domestic heating. Industrial sources lie along the valley and approximately more than 50 small factories emitting pollutants into the atmosphere in the area. Diesel powered motor vehicles are also major traffic sources in this location. Investigations concerning diurnal variations of VOC concentrations were carried out at an air quality station in Kağıthane district of Istanbul. Meteorological data, atmospheric pressure, temperature, relative humidity, wind direction and speed were also obtained from the same station. Measurements were conducted from 5 January to 6 February 2012.

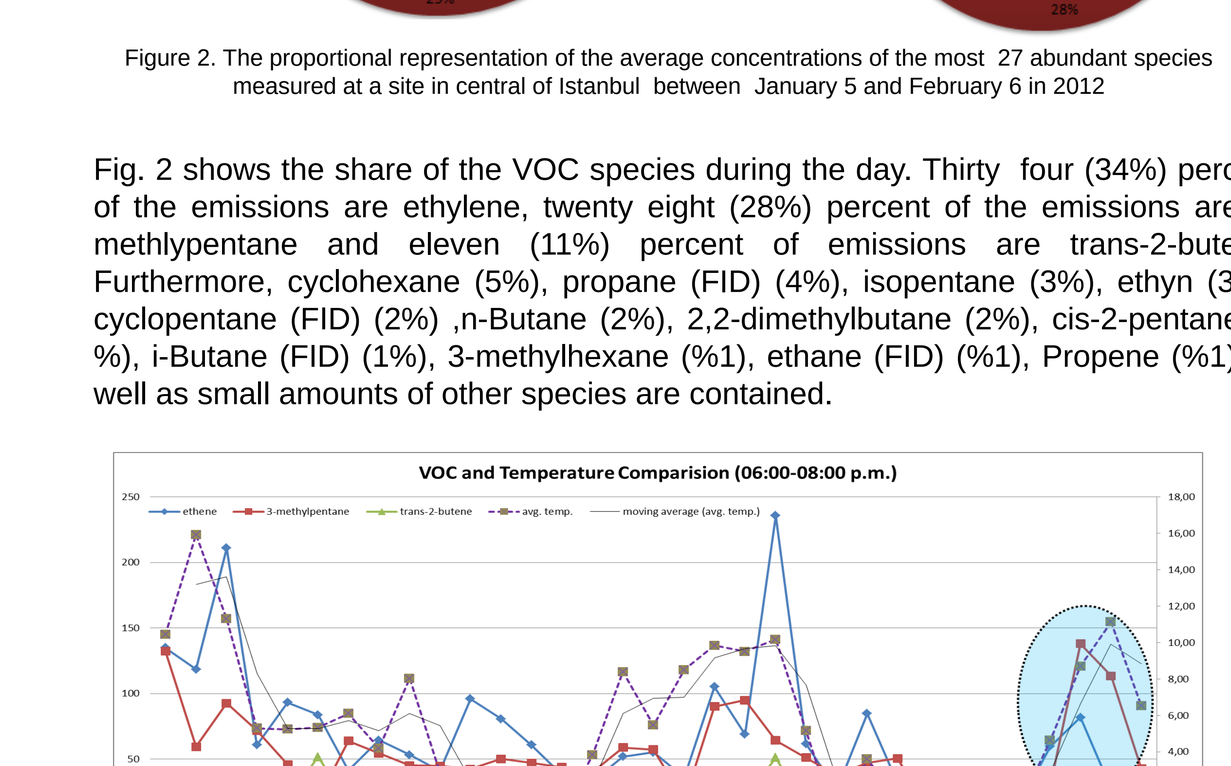

Figure 2. The proportional representation of the average concentrations of the most 27 abundant species measured at a site in central of Istanbul between January 5 and February 6 in 2012

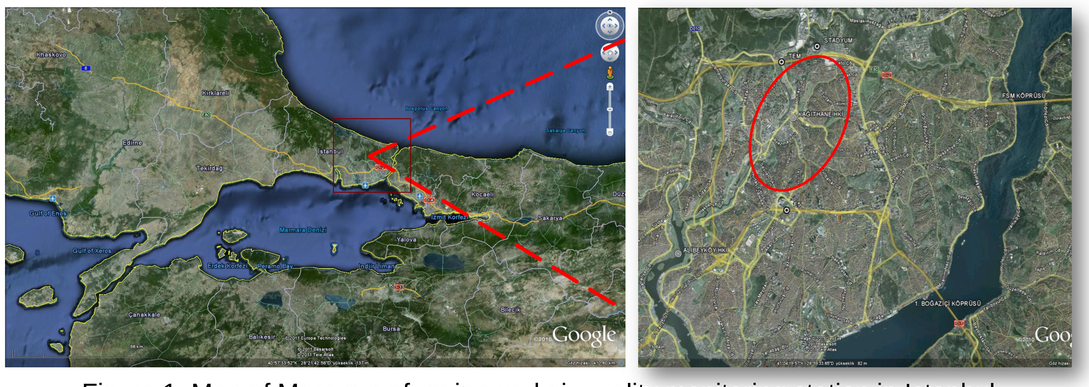

Figure 1. Map of Marmara of region and air quality monitoring station in Istanbul

Result and Discussion

To observe general characteristics and diurnal variations of VOC concentrations, the three 2-h averaged concentrations were measured in the morning, afternoon and evening. A summary of the mean concentrations of the 27 most abundant species based on the identified VOCs is presented in Table 1. On average, ethylene (61,2 ppb) was the most abundant species, followed by 3-methylpentane (49,4 ppb), trans-2-butene (19 ppb) and cyclohexane (9 ppb). High emissions from the industrial activities combined with the traffic and residential emissions during the afternoon and evening hours may be explain this results. Since the concentration rankings of the compounds closely associated with industrial activities such as ethylene, 3-methylpentane and trans-2-butene were higher in the afternoon and in the evening than in the morning. In addition, the average temperature was higher in the afternoon (6,98 °C) and in the evening (5,82 °C) than in the morning (3,76 °C) which could make a positive contribution to high concentration values as seen in the Figure 3.

Table 1. The average concentrations of the most 27 abundant species measured at a site in central of Istanbul between January 5 and February 6 in 2012 (unit : ppbv)

Morning 07:00 – 09:00 a.m.		Afternoon 02:00 – 04:00 p.m.		Evening 06:00 – 08:00 p.m.	
ethylene (ethene)	49,9	ethylene (ethene)	64,9	ethylene (ethene)	68,6
3-methylpentane	40,7	3-methylpentane	52,1	3-methylpentane	55,4
trans-2-butene	13,8	trans-2-butene	21	trans-2-butene	22,1
cyclohexane	11,7	isopentane (FID)	6,51	cyclohexane	9,71
propane (FID)	6,7	propane (FID)	5,95	isopentane (FID)	7,21
Ethyn (FID)	5,66	cyclohexane	5,68	propane (FID)	6,4
isopentane (FID)	4,59	Ethyn (FID)	4,53	Ethyn (FID)	5,64
n-Butane (FID)	3,56	cyclopentane (FID)	3,78	cyclopentane (FID)	4,32
i-Butane (FID)	3,15	n-Butane (FID)	3,11	n-Butane (FID)	3,45
cyclopentane (FID)	2,52	2,2-dimethylbutane	2,78	cis-2-pentene	3,22
2,2-dimethylbutane	2,39	cis-2-pentene	2,7	2,2-dimethylbutane	3,21
cis-2-pentene	2,35	i-Butane (FID)	2,17	i-Butane (FID)	2,44
ethane (FID)	1,34	3-methylhexane	1,74	3-methylhexane	2,09
Propene	1,09	ethane (FID)	1,48	Propene	1,44
1-3 butadiene	0,8	Propene	1,45	ethane (FID)	1,36
isobutene	0,64	1-3 butadiene	0,65	1-3 butadiene	0,74
toluene	0,29	isobutene	0,5	isobutene	0,5
1-butene	0,27	benzene	0,37	1-butene	0,37
benzene	0,25	toluene	0,35	benzene	0,37
3-methylhexane	0,16	1-butene	0,32	toluene	0,36
o-xylene	0,12	o-xylene	0,13	o-xylene	0,15
trans-2-pentene	0,1	trans-2-pentene	0,12	trans-2-pentene	0,12
ethylbenzene	0,08	ethylbenzene	0,09	ethylbenzene	0,1
2,2,4-trimethylpentane	0,07	2,2,4-trimethylpentane	0,07	2,2,4-trimethylpentane	0,07
n-heptane	0,06	n-heptane	0,02	n-heptane	0,05
o-ethyltoluene	0,02	o-ethyltoluene	0,02	o-ethyltoluene	0,02
1,2,4-trimethylbenzene	0,01	1,2,4-trimethylbenzene	0,01	1,2,4-trimethylbenzene	0,01

Fig. 2 shows the share of the VOC species during the day. Thirty four (34%) percent of the emissions are ethylene, twenty eight (28%) percent of the emissions are 3-methlypentane and eleven (11%) percent of emissions are trans-2-butene. Furthermore, cyclohexane (5%), propane (FID) (4%), isopentane (3%), ethyn (3%), cyclopentane (FID) (2%) ,n-Butane (2%), 2,2-dimethylbutane (2%), cis-2-pentane (2 %), i-Butane (FID) (1%), 3-methylhexane (%1), ethane (FID) (%1), Propene (%1) as well as small amounts of other species are contained.

Figure 3. The time series of the average temperature and the average concentrations of the most 3 abundant species measured at 06:00-08:00 p.m. between January 5 and February 6 in 2012

Figure 3 clearly shows that higher VOC concentations are proportional to higher temperature values. As temperature rises from 0 °C to 8,7 °C in the evening between January 31 and February 4, VOC concentrations also rise proportionally.

Conclusion

Ethylene, 3-methylpenatene and trans-2-butene were found to be the high ranked species among the most 27 abundant species in Kağıthane. Inside an industrial area of Istanbul, combined industrial emissions with the traffic activity and residential emissions resulted in 61,2 ppb ethylene, 49,4 ppb methylpentane and 19 ppb trans-2-butene. Ethylene is a hydrocarbon and is the simplest alkene. It's main anthropogenic sources are from combustion of gas, fuel, coal and biomass. Although no risk to human health has been identified, ethylene levels in urban areas could reach levels which inhibit growth of certain plant species since the vegetation has proven highly susceptible to this gas. 3-Methylpentane is a branched-chain alkane. 3-Methylpentane's production and use as solvent, raw material, fuel, and lubricant may result in its release to the environment. 3-Methylpentane is often found in glue used in shoe manufacturing, yet studies indicate that transportation exhaust is the major source of 3-methylpentane concentration in air. 3-Methylpentane can be absorbed into the body by inhalation of its vapor. There is some evidence to suggest that the material can cause respiratory irritation in some persons. The body's response to such irritation can cause further lung damage. Trans-2-Butene is an acyclic alkene with four carbon atoms. It is a petrochemical, produced by the catalytic cracking of crude oil. Trans-2-butene may be used for the manufacture of plastics materials and articles intended to come into contact with foodstuffs. Based upon the available information, peak concentrations of trans-2-butene could be a concern for humans.