Environ Res Tec, Vol. 6, No. 2, pp. 118–132, June, 2023

Environmental Research and Technology
https://ert.yildiz.edu.tr - https://dergipark.org.tr/tr/pub/ert
DOI: https://doi.org/10.35208/ert.1235618

Environmental Research & Technology

Research Article

Interpretation of odor complaint records with BTEX pollutants and meteorological factors: Çorlu case study

Can Burak ÖZKAL[1], Lokman Hakan TECER[1]

[1]*Department, of Environmental Engineering, Tekirdağ Namık Kemal University, Çorlu 59860, Tekirdağ, Türkiye*

ARTICLE INFO

Article history
Received: January 16, 2023
Revised: May 21, 2023
Accepted: May 31, 2023

Keywords:
Odor pollution; Air pollution; BTEX; VOC; Odor complaint; Citizen survey; Mobile app; Smart city; GIS

ABSTRACT

Air pollution in urban areas increases as a result of emitted air from different sources within the mixing layer of troposphere. Odor pollution is amongst the primary reasons behind environmental nuisance and occurrence of citizen complaints. Frequent exposure to odorous compounds and/or odor nuisance are increasingly associated with air pollution problems. Besides, there is no universally accepted environmental odor management method reported so far. Level of air pollutants emission, distance of emission sources to residential areas, topography, geographical and meteorological conditions have influence on imposed level of air pollution and odor pollution in cities.

This study is built on the citizen odor complaint data (based on frequency, intensity, duration, odor tone and location (namely the FIDOL factors) collected in Çorlu/Tekirdağ through the GIS integrated public participated platform, namely the Çorlu KODER mobile application. The annual odor complaint data was briefly introduced and given an evaluation with the mobile app users demographic information. The obtained data between August 28-November 2 of 2021, was subjected to interpretative evaluation and statistical analysis with BTEX (benzene, toluene, ethylene benzene and xylen) concentrations, inorganic air pollution concentrations and meteorological factors. In light of the obtained results, temperature, wind speed, relative humidity and toluene concentration were found to play a significant role on the number of citizen odor complaints. The EU reported limit value, lower rating threshold and upper rating threshold for BTEX pollutants have been exceeded several times.

The average Toluene/benzene ratios obtained during the study show that; non-traffic sources contribute significantly to VOC emissions. Air pollutants transportation mechanism from neighbouring OIZ settlements become a prominent justification and support the hypothesis that residential areas of Corlu are under the effect of industrial air pollution and odor pollution constituents. There is low level of negative correlation between the benzene measured in Çorlu and WS (r=-0.63). Below 2.4 m/s, the average number of odor complaints (ANOC) tend to increase, while above this level odor complaints are diminished). The ANOC remained around 4 for $[C]_{BTEX\ total} < 4$ ug/m^3 and reached to 18 for $[C]_{BTEXtotal} > 8$ ug/m^3. Above $[C]_{Toluen}=3$ ug/m^3 conditions, Daily ANOC increase from 7 to 19. Over $[C]_{Toluen}= 4$ ug/m^3 conditions, it reached up to 23. Increses in the number of daily ANOC by temperature is distinct over 21 C^0 and reaches to 35.

The GIS integrated citizen complaint collection platforms are critical for real-time data collection of environmental complaints with high spatiotemporal accuracy. Citizen odor complaint surveys are useful monitoring tools and obtained data sets can be used to identify sensitive areas where and when specific actions should be taken and air pollutants measuement studies be performed.

Cite this article as: Özkal CB, Tecer LH. Interpretation of odor complaint records with BTEX pollutants and meteorological factors: Çorlu case study. Environ Res Tec 2023;6(2):118–132.

*Corresponding author.
*E-mail address: cbozkal@nku.edu.tr

INTRODUCTION

Air pollution and odor pollution are serious environmental issues with regard to air quality and handled as public health problems. It constitute of inorganic and organic components originating from industrial processes, energy production, housing and traffic [1–4]. It is an indicator of environmental change that affects health, human well-being and is subject to the most frequent public complaints [5, 6]. Environmental information is necessary for governments to follow environmental policies and management goals. The collected information also may serve in identification of environmental problems, regional and temporal citizen complaints and disorders. Data related to pollution, ecosystem and landscape, also epidemiological and psychological data have a determining role on a healthy environment, health and life style [7].

All European countries are required to comply with the framework and for air quality management as described in the Air Quality Directive (AQD) 2008/50/EC (EU, 2008) which opens the door for the use of other supplementary techniques, such as air quality models and indicative measurements [8]. Because of their physical, operational, maintenance and economical aspects, stable air quality monitoring stations (AQMS) are preferred to be built only at the most representative location. Mobile AQMS are mainly used with intent to increase spatial sampling density. Passive samplers are inexpensive to deploy and operate [8–10], they only allow the quantification of cumulative air pollutant levels, and cannot identify short-term pollutant episodes [8, 10].

Due to widespread economic development models, the level of interaction between the residential area and the surrounding industrial activity and tend to rise day by day [11]. Air pollutant emission levels, the distance of emission sources to residential areas, topography, geographical conditions, seasonal and daily variation of meteorological factors have influence on the imposed level of air pollution, odor pollution, odor annoyance and nuisance levels [12–15]. Around metropolitan and industrial settlements, emitted air pollutants can be accumulated under influence of the wind speed/direction (called dry deposition) and may result in wet deposition on the ground as a result of relative humidity and precipitation [16–18]. High RH favors the partition of semi-volatile species into the aerosol phase [19–22].

Volatile organic compounds (VOCs) constitute the major component of the atmospheric composition and compose of large group of organic chemicals and characterized by their volalitity [23]. Odorous VOCs may originate from natural and anthropogenic sources [24]. The most common VOCs are called BTEX (Benzen, toluen, ethylbenzen and xylen) which contitute more than 60% of the non-methane VOCs within the urban atmosphere [25]. The odorous VOCs can be subcategorized into five main groups; alkanes, alkenes, halogenated hydrocarbons, aromatic hydrocarbons (where the BTEX pollutants belong) and helogenated aromatics. Aromatic hydrocarbons accounts for about the 97% of paint solvents composition where toluene is dominating [26, 27]. According to literature, based on cumulative measurement carried out on a number of VOCs in industrial areas and around the neighboring residental areas; the ratio of odorous VOCs to the total VOCs were reported to be distinctly high [5]. According to another literature finding, toluene concentration may reach 15-20 times of the remaining BTEX pollutants in an industrial area under dominance of spraying, painting and petrochemical processes and manufacturing [5, 20, 27, 28]. Inorganic compounds have low molecular weights and play a determining role on the odor sensing mechanism by binding to olfactory receptors and affecting odor levels [2]. An odor may be characterized by its hedonic tone and by intensity. While the acceptability of an odor is defined hedonic tone parameter, it may also be descriptive of some characteristic properties of odor (sweat, spicy, lime etc.) On the other hand, the odor intensity assessment ranges from the detection threshold to the level of disturbance [3]. Mostly, toluene is found related with sour and burnt descriptions. While, benzene is associated with aromatic, sweet definitions. Odor issues caused by those two air pollutants are analogously described by most of the citizen as "solvent like" smell. Majority of exposed odors are described as; oily, burnt oil, gas, garlic, varnish like, petrochemical, burned match and many others inline with the study area and odor emitting sources at its surroundings.

Research is limited on the evaluation between odor pollution and industrial emissions. Sole use of odorous VOC concentrations would be inadequate for the assessment of odorants strength and perceived nuisance; therefore odor indexes, odor units, odor activity values etc. and similar approaches are used with intent to determine certain thresholds [29, 30]. Odor pollution and/or odor episodes are tracked by using traditional sensorial techniques such as dynamic olfactometry (EN Standard 12725:2003) and impact models, scheduled field observations according to European standard EN 16841:2016 and recording from residents by citizen surveys. The "odor hours" definiton ise used for the hours which have recognizable odor for at least 10% of the time period), while "odor nuisance" occurs due to series of odor episodes experience, and "odor episodes" are composed of several odor hours within a limited period of time. The ability to smell a certain odor in the populations follows a log normal distribution and >96% of the population theoretically have a normal sense [31]. The collected sensorial data have potential to be used in environmental odor characterization of the study area from a nuisance perspective [12, 32–34].

A pioneering study have integrated olfactometric field survey data with the CALPUFF emission dispersion model outputs with intent to determine the major contributing source of odor issue in a residental area [10, 32, 35]. Use of electronic noses may actualize classification of the analyzed air, and assign the air sample to a certain olfactory class. An e-nose is composed of a sensor matrix, data processing system and a system for pattern recognition in order to represent human odor sensing mechanism [3]. Citizen surveys are eligible for collecting real time data and can be descriptive of the full odour episode. [34, 36, 37]. The intermittent and variable natures of environmental odors require continuous monitoring to capture short-term episodes [38, 39]. Social participation can be used for identifying odor episodes, keeping records of odor issues, and allow building sensory databases [3]. Specific guidelines [40] emphasizes the importance of annoyance assessment. [36, 41, 42]. Continent wide projects like the D-noses and Prolor have developed useful models that are able to determine the time-dependent effect levels of the odor source on living spaces [12, 32].

This study was carried out at Çorlu/Tekirdağ and built on collected annual citizen odor complaint data, meteorological factors, inorganic and BTEX air pollutants values between the August 28 2021 –November 2 2021 period. Citizen odor complaints were collected by use of a mobile application in residental area of Corlu around which number of OIZs are positioned. The annual odor complaint data was briefly introduced considering the user demographic profile. This study aims to reveal out the relation between the number of citizen odor complaints and their spatiotemporal distribution with constituents of air pollution (that arise from neighboring industrial activity), meteorological factors and their interactions. Accordingly, the number of odor complaints between August 28 – November 2 of 2021 was subjected to correlation and multi-variance statistical analysis with the measured BTEX concentration, inorganic air pollutant concentration and the meteorological parametes; Windspeed, temperature and relative humidity. The incidence of odor complaints occurence in certain ranges of relative humidity, temperature, wind speed and total and specific BTEX parameters were given an evaluative discussion.

MATERIALS AND METHODS

This study is structed on a descriptive cross-sectional measurement and field study including; the statistical examination of the relationship between meteorological factors, odor complaint records and inorganic-organic (BTEX) air pollutants.

Odor complaints were collected through the mobile application named Çorlu KODER, that is served as a complaint collection mechanism offered by the Municipality of Çorlu and developed by Corlu KODER project group from Çorlu Engineering Faculty (as described at http://corlukoder.com website and under Corlu KODER mobile app privacy policy document https://corlukoder.com/privacy-policy.pdf).

Location of Interest

Tekirdağ city host over 1100 factories (with the frequency of occurrence; textile, paper, packaging, chemical and metal industries respectively). In Tekirdağ, there are total of 14 organized industrial zones, while 5 of them established around Çorlu district and its immediate surroundings. 4 of the organized industrial zones (OIZ) are lined up in the west-east direction along Çorlu, where the Velimeşe OIZ (where more than 500 facilities operate) is one of the closest one to residental areas of Çorlu and located between Çerkezköy and Çorlu (alongside the North south direction).

Corlu is the area where the new settlement is located and the traffic is concentrated while Çerkezkoy (at the north) host one of the Turkey's largest OIZ under which more than 270 facilities operate [43]. The topographical properties (as indicated in Figure 1) can be described as land appearance in the form of way plains and is uneven, with low to mid slope values. Çorlu is under the influence of a transition type climate where Black Sea, Mediterranean and continental climate characteristics are encountered together. Cold air masses descending from the north and humid-warm air currents coming from the south, the Mediterranean and the Aegean affect the climate structure of the region. Typical directions of the wind are NNE-NE and rarely from the directions of SW-SSW around Corlu [44].

Collection of Odor complaint Data

The GIS integrated public participated (PPGIS) odor complaint collection and management platform Corlu KODER was developed under project collaboration between Tekirdag Namık Kemal University, Faculty of Engineering and Municipality of Corlu. The developed odor complaint collection mobile app Corlu KODER was introduced and publicized as a free service of Municipality through the IOS and Android app merket platforms. The odor complaint collection started by 2020 October and been carried out in Corlu city that has over 200k population. The number of verified mobile app users are >1600.

The proposed methodology is built on collecting citizen odor complaints based on FIDOL factors (frequency, intensity, duration, tone and location of the odor complaint) through a mobile application [45].

Mobile app users, are able to define the percieved level of odor strength and describe the odor tone (by level of annoyane or satisfaction). Çorlu KODER mobile app users may interprete percieved odor with its potential source by making selection from a list of odor type/sources. On the other hand, citizen odor complaint locations are recorded according to geographical coordinate system. Citizen odor compliant records are monitored and managed thorugh a web based compliant management panel by Municipality and the University.

Air Pollution and Meteorological Data Collection

The air pollutant data source is the official Air Quality Monitoring Network website of the Ministry of

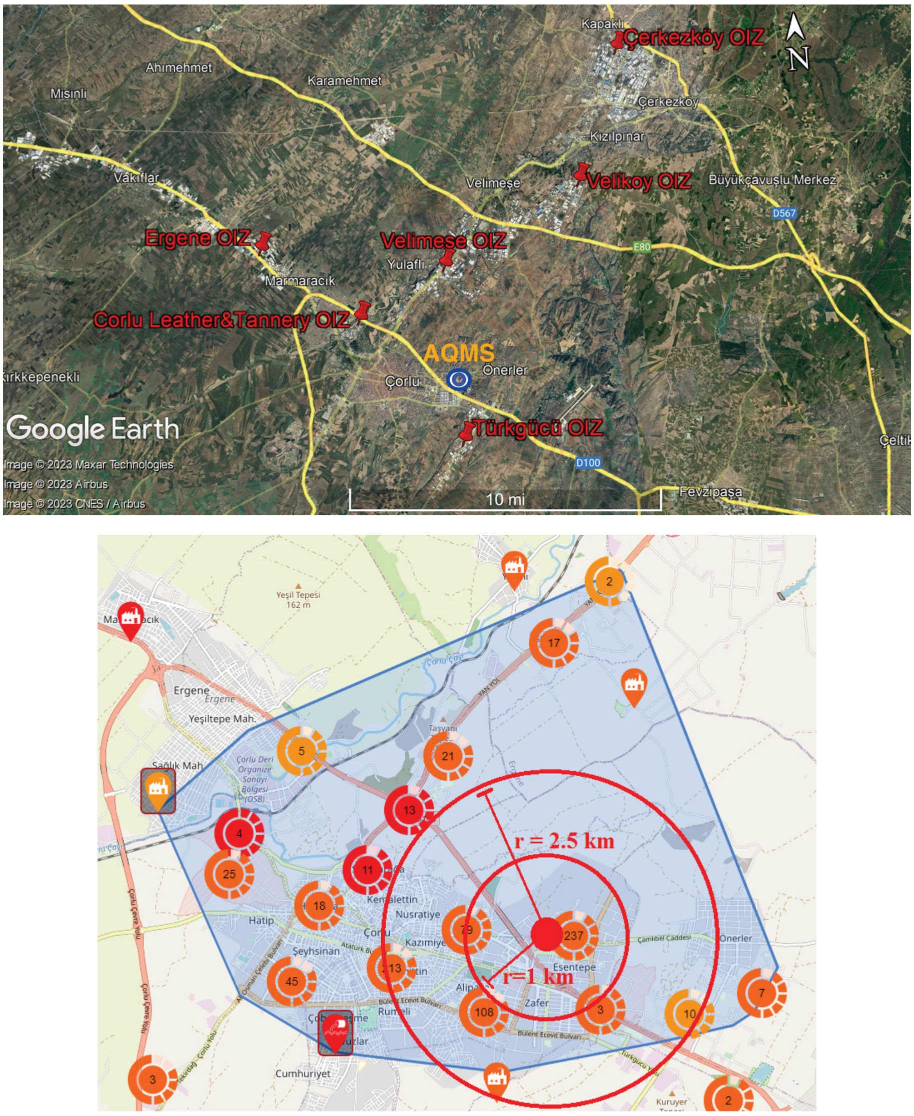

Figure 1. Organized Industrial Zones locations around Corlu and distribution of total number of odor complaints around the BTEX measurement station; Cerkezkoy, Velimese, Kapakli, Ergene, Corlu 1-2. OIZs.

Environment, Urbanization and Climate Change. Daily average values were used and taken as references all along the study. PM_{10}, SO_2, NO_x, O_3 data, and meteorological parameters; air temperature (T), wind direction (WD), wind speed (WS), relative humidity (RH) and Atmospheric pressure (AP) were used as as received from General Directorate of Meteorology (MGM) Tekirdag.

BTEX (benzene, toluen, ethylbenzene, o-xylene and m,p-xylene) concentrations were measured as Daily averages by the mobile air qulity monitoring station of Ministry of Environment, Urban Planning and Climate Change, temporarly located at Esentepe avenue of Corlu between August 28 to November 2 2021 period. Measured BTEX concentration data were used as received from the Marmara Clean Air Central Directorate of the Ministry of Labor and Social Security. BTEX measurement was carried out according to EN-14662-2 standard method based on active carbon sampling and GC-MS analysis. The sampling was performed at the mobile sampling device positioned at the Hürriyet district of Corlu, as shown in Figure 1.

Statistical Analysis

Correlation analysis were performed between the daily variation in meteorological factors, BTEX concentrations,-inorganic air pollutant concentrations, and the total number of odor complaints. Multiple regression analysis can be built on a dependent variable between two or more independent variables were considered [46] Outputs of the analysis, was used to explain the relationship with a linear model and determines the effect levels of the independent variables [46, 47].

Regarding data acquisition, data obtained from the air pollutant measurement stations, the number of reported odor complaints and the meteorological parameters were calculated and used as daily average values.

All analysis and evaluation were performed on the complaints records (reporting unpleasant odor issues (hedonic tonebetween -4 and -1) within August 28 – November 2 2021 period. Sturges classification method was applied to determine the ideal class range and number for wind speed, temperature, relative humidity parameters. Average number odor complaint reports distribution within those class intervals was given an evaluation and discussion [15]. Annual odor complaint data was solely introduced and used for interpretation with the mobile app users demographic information.

RESULTS AND DISCUSSION

Odor Complaint Records

The total number of annual odor complaints (NAOC) (reported by over 550 individual users) is 2389 between the November 2 2020 to November 2 2021 period. While between August 28 – November 2 of 2021, number of odor complaints is 868 (reported by over 400 individual). Regarding the total NAOC; the average number of daily odor complaints (calculated based on the days with at least one complaint: 277 days of 365) was calculated as 10 with a standard deviation (±) of 7. Referringly, an odor episode day is defined as the day with NOC > 17 [data not shown] [34]. In this context, there are 20 odor episode days between the 28 August - 2 November 2021 period, annually the total number is 40.

Interpretation of the Citizen Demographic Information with Annual Odor Complaint Data

Comparing the evaluation findings carried out on annual odor complaint data and August 28-November 2 2021 period specific data, difference was not significant in the distribution of the number and type of complaints according to the age and gender of the users. For this reason, only the evaluation made on the annual data is provided under this section.

Percentage distribution of total number of Corlu KODER mobile app users according to their gender and age is presented in Figure 2. Male and female users constitute %57-%43 of the total users respectively. Users between 31-40 ages constitute the %40 of the total number users. Annually, 63% of the total number of odor complaint records belong to male users and 37% to female users. While, 22% of odor complaints were reported by users aged between 31-35, and 24% from 36-40. 35% of odor complaints reported by users aged between 41-55.

According to randomly selected 10 odor episode; 12% of total odor complaints reported by users between the ages of 31-35. 15%, 18% and 9% of total odor complaints were reported by users aged between 41-45, 46-50 and 51-55 (Figure 3). Distribution of odor complaints according to user gender did not possess a significant difference between the annual and odor episode specific data,

Effect of user age and gender on odor complaint characteristics

Users aged between 35-40, 45-50 and 55-60 have reported odor issues with higher intensities (Figure S1). The hedonic tone scores of the users in the 50-55 age range are more homogeneously distributed on the scale of the parameter.While users between 40-45 reported odor issues with low hedonic tones (-4).

58% of the total number of odor complaints reported by male users are between 4-6 intensity (referring to strong – extremely strong), while it is 77% for female users (data not shown). 63% of the total NOC reported by male users are between -4 and -3 hedonic tone (representative of very

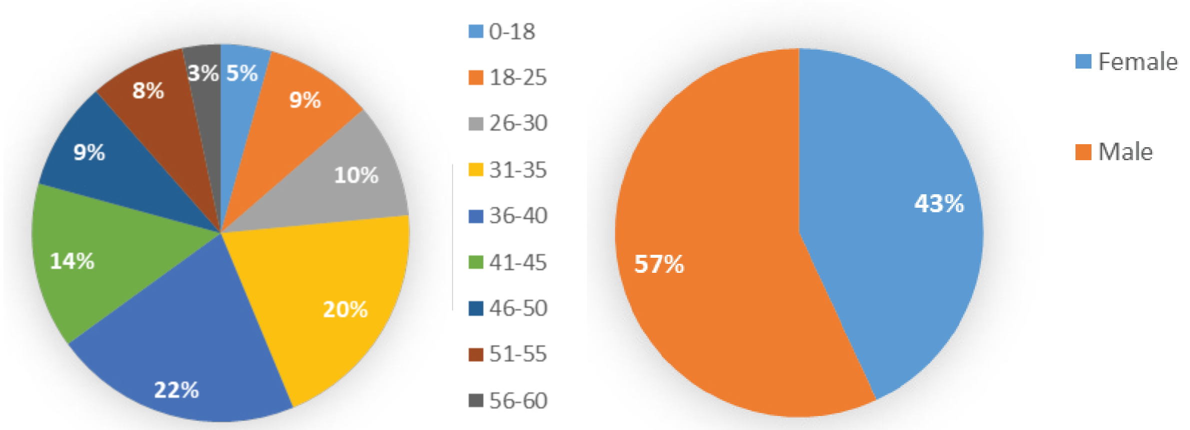

Figure 2. Percentage distribution of the total number of users by age range and gender.

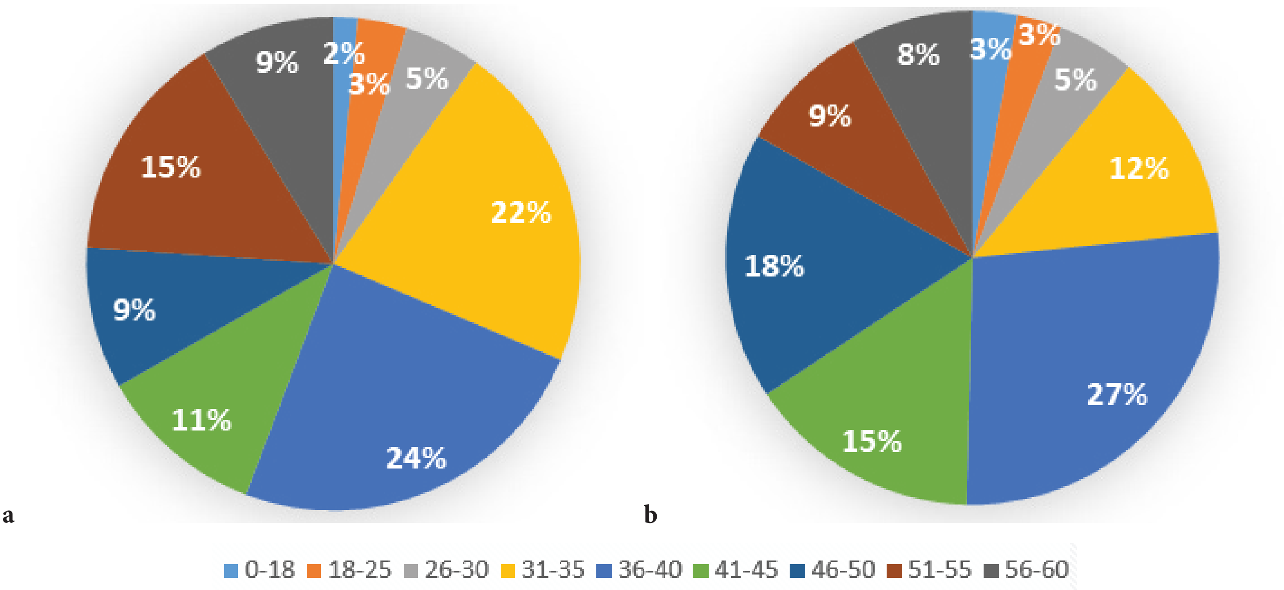

Figure 3. a) Annual and b) odor episode specific percentage distribution odor complaints within user age intervals.

unpleasant and extremely unpleasant odors), while it is is 73% for female users (Figure S2).

Regarding the distribution of odor complaints according to sources, 11% of total odor complaints reported by male users belong to urban sources, while it is 18% for female users. 64% of total odor complaints reported by male users were associated with industrial sources, while it is 57% for female users (Figure S3). It is seen that majority of urban odors were reported by users at 36-40 age interval. Also the majority of industrial odor complaint were reported by users between 41-55, which is distinctly higher than 26-40 interval. Besides, most of the food industry based odor complaints were reported by users between 56-60 ages (Figure S3).

Source Distribution of Odor Complaints within the Study Period

According to distribution of citizen odor complaint characteristics among the odor sources, 80% of the odor complaints were found interrelated with industrial sources between August 28 – November 2, 2021 (Figure 4).

On the other hand, according to analogic evaluation by users; odor complaints are interpreted with various types of odors and possible sources; examples like"Chemical" or "Plastic" are most widely encountered. Besides, chimney, gas, leather, sulphurous compounds, ammonia, asphalt and rubber stand out as other types of related odors/odor sources (Figure 5). Also, the distribution of annual odor complaint data among odor sources exhibited a similar trend with the study period in Corlu (not shown). The distribution profile is analogous with recent research carried out in different industrial areas [20].

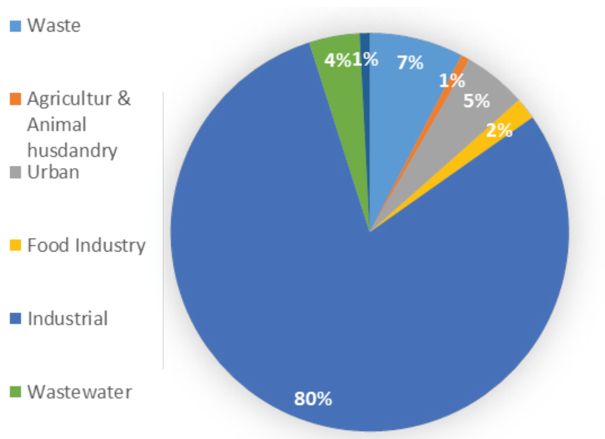

Figure 4. Odor complaints by source.

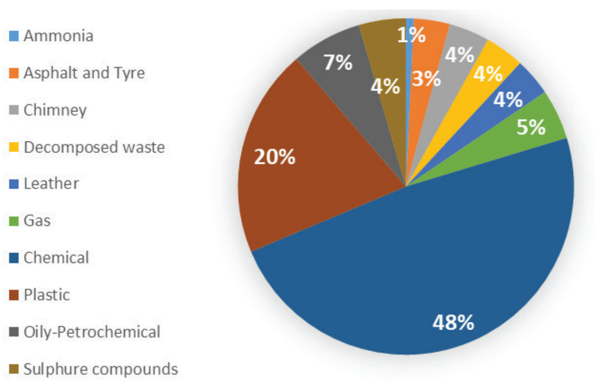

Figure 5. Odor complaints by type.

Spatial Distribution of Odor Complaints within the Study Period

The average percentage of odor complaints with in 1 km diameter (taken the mobile AQMS location as center) is >12% while for the 3rd week (between the September 12-18) the value is >20%. The percentage of odor complaints within 5 km diameter is >58%, that can be interpreted with the population density distribution in different parts of Corlu [48]. Spatial distribution and exact location of OIZs and odor emission source characteristics (point-line-clustered), have a determining role on citizen reported odor issues occurence, spatial distribution and characteristics [16]. Windspeed and wind direction play a determining role on the pollutants spead mechanism by diffusion and advection [36 conti,40,49,50]. Within the studied period; winds from NW-N and NW directions are dominating (f4-j). Also, the percentage of days with wind speed values higher than the average is 50%, and for the rest of the period it is around 30%. The level of correlation between the number of odor complaints, BTEX pollutants and wind-speed, also the number of odor complaints occurence within certain wind-speed intervals are revealed out and given discussion under the statistical analysis section.

Inorganic Air Pollutant Concentration Levels

During the study period, the PM_{10} parameter has exceeded the national limit/threshold (50 μg/m^3) values for 27 days. For the $PM_{2.5}$ parameter, the limit/threshold values have never been exceeded. O_3 has been reported to increase between 6-8 September to 83-89 ug/m^3 that are close to national daily limit values of 120 μg/m^3 (data not shown).

BTEX Concentration Levels

The BTEX concentrations measured in Çorlu Esentepe neighborhood are given in Table 1. Toluene and (m,p)-xylene constitute the highest concentration among BTEX compounds (3.09 and 3.49 ug/m^3 respectively). Between the days 44 and 49 (week 7), there is an increase in the level of m-p Xylene contrubiton to the total BTEX value. During the study period, the EU reported limit value of 5 μg/m^3 for BTEX pollutants in residental areas have been exceeded 5 times for toluen, 8 times for p-m xylen and 4 times for o-xylen. While the EU reported, lower rating threshold (LRT) (2 μg/m^3) and upper rating thresholds (URT) (3.5 μg/m^3) for toluen have been exceeded 55 and 17 times respectively. The LRT (2 μg/m^3) and URT (3.5 μg/m^3) for ethylbenzene have been exceeded 5 and 2 times respectively. The LRT (2 μg/m^3) and URT (3.5 μg/m^3) for p-m xylen have been exceeded 43 and 9 times respectively. The LRT (2 μg/m^3) and URT (3.5 μg/m^3) for o-xylen have been exceeded 9 and 4 times respectively [53]. These values are at comparable level with the measured BTEX concentrations according to the passive sampling study performed in Corlu at 2017; Toluen, Ethylbenzen, m-p xylen and o-xylen concentrations have been reported as: 2.7-6 μg/m^3, 1-1.7 μg/m^3, 3.5 – 6.3 μg/m^3 and 1 – 1.5 μg/m^3 [28].

According to literature, the concentrations measured in urban areas are lower compared to industrial areas. The traffic composition, the type, number and distribution of the industries established in the region, the fixed emission sources and the differences in the meteorological conditions may bring along the measurement differences between studies. According to literature, for the case that the Toluen/benzene (T/B) ratio in urban atmosphere is between 1-4, traffic emissions are considered to be the main source of toluene and benzene [25]. In this study, the average T/B ratio was calculated as 5 and is an indicator that toluene is emitted from sources other than traffic emissions (Table 1) [26, 52].

Despite the fact that they are released into the atmosphere from the same sources, the variation in the rates of OH oxidation in the atmosphere bring along the difference. in (m,p)xylene/Ethylbenzene occurence levels. Xylen to Ethylbenzene (K/E) ratio is used as a parameter to express the intensity and duration of photochemical reactivity in the atmosphere (the photochemical age of the atmosphere) [53]. The K/E values above 3.0 are considered high and low between 1.0-1.5. The range of 2-4 in K/E ratios represents fresh emissions [53, 54].

In this study, the K/E ratio was calculated as 3.30 on average. Accordingly, it can be said that the environment in which the study is carried out is under the influence of fresh emission sources throughout the study period. The fact that the K/E ratio is in the range between 2-4, is closely related to the distance of the measurement station to the air pollutant source. There are six OIZs located within 1.5 km (Turkgucu, Corlu), 5 km (Ergene), 10 km (Velimese) and 15 km. (Cerkezkoy) km of the air quality monitoring stations. It is an expected result that air masses will age until they reach the measurement stations.

Major industrial activites carried out in the Turkgucu, Corlu 2, Ergene and Velimese OIZs can be listed as textile manufacturing, dyeing, paper and products, chemical manufacturing, leather and tannery, rubber and plastic [55,56].

Benzene are mainly released into the atmosphere from dyes, pesticied, lubricants, detergent and pharmaceuticals industry. Ethylbenzene are derived from adhesive and paint using processes,pesticides and fragrance agents**.** While, m-xylene, o-xylene and p-xylene mainly result from solvent using industries such as; paint and plastics, herbicides. While toluene, result from solvent use in paints and inks, foams [29]. On the other hand, (m,p)-xylene and o-xylene compounds and ethylbenzene are emitted from vehicle exhausts, evaporation of solvents and industrial activities to the atmosphere. According to literature, the total number of textile industry/facilities operating in Ergene basin exceeds 600 by 2017, most of which is located in Tekirdağ. These facilities are distributed as 67 in Çorlu, 72 in Velimeşe, 20 in Türkgücü, 37 in Vakıflar and 26 in Ulaş [55]. The most common volatile organic air pollutant compounds (including the toluene, xylene, n-hexane, n-heptane) are emitted into the atmosphere from the stenter chimneys connected

Table 1. Daily average BTEX pollutant concentrations and # of odor complaints between the 28th August – 2 November 2021 period

	µg/m³						Toluen/ Benzen	(m+p) Ksilen/ Etilbenzen	# of odor complaints
Day	**Benzen**	**Toluen**	**Etilbenzen**	**p,m-Xylen**	**o-Xylen**	**Total BTEX**			
1	0.65	4.13	0.84	2.71	1.49	9.82	6.34	3.22	23
2	0.66	3.38	0.83	2.61	1.45	8.93	5.13	3.14	42
3	0.64	3.36	0.91	2.91	1.52	9.34	5.28	3.20	50
4	0.55	3.21	0.64	2.01	1.08	7.49	5.87	3.13	20
5	1.06	5.08	0.87	2.91	1.38	11.30	4.79	3.34	87
6	0.62	2.62	0.65	2.08	1.10	7.08	4.20	3.23	28
7	0.48	5.61	2.59	9.64	8.40	26.73	11.60	3.72	20
8	0.50	4.07	0.72	3.59	2.53	11.41	8.19	4.96	28
9	0.45	3.31	0.53	2.68	1.38	8.35	7.40	5.04	20
10	0.39	4.25	0.61	2.26	1.31	8.83	10.79	3.69	3
11	0.46	2.59	0.60	1.93	1.12	6.70	5.60	3.22	2
12	0.37	2.19	0.62	2.15	1.20	6.54	5.89	3.47	2
13	0.61	2.71	0.57	2.10	1.13	7.12	4.42	3.67	6
14	0.76	3.45	0.67	2.13	1.10	8.11	4.56	3.17	19
15	0.88	3.56	0.71	2.40	1.20	8.75	4.06	3.38	13
16	0.71	2.73	0.54	1.90	0.98	6.87	3.84	3.50	30
17	0.77	6.06	1.11	3.38	1.55	12.88	7.85	3.06	16
18	0.83	6.06	1.07	3.51	1.68	13.15	7.28	3.27	38
19	0.68	3.68	0.69	2.36	1.22	8.62	5.45	3.44	39
20	0.59	5.10	0.80	2.79	1.45	10.74	8.58	3.48	21
21	0.62	4.11	0.81	2.75	1.48	9.77	6.59	3.39	14
22	0.67	2.92	0.71	2.51	1.40	8.22	4.36	3.53	10
23	0.67	3.94	0.90	3.04	1.65	10.19	5.92	3.39	24
24	0.57	3.07	0.84	3.05	1.46	8.98	5.35	3.63	16
25	0.55	2.13	0.49	1.50	0.76	5.43	3.89	3.08	9
26	0.78	3.89	0.76	2.58	1.19	9.20	4.97	3.39	10
27	0.58	2.66	0.55	1.78	0.94	6.51	4.61	3.26	12
28	0.67	3.38	0.70	2.15	1.08	7.98	5.06	3.07	23
29	0.56	2.30	0.61	1.97	0.99	6.43	4.13	3.24	7
30	0.67	3.43	0.57	1.96	0.94	7.57	5.15	3.41	7
31	0.56	4.66	0.51	1.73	0.87	8.33	8.29	3.38	5
32	0.61	2.55	0.48	1.59	0.79	6.02	4.18	3.32	27
33	0.42	1.92	0.41	1.34	0.67	4.75	4.61	3.30	8
34	0.45	2.45	0.50	1.58	0.80	5.78	5.45	3.16	2
35	0.51	1.98	0.48	1.50	0.78	5.24	3.92	3.15	5
36	0.59	2.29	0.44	1.44	0.75	5.51	3.91	3.25	6
37	0.70	3.24	0.64	2.16	1.00	7.73	4.65	3.40	12
38	0.50	2.37	0.52	1.78	0.82	5.99	4.78	3.45	21
39	0.42	1.71	0.43	1.51	0.76	4.83	4.12	3.55	8
40	0.50	2.32	0.52	1.85	0.96	6.14	4.65	3.57	5
41	0.42	1.66	0.44	1.53	0.82	4.87	3.90	3.43	4
42	0.58	2.23	0.50	1.70	0.93	5.95	3.84	3.41	3
43	0.65	5.55	0.74	2.54	1.23	10.71	8.54	3.42	0
44	0.63	3.28	9.09	28.73	14.12	55.85	5.23	3.16	2
45	0.76	2.36	4.51	13.76	7.26	28.65	3.11	3.05	3
46	0.77	2.34	3.45	10.10	5.28	21.94	3.03	2.93	3
47	1.02	2.77	2.86	8.57	4.42	19.65	2.71	2.99	3
48	1.05	3.94	2.20	6.54	3.42	17.15	3.76	2.98	3
49	0.74	2.48	1.84	5.46	3.16	13.67	3.34	2.97	4
50	0.77	2.62	1.79	5.34	3.19	13.72	3.38	2.98	4
51	0.73	2.04	1.23	3.62	1.89	9.51	2.78	2.95	12
52	0.48	1.39	1.03	2.90	1.48	7.27	2.92	2.82	33
53	0.54	2.17	1.09	3.20	1.63	8.62	4.02	2.94	4
54	0.62	2.05	1.02	2.89	1.75	8.33	3.31	2.83	8
55	0.50	2.20	0.84	2.46	1.23	7.23	4.42	2.94	7
55	0.60	2.25	0.86	2.59	1.30	7.61	3.75	3.00	1
56	0.49	1.29	0.79	2.28	1.22	6.07	2.61	2.90	1
57	0.72	1.82	0.81	2.38	1.27	6.99	2.55	2.95	10
58	0.79	2.54	0.73	2.22	1.14	7.43	3.21	3.04	2
59	1.03	3.80	0.86	2.65	1.36	9.69	3.70	3.07	2
Average	**0.64**	**3.09**	**1.09**	**3.49**	**1.87**	**10.17**			

Extreme BTEX values between 13th – 15th October are intentionally removed and not listed to the stenter machines of the the textile finishing process. The average number of stenter chimneys around the study area is over 700; mainly located in the Velimeşe OIZ and Ergene OIZ. As a result, the high BTEX concentrations can be interpreted with the number and location of OIZs around Corlu [55, 56].

Accordingly, an interpretative evaluation was made in the next section, considering the relation between total number of odor complaints, BTEX measurement results and meteorological parameters [5, 20].

Statistical Analysis and Interpratative Evaluation of BTEX concentrations, Odor complaints and Meteorological Factors

The daily BTEX concentrations, inorganic air pollutant concentrations, meteorological factors and temporal distribution of total number of odor complaints within the August 28 -November 2 2021 periods were evaluated by using statistical analysis. The correlation findings are presented in Table 2.

The level of correlation is moderate between the total number of odor complaints and toluene concentration, with correlation coefficient (r) of 0.52. Since the data collection methodology have some limitations such as; uniformity of sensing and judgement differences between citizens, the correlation coefficient can be assumed quite significant.

Also, the level of correlation is moderate between the total number of odor complaints and temperature (r=0.64), and between the total numer of odor complaints and NO_2 (r=0.50). High correlation was found between temperature and toluene concentration (r=0.71). Also the level of correlation was high between Benzene and NO_x (r=0.72). Very high correlation was found between the p-m Xylen, o-Xylen and Ethylbenzene (r=0.96 and 0.95)

It can be concluded that the average wind speed in Çorlu is negatively correlated with NO_X and NO_2 parameters. Negative and low level of correlation is reported between the relative humidity (RH) and total number of odor complaints (-0.33) Theoretically RH may enhance the citizens' sense of small by trapping odor molecules and is listed among the parameters that have a deteriorating effect on the atmospheric diffusion mechanism. Therefore, significance of RH values below and above certain thresholds have been examined by ANOVA analysis (Table S1)

Also, there is strong negative correlation between the average wind speed in Çerkezköy and NO_2 values in Çorlu (-0.75) and also with Benzene (-0.65). Those findings are also supportive of the negative correlation coefficient (r= -0.48) between total number of odor complaints and wind speed in Çerkezköy. Odorous compoounds can be transported considerable distances in just a matter of minutes depending on the strength of the source, weather patterns, wind speed and direction [57]. Mostly, it is reported that slight air pollution scenarios are under the effect of windspeed and horizontal diffusion capability. The dispersion of odors is partly determined by the presence of wind. And Below certain limits, odor stagnation may be favoured [60]. Discussion was supported with the NOC distribution within certain windspeed intervals according to the Sturges classification (Table 3) [16, 57, 59]. There is low level of negative correlation between the benzene measured in Çorlu and wind speed (r=-0.63). While correlation is obtained with the rest of BTEX (r values < 0.38).

In the light of the obtained correlation findings; two independent variables were selected. By 2 way ANOVA analysis, it was examined whether those two variables have significant effect on the total number of daily odor complaints. For this purpose, two evaluations were made as stated below;

a- The analysis were performed with an assumption of certain conditions; i) above and below the daily average BTEX value ii) below and above the relative humidity average value.

b- Similarly, the 2-way ANOVA analysis were performed, based on the number of odor complaint records collected in conditions below or above the daily average Toluene concentration and relative humidity.

For the case that the relative humidity values are below the average, the BTEX values make a significant contribution on the total number of odor complaints variation. Similarly, under the conditions where the BTEX value is above the average, the RH values make a significant contribution on the total number of odor complaints (Table S1: Sig value=1 demonstrate significant effect on number of odor complaints).

The mean and standard deviation of odor complaint numbers significantly differed based on toluene concentration range above or below the mean value. The results did suggest that the contribution of toluene to number of odor complaints in the residental area of Corlu become prominent in comparison with the other BTEX air pollutant concentration levels (Table S2).

Frequency of Odor Complaints Occurence within Certain Intervals of Meteorological Parameters and BTEX Concentrations

The number of odor complaints encountered in specific daily average wind speed, temperature, relative humidity and BTEX concentration intervals (specifically Toluene and total BTEX) are demonstrated in (Table 3 and 4). The parameters were sub-classified, class width and class numbers were set by using the Sturges classification method [15,58].

For common weather situations with mean temperature, winds-speed and relative humidity that are nearly horizontally uniform, turbulent transport in any horizontal direction nearly cancels transport in the opposite direction, and thus can be neglected. But vertical transport is significant [17, 18, 60].

The total NOC within each WS interval is expressed in Table 3. The daily average number of odor complaints makes a decent increase and keep increasing between 0.8

Table 2. Correlation analysis of daily average BTEX and inorganic air pollutants concentrations with meteorological factors and number of odor complaints

	# of odor comp.	*Benzen*	*Toluen*	*Etilbenzen*	*p,m-Xylen*	*o-Xylen*	*T [°C]*	*P*	*PM10 (µg/m³)*	*SO_2 (µg/m³)*	*NO_2 (µg/m³)*	*NOX (µg/m³)*	*O_3 (µg/m³)*	*Sum of BTEX*	*Avg WS Corlu*	*Avg RH Corlu*	*Avg WS Cerkezkoy*
# of odor comp.	1.00	0.24	0.52	0.01	0.04	0.03	0.64	-0.38	0.34	-0.06	0.50	0.18	0.22	0.16	-0.42	-0.33	-0.48
Benzen	0.24	1.00	0.33	0.57	0.50	0.44	0.10	-0.24	0.36	0.27	0.72	0.72	-0.30	0.59	-0.63	0.28	-0.65
Toluen	**0.52**	0.33	1.00	0.31	0.38	0.34	0.71	-0.52	0.47	0.02	0.56	0.18	0.19	0.63	-0.33	-0.40	-0.42
Etilbenzen	0.01	0.57	0.31	1.00	0.96	0.95	0.02	-0.10	0.11	0.03	0.18	0.48	-0.41	0.88	-0.37	0.22	-0.34
p,m-Xylen	0.04	0.50	0.38	0.96	1.00	0.98	0.07	-0.16	0.09	0.06	0.19	0.41	-0.37	0.93	-0.28	0.19	-0.28
o-Xylen	0.03	0.44	0.34	0.95	0.98	1.00	0.09	-0.18	0.05	0.00	0.10	0.32	-0.32	0.91	-0.28	0.19	-0.26
T [°C]	0.64	0.10	0.71	0.02	0.07	0.09	1.00	-0.70	0.31	-0.33	0.41	-0.16	0.63	0.26	-0.27	-0.52	-0.33
P [hPa]	-0.38	-0.24	-0.52	-0.10	-0.16	-0.18	-0.70	1.00	0.06	0.32	-0.42	0.04	-0.30	-0.33	0.28	0.06	0.32
PM10 (µg/m³)	0.34	0.36	0.47	0.11	0.09	0.05	0.31	0.06	1.00	0.31	0.27	0.22	0.11	0.15	-0.15	-0.17	-0.20
SO_2 (µg/m³)	-0.06	0.27	0.02	0.03	0.06	0.00	-0.33	0.32	0.31	1.00	0.19	0.47	-0.36	0.01	0.00	0.23	-0.04
NO_2 (µg/m³)	0.50	0.72	0.56	0.18	0.19	0.10	0.41	-0.42	0.27	0.19	1.00	0.71	-0.14	0.40	-0.66	0.07	-0.75
NOX (µg/m³)	0.18	0.72	0.18	0.48	0.41	0.32	-0.16	0.04	0.22	0.47	0.71	1.00	-0.62	0.36	-0.55	0.45	-0.56
O_3 (µg/m³)	0.22	-0.30	0.19	-0.41	-0.37	-0.32	0.63	-0.30	0.11	-0.36	-0.14	-0.62	1.00	-0.23	0.12	-0.69	0.09
Sum of BTEX	0.16	0.59	0.63	0.88	0.93	0.91	0.26	-0.33	0.15	0.01	0.40	0.36	-0.23	1.00	-0.29	0.06	-0.32
Avg WS Corlu	-0.42	-0.63	-0.33	-0.37	-0.28	-0.28	-0.27	0.28	-0.15	0.00	-0.66	-0.55	0.12	-0.29	1.00	0.00	0.96
Avg RH Corlu	-0.33	0.28	-0.40	0.22	0.19	0.19	-0.52	0.06	-0.17	0.23	0.07	0.45	-0.69	0.06	0.00	1.00	0.01
Avg WS Cerkez	-0.48	-0.65	-0.42	-0.34	-0.28	-0.26	-0.33	0.32	-0.20	-0.04	-0.75	-0.56	0.09	-0.32	0.96	0.01	1.00

Table 3. Average Number of odor complaints and average BTEX concentrations within certain wind speed intervals

Wind speed (Corlu)	# of odor complaints	Average Total BTEX
0 - 0.8 m/s	0	0
0.8 - 1.6 m/s	13	9.2
1.6 - 2.4 m/s	20.7	10.1
2.4 - 3.2	11.7	13.2
3.2 - 4	9	9.6
4 - 4.8	6	7.2
4.8 - 5.6	3.3	5.8
>5.6	2.8	6.8

Table 4. Average Number of Odor Complaints within Daily Average BTEX concentration, Toluen concentration, temperature and relative humidity intervals

Total BTEX (μg/m³)	Average # of odor complaints
1 - 4	4
4-6	7.6
6-8	9.8
>8	18
Toluen (μg/m³)	**Average # of odor complaints**
0-2	5.3
2—3	7.3
3—4	19.4
4—5	14.4
>5	33
Temperature (0C)	**Average # of odor complaints**
12--15	3.4
15--18	6.4
18-21	10
21-24	17.7
>24	35.4
Relative humidity	**Average # of odor complaints**
<66	7.9
66-72	13.4
72-78	24.6
78-84	4.3
>84	2.8

– 2.4 m/s interval. While the daily average NOC tend to decrease for WS > 2.4 m/s conditions. The total BTEX concentrations reflected to the average number of daily citizen odor complaints where; the average number of odor complaints remained around 4 for $BTEX_{total}$ < 4 μg/m³. The average number of odor complaints demonstrated a lineer increase for the $BTEX_{total}$ conditions between 4-8 μg/m³ and > 8 μg/m³ [5,29,61].

The daily average Toluen concentration remained around 3 μg/m³ during the study period. As demonstrated in Table 4, above the 3 μg/m³ toluen concentration, average NOC have increased from 7.3 to 19.4. Over the $[C]_{toluen}$= 4 μg/m³ conditions, average NOC increased up to 23. In line with the obtained results, it was concluded that the toluene concentration was associated with the increase in the NOC.

The increases in the average number of daily odor complaints by temperature is distinct. Over 21 ^{0}C, the average number of daily odor complaints increases from 10 to 17.7 and reaches over 35 [15,57]. In this study, increased number of odor complaints between the 55-78 RH conditions can be ascribed to trapping of odorous compounds close to the surface by RH [62]. The average number of daily citizen odor complaints have reached to its maximum, between RH conditions 72-78 (average RH was 70 during the study period).

CONCLUSION

In this study, the relationship between the citizen odor complaints, BTEX concentrations and meteorological factors were investigated in Çorlu residental area. The nearby OIZs and industrial activity were found to have a determining role on the occurence of citizen odor complaints. Number of odor complaints generally increased during high atmospheric BTEX concentration conditions. Also the level of BTEX concentrations and number of odor compliants were found to be related with meteorological factors such as temperature, relative humidity and wind speed.

Regarding the demographic profile of mobile app users; %46 of total odor complaints were reported by users between 30-40 ages. Within the odor episode days, the total number of odor complaints were distributed more homogenously within age intervals. User gender was not find effective on odor complaint source distribution. Users between 35-40 ages have reported more urban odors as compared to remaining users. On the other hand users between 40-50 ages have reported more industrial odors as compared to users between 25-40. Regarding odor tone and intensity, female users have reported odor issues with higher level of intensity and annoyance.

Average Toluen/Benzene ratio was calculated as 5 and is indicative of non-traffic source of toluen emission. The type and level of total BTEX pollutant concentrations were found related with the nearby industrial activities around Corlu. There is a significant correlation between the total number of odor complaints and toluene concentrations. Also high correlation was found between temperature and toluene concentrations. Regarding the days above average BTEX concentrations (> 8 μg/m^3), the RH value have significant effect on the total number of odor complaints. Below average RH conditions, the toluene concentration has a significant effect on the total number of complaints.

The average number of odor complaints increases between 0.8-1.6 and 1.6-2.4 m/s windspeed levels, and exhibits a lineer decrease within 2.4-5.6 m/s windspeed interval. Also, the average number of odor compliants increases, when the BTEX concentrations are between 4-8 μ/m^3 and increase over >8 μg/m^3. The average number of odor complaints exhibits an almost lineer increase from 5.3 to 33, when the Toluen concentrations increase from 0-2 μg/m^3 interval to >5 μg/m^3.

Besides the air pollutant measurement and air quality indexes, there is a lack of clear indicators regarding the level of odor discomfort in the field. Citizen odor complaint surveys are useful monitoring tools and can be used to identify sensitive areas where volatile organic compounds should be measured and monitored. Besides, measurement/monitoring studies such as field olfactometry, odorous VOC measurement can be planned, also building odor sensor networks can be realized accordingly.

ACKNOWLEDGEMENT

As the authors of the study, we would like to acknowledge that the so-called “Corlu Koder” mobile app and project has been developed and is carried out according to project collaboration between Tekirdag Namık Kemal University - Corlu Faculty of Engineering and Municipality of Corlu based on the municipality parliament act no: 2019/127. As the authors of the study, we would like to acknowledge and appreciate the efforts of TNKU Computer Engineering department research assistant Burak SEVİNÇ and students Hasan ÖZER and Muhammed AKYÜZLÜ on the software development. Also, authors would like to thank to Ministry of Environment, Urban Planning and Climate Change, Directorate of Marmara Clean Air Central and directorate of Tekirdag meteorology station for their support and approval on providing air pollutant measurement data and meteorological data.

AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

REFERENCES

[1] G. Varol, B. Tokuç, S. Ozkaya, and Ç. Çağlayan, "Air quality and preventable deaths in Tekirdağ, Turkey," Air Qual Atmos Health, Vol. 14, pp. 843–853, 2021. [CrossRef]

[2] B. Can-Terzi, M. Ficici, L. H. Tecer, and S. C. Sofuoglu, "Fine and coarse particulate matter, trace element content, and associated health risks considering respiratory deposition for Ergene Basin, Thrace," Science of The Total Environment," Vol. 754, Article 142026, 2021. [CrossRef]

[3] E. Ünver, E. Bolat, S. Altın, A. Çoban, M. Aktaş, M. Fıçıcı, A. Saral, and L. H. Tecer, "The effect of air pollution on respiratory system disease admissions and health expenditures," Eurasian Journal of Medical Investigation, Vol. 3(2), Article 56609, 2019. [CrossRef]

[4] G. Varol Saraçoğlu, and Ç. Çağlayan, "The struggle for clean air in Turkey and in the World," Toplum ve Hekim, Vol. 32, 219–227, 2017. [Turkish]

[5] R. Hu, G. Liu, H. Zhang, H. Xue, X. Wang, P. K. S. Lam, "Odor pollution due to industrial emission of volatile organic compounds: A case study in Hefei, China," Journal of Cleaner Production, Vol. 246, Article 119075, 2020. [CrossRef]

[6] Ütebay, P. Çelik, and A. Çay, "Textile wastes: Status and perspectives, waste in textile and leather sectors," Intech Open, 2020. [CrossRef]

[7] G. Brown, "Engaging the wisdom of crowds and public judgement for land use planning using public participation geographic information systems," Australian Planner, Vol. 52, pp. 199–209, 2015. [CrossRef]

[8] N. Liu, X. Liu, R. Jayaratne, and L. Morawska, "A study on extending the use of air quality monitor data via deep learning techniques," Journal of Cleaner Production, Vol. 274, Article 122956, 2020. [CrossRef]

[9] N. Castell, F. R. Dauge, P. Schneider, M. Vogt, U. Lerner, B. Fishbain, D. Broday, and A. Bartonova, "Can commercial low-cost sensor platforms contribute to air quality monitoring and exposure estimates?," Environment International, Vol. 99, pp. 293–302, 2017. [CrossRef]

[10] S. Munir, M. Mayfield, D. Coca, S. A. Jubb, and O. Osammor, "Analysing the performance of low-cost air quality sensors, their drivers, relative benefits and calibration in cities-a case study in Sheffield," Environmental Monitoring and Assessment, Vol. 191, Article 94, 2019. [CrossRef]

[11] R. E. Hester, R. M. Harrison, and R. G. Derwent, Sources, distributions, and fates of VOCs in the atmosphere, In "Volatile Organic Compounds in the Atmosphere," pp. 1–16, 1995. [CrossRef]

[12] R. Arias, L. Capelli, and C. Díaz, "A new methodology based on citizen science to improve environmental odour management, Chemical Engineering Transactions, Vol. 68, pp. 7–12, 2018.

[13] C. M. Mcginley, T.D. Mahin, L. Street, and M. Pirnie, "Elements of successful odor / Odour laws," WEF Odor / VOC 2000 Specialty Conference Cincinnati, OH. 16-19, April, 2000. [CrossRef]

[14] Department of Enviromental Protection, Goverment of Western Australia, "Odour methodology guideline," Goverment of Western Australia, 2002.

[15] P. Wagner, and K. Schäfer, "Influence of mixing layer height on air pollutant concentrations in an urban street canyon," Urban Climate, Vol.22, pp. 64–79, 2017. [CrossRef]

[16] C. Jia, J. Holt, H. Nicholson, J. E. Browder, X. Fu, X. Yu, and R. Adkins, "Identification of origins and influencing factors of environmental odor episodes using trajectory and proximity analyses," Journal of Environmental Management, Vol. 295, Article 113084, 2021. [CrossRef]

[17] H. Zhang, Y. Wang, J. Hu, Q. Ying, and X. M. Hu, "Relationships between meteorological parameters and criteria air pollutants in three megacities in China," Environmental Research, Vol. 140, pp. 242–254, 2015. [CrossRef]

[18] H. K. Elminir, "Dependence of urban air pollutants on meteorology," Science of the Total Environment, Vol. 350, pp. 225–237, 2005. [CrossRef]

[19] G. Tang, J. Zhang, X. Zhu, T. Song, C. Münkel, B. Hu, K. Schäfer, Z. Liu, J. Zhang, L. Wang, J. Xin, P. Suppan, and Y. Wang, "Mixing layer height and its implications for air pollution over Beijing, China," Atmospheric Chemistry and Physics, Vol. 16, pp. 2459–2475, 2016. [CrossRef]

[20] B. Han, Y. Liu, J. Wu, and Y. Feng, "Characterization of industrial odor sources in Binhai New Area of Tianjin, China," Environmental Science and Pollution Research, Vol. 25, pp. 14006–14017, 2018. [CrossRef]

[21] H. Maleki, A. Sorooshian, G. Goudarzi, Z. Baboli, Y. Tahmasebi Birgani, and M. Rahmati, "Air pollution prediction by using an artificial neural network model," Clean Technologies and Environmental Policy, Vol. 21, pp. 1341–1352, 2019. [CrossRef]

[22] U. Pak, J. Ma, U. Ryu, K. Ryom, U. Juhyok, K. Pak, and C. Pak, "Deep learning-based PM2.5 prediction considering the spatiotemporal correlations: A case study of Beijing, China," Science of the Total Environment, Vol. 699, Article 133561, 2020. [CrossRef]

[23] S. R. Shams, A. Jahani, S. Kalantary, M. Moeinaddini, and N. Khorasani, "Artificial intelligence accuracy assessment in NO2 concentration forecasting of metropolises air," Scientific Reports, Vol. 11, pp. 1–9, 2019. [CrossRef]

[24] D. P. Komilis, R. K. Ham, and J. K. Park," Emission of volatile organic compounds during composting of municipal solid wastes," Water Research, Vol. 38, pp. 1707–1714, 2018. [CrossRef]

[25] R. R. Hoque, P. S. Khillare, T. Agarwal, V. Shridhar, and S. Balachandran, "Spatial and temporal variation of BTEX in the urban atmosphere of Delhi, India," Science of the Total Environment, Vol. 392, pp. 30–40, 2018. [CrossRef]

[26] F. Dinçer, Ö. Ercan, and Ö. Ceylan. "Çerkezköy organize sanayi bölgesinde pasif örnekleme metodu ile BTEX (Benzen, Toluen, Etil benzen ve Ksilen) seviyelerinin belirlenmesi ve değerlendirilmesi," VII. Ulusal Hava Kirliliği ve Kontrolü Sempozyumu, Hava Kirlenmesi Araştırmaları ve Denetimi Türk Milli Komitesi Akdeniz Üniversitesi Mühendislik Fakültesi Çevre Mühendisliği Bölümü 1-3 Kasım 2017-Antalya. [Turkish]

[27] A. K. Roy Choudhury, Environmental impacts of the textile industry and its assessment through life cycle assessment, In: "Roadmap to Sustainable Textiles and Clothing," Springer, pp. 1–39, 2014. [CrossRef]

[28] L. H. Tecer, Ş. Tağıl, and M. Fıçıcı, "Is Corlu (Tekirdag, Turkey) affected by air pollution?" European Journal of Engineering and Applied Sciences, Vol. 1(1), pp. 1-8, 2018.

[29] E. Gallego, F. J. Roca, J. F. Perales, and G. Sánchez, P. "Esplugas, Characterization and determination of the odorous charge in the indoor air of a waste treatment facility through the evaluation of volatile organic compounds (VOCs) using TD-GC/MS," Waste Management, Vol. 32, pp. 2469–2481, 2012. [CrossRef]

[30] R. M. Fisher, R. J. Barczak, J. P. Alvarez Gaitan, N. Le-Minh, and R. M. Stuetz, "Odorous volatile organic compound (VOC) emissions from ageing anaerobically stabilised biosolids," Water Science and Technology, Vol. 75, pp. 1617–1624, 2017. [CrossRef]

[31] Scottish Environment Protection Agency, "Integrated pollution prevention and control (IPPC), H4(1) odour part 1 draft for consultation," Scottish Environment Protection Agency, 2002.

[32] D. Cipriano, and L. Capelli, "Evolution of electronic noses from research objects to engineered environmental odour monitoring systems: A review of standardization approaches," Biosensors (Basel), Vol. 9, Article 75. [CrossRef]

[33] T. Zarra, V. Belgiorno, and V. Naddeo, "Environmental odour nuisance assessment in urbanized area: Analysis and comparison of different and ıntegrated approaches," Atmosphere (Basel), Vol. 12, Article 690, 2021. [CrossRef]

[34] C. B. Özkal, L. H. Tecer, B. Sevinç, M. Akyüzlü, and H. Özer, Citizen participation in reporting environmental nuisance, In Ö. Demirel, and E. Düzgüneş, "Introducing the Environmental report tracking and management system (ERTMS)," In 2nd International CITY and ECOLOGY Congress within the Framework of Sustainable Urban Development, pp. 83–94, 2021.

[35] S. Sironi, L. Capelli, P. Céntola, R. del Rosso, and S. Pierucci, "Odour impact assessment by means of dynamic olfactometry, dispersion modelling and social participation," Atmospheric Environment, Vol. 44, pp. 354–360, 2010. [CrossRef]

[36] C. Conti, M. Guarino, and J. Bacenetti, "Measurements techniques and models to assess odor annoyance: A review," Environment International, Vol. 134, Article 105261, 2020. [CrossRef]

[37] M. Piringer, W. Knauder, K. Baumann-Stanzer, I. Anders, K. Andre, and G. Schauberger, "Odour impact assessment in a changing climate," Atmosphere (Basel), Vol. 12, pp. 1–12, 2021. [CrossRef]

[38] L. Capelli, S. Sironi, R. Del Rosso, and J.-M. Guillot, "Measuring odours in the environment vs. dispersion modelling: A review," Atmospheric Environment, Vol. 79, pp. 731–743, 2013. [CrossRef]

[39] L. Capelli, S. Sironi, R. Del Rosso, P. Céntola, and M. Il Grande, "A comparative and critical evaluation of odour assessment methods on a landfill site," Atmospheric Environment, Vol. 42, pp. 7050–7058, 2008. [CrossRef]

[40] M. Wojnarowska, G. Plichta, A. Sagan, J. Plichta, J. Stobiecka, and M. Sołtysik, "Odour nuisance and urban residents' quality of life: A case study in Kraków's in Plaszow district," Urban Climate, Vol. 34, Article 100704, 2020. [CrossRef]

[41] L. Weitensfelder, H. Moshammer, D. Öttl, and I. Payer, "Exposure-complaint relationships of various environmental odor sources in Styria, Austria," Environmental Science and Pollution Research, Vol. 26, pp. 9806–9815, 2019. [CrossRef]

[42] M. Castelli, F. M. Clemente, A. Popovič, S. Silva, and L. Vanneschi, "A machine learning approach to predict air quality in California," Complexity, Article 8049504, 2020. [CrossRef]

[43] Thrace Development Agency, "Thrace region plans," https://www.trakyaka.org.tr/en/35343/Thrace-Region-Region-Plans, 2019

[44] A. Vardar, R. Okursoy, and Y. Tekin, "Local wind characteristics for east thrace, Turkey, energy sources, part B: Economics," Planning and Policy, Vol. 7, pp. 1–9, 2012. [CrossRef]

[45] T. Zarra, M. G. Galang, F. Ballesteros, V. Belgiorno, and V. Naddeo, "Environmental odour management by artificial neural network - A review," Environment International, Vol. 133, Article 105189, 2019. [CrossRef]

[46] L. L. Harlow, "What is multivariate thinking, the essence of multivariate thinking," Lawrence Erlbaums, pp. 3–27, 2005. [CrossRef]

[47] O. Demir, "Çok değişkenli analizler ile Tokat ili hava kirliliğinin tahmininde erken uyarı sisteminin geliştirilmesi," [Yüksek Lisans Tezi], 2012. [Turkish]

[48] C. B. Özkal, "Analysis of annual citizen odor observation records and its relationship with meteorological factors: Çorlu / Tekirdağ case study," Atmospheric Pollution Research, Vol. 14(5), Article 101734, 2023. [CrossRef]

[49] J. Badach, P. Kolasińska, M. Paciorek, W. Wojnowski, T. Dymerski, J. Gębicki, M. Dymnicka, and J. Namieśnik, "A case study of odour nuisance evaluation in the context of integrated urban planning," Journal of Environmental Management, Vol. 213, pp. 417–424, 2018. [CrossRef]

[50] Z. Sakawi, S. A. Sharifah, O. Jaafar, and M. Mahmud, "Community perception of odor pollution from the landfill," Research Journal of Environmental and Earth Sciences, Vol. 3, pp. 142–145, 2011.

[51] EU-Commission, "Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe," Official Journal of the European Communities, Vol. 15, pp. 169–212, 2008.

[52] E. S. Uzunpınar, S. Aslan Kılavuz, İ. İmamoğlu, E. Sert, S. Yurdakul, and S. Gürdal Tuncel. "Source apportionment of volatile organic compounds in Ankara atmosphere," Çevre Bilim ve Teknoloji, pp. 89–105, 2015. [Turkish]

[53] P. F. Nelson, and S. M. Quigley, "The m, p-xylenes: ethylbenzene ratio. A technique for estimating hydrocarbon age in ambient atmospheres," Atmospheric Environment, Vol. 17, pp. 659–662, 1983. [CrossRef]

[54] A. Monod, B. C. Sive, P. Avino, T. Chen, D. R. Blake, and F. S. Rowland, "Monoaromatic compounds in ambient air of various cities: a focus on correlations between the xylenes and ethylbenzene," Atmospheric Environment, Vol. 35, pp. 135–149, 2001. [CrossRef]

[55] Çorlu Ticaret ve Sanayi Odası, "Sanayinin başkenti Çorlu ekonomik rapor 2018-19," 2018. [Turkish]

[56] Y. Tahiroğlu, "Tekstil sektörü ram bacası uçucu organik bileşiklerinin kaynak ve kontrol yöntemlerinin araştırılması," [Yüksek Lisans Tezi], Namık Kemal Üniversitesi Fen Bilimleri Enstitüsü, 2019. [Turkish]

[57] M. Vidovic, "Meteorological conditions affecting the dispersion of landfill odor complaints, [Master Thesis], Faculty of The College of Engineering and Computer Science, pp. 14–15, 2017.

[58] C. Chemel, C. Riesenmey, M. Batton-Hubert, and H. Vaillant, "Odour-impact assessment around a landfill site from weather-type classification, complaint inventory and numerical simulation," Journal of Environmental Management, Vol. 93, pp. 85–94, 2012. [CrossRef]

[59] C. B. Özkal, and Ö. Arslan, "Developing a GMDH-type neural network model for spatial prediction of NOx: A case study of Çerkezköy, Tekirdağ," Environmental Research and Technology, Vol. 5, pp. 56–71, 2022. [CrossRef]

[60] A. Vranková, and M. Palko, "Atmospheric boundary layer modelling," Applied Mechanics and Materials, Vol. 820, pp. 351–358, 2016. [CrossRef]

[61] F. Cao, P. Qin, S. Lu, Q. He, F. Wu, H. Sun, L. Wang, and L. Li, "Measurement of volatile organic compounds and associated risk assessments through ingestion and dermal routes in Dongjiang Lake, China," Ecotoxicol Environmental Safety, Vol. 165, pp. 645–653, 2018. [CrossRef]

[62] M. Kuehn, H. Welsch, T. Zahnert, and T. Hummel, "Changes of pressure and humidity affect olfactory function," European Archives of Oto-Rhino-Laryngology, Vol. 265, pp. 299–302, 2008. [CrossRef]