ODOR POLLUTION ASSESSMENT IN RESIDENTIAL URBAN SPACES IN TRIPOLI CITY

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Abstract

The odor pollution is a real problem that could threat a city and influence negatively the health of people. The odor is formed from invincible substances and several previous researches in both fields of chemical and meteorological specialization have created visualization maps for odor as an intending to locate the odor source, substances, and affected areas. This research aims to benefit from previous studies in the architectural field in providing a visualization for the odor in the city especially in the residential areas. The objective of the research is to create an assessment of the odor sources and affected residential areas in three different settings in Tripoli city, as a smellscape with considering one environmental factor that is the wind as an influencing element in the dispersion of odor in the city. The study depends on ArcGIS map to set the odor different location sources, and the affected residential areas by these sources in Tripoli city. The study of wind is conducted based on the GFS model (Global Forecast System) to find out the changed wind direction and speed between 21st to 31st of May in Tripoli city. The data collected is visualized as first in pivot tables for each wind speed category, these tables help to find out the role of wind in the dispersion of odor in each of the selected residential areas. The results show that visualizing the data in pivot tables helps in conducting the influence of wind in spreading the odor in the selected residential areas in Tripoli city. The outcome of this study is to benefit from the wind study to define one of the factors that influence the odor dispersion in each of the selected areas and according to the different odor sources that help in assessing the odor pollution in each area.

Keywords

1. INTRODUCTION

"If You Smell Something, Say Something" Melanie A. Kiechle. Smell Detectives. (Valencius, 2018). Odors have the potential to cause significant adverse effects on people's lives and wellbeing. Complaints about odor emissions are one of the most frequent environmental pollution incidents reported to regulatory authorities. (Good Practice Guide for Assessing and Managing Odour, 2016)

The problem in the city that suffers from the unpleasant odor areas, especially in the residential zones is considered a serious dilemma. This problem negatively affects the human health and wellbeing, as well as these areas are neglected from the municipality of the city, which force the inhabitants in many cases to leave their homes looking for a better place to live. The odor sources are varied as could be from waste, sanitary sewers, factory smoke, or other resources.

Tripoli city' s people are suffering in many residential areas from this problem, so the focus as a case study will be in this city.

The aim of this research is to provide a visualization for the distribution of unhealthy odor levels in the city, which will help in selecting appropriate locations for new residential communities through providing a map clarifies the areas that are affected from odors to help find out the areas that provide the best clean environment for the inhabitants.

By providing such map for the city that could clarify the affected zones by odor, people will not be eligible to change their living areas, as well as the companies or contractors, which invest in the residential construction sector will be able to achieve their economic benefits in such a healthy area.

The research objective is to achieve a smellscape that combine the previous chemical assessment of odors and the environmental factor (wind) that affect the dispersion of odors in one smellscape that help in designing new urban residential area as few urban research tackles this problem, although it affects the health and wellbeing.

The research question is how the dominant wind in the city plays a major role in dispersion odors which create more disturbance for the residents.

The research methodology is summarized in four main parts:

1. Specify the different odor sources in Tripoli city and the affected residential areas.
2. Providing a study of wind direction and speed in the city.
3. Providing wind rose in different days to show the dominant wind in the city.
4. Depending on the results, the odor dispersion in the city is evaluated.

The research case study includes three different residential areas in Tripoli city (Al Mina, Al Meetein, Bahsas) that are affected by different odor sources. The factor of wind will be studied as an influential element on odor dispersion, and the collected data will be visualized on maps to show the affected areas and the dispersion of odors affected by dominant wind in Tripoli city.

Research background: Unpleasant odors may cause a variety of emotional and unfavorable consequences in individuals, extending from irritation to archived wellbeing impacts, prompting a decreased personal satisfaction (Blanes-Vidal, 2015). The developing enthusiasm of individuals towards the earth and the more prominent regard for the personal satisfaction has prompted characterizing smells as unsafe climatic poisons (Capelli, Sironi, Del Rosso, & Guillot, 2013), as stinking conditions are for the most part connected with inappropriate air circumstances (Atamila, 2011). As a result of quickened urbanization and the absence of reasonable areas, urban regions are now and then assembled precisely inside or near existing waste treatment plants and farms (Peters, 2014). Disturbance because of smell age by squander treatment plants (Rodriguez, 2018), also animal production operations are one of the main sources of objections of individuals living close to these facilities (Keck, 2018). Several communities have activated expanded accentuation on controlling the effect of climatic poisons on neighboring zones (Bibbiani, 2012). The scent is characterized as an organoleptic quality, recognizable of the olfactory organ on sniffing certain unpredictable substances (International Organization for Standardization, 2008). In this manner, the scent can be characterized as "view of smell". Though odorant is a substance which animates a human olfactory framework with the goal that a smell is seen (Blanco-Rodríguez et al.,2018).

Based on the previous reasons, the problem of the odors should take wild attention in the field of architecture, as an important part in planning and designing healthy, and clean urban cities.

1.1. The Effect of Odor Pollution in Urban Spaces

Personal satisfaction in urban space is a difficult that decides, the choice on the acceptance of the present spot of living arrangement and is the subject of evaluation with regards to its conceivable change. Specific smells are oppressive to such an extent that they may make the need leave the spot of living arrangement in light of the fact that the respondents feel different terrible scents that have an incompatible effect upon the personal satisfaction that they see (Wojnarowska , et al., 2020). As of late, a few overviews focused on three basic focuses, including the smell impact on wellbeing, prosperity, and how the scent impacts are affected by the occupants' reaction (Tran, Murayama, & Nishikizawa, 2019). Lately, there has been a developing worry about potential effects on general wellbeing and prosperity because of introduction to natural smell. Partition removes between smell discharging sources and local locations can be determined utilizing scattering models, as a method for shielding the area from scent disturbance (Brancher, et al., 2019). Smells radiated from landfills can bring about objections by the occupants living close to the landfills (Tansel & Inanloo, 2019). Governments are progressively presenting odor impact criteria (OIC) to decide partition separates between smell sources and neighborhoods. (Brancher, Piringer, Grauer, & Schauberger, 2019). Odor inconvenience contrarily impacts inhabitants of networks neighboring determined annoyance businesses. These inhabitants experience emotional and target impacts on wellbeing and prosperity. (Kitson , Leiva , Christman, & Dalton, 2019). The odoriferous contamination is the tainting brought about by awful scents that you can see outside or inside with the windows open and which can turn into a disturbance. This kind of contamination is an expanding issue in a few urban areas, influencing to a significant level of the populace, it is assessed that in urban communities like Madrid or Barcelona this worth emerge to 25 %. Despite the fact that this defilement doesn't in all cases infer harmfulness, it very well may be irritating and lead to distress or respiratory issues (Urquijo, 2017). The odor pollution became the second most frequent issue of public criticisms around Europe. Scent contamination is a marker of real ecological matters, even specialists discover it some of the time hard to characterize the actual reason for an unpleasant exceptional smell. The issue of bad odor is not noticed solely in "poor" urban districts, in contrast, it could be found in large area as in Fòrum in Barcelona city that suffers from odor pollution despite the advanced design of the city (Daher, 2018). Also, in California's Central Valley emanations from petroleum treatment facilities and agribusiness make Bakersfield America's most air-polluted city (Berg, 2017). In addition, Valenzuela City in Philippines, the occupants accuse reusing plants of sharp scents and respiratory diseases (Fonbuena, 2019).

Depending on the previous, it is noticeable that the significance of studying the odor nuisance in the cities is a necessary demand as several recent research focuses on the role of the odor in controlling people's life. This problem is not restricted cities, in contrast it is a problem that threat not only poor cities, but also the developed ones. According to recent research, the odor disturbing living areas considered as a chemical issue. This issue should be considered as a serious problem that affect the architectural field as well.

1.2. Urban Smell Taxonomy

According to (Schifanella & Aiello, 2016) the smell causes include different sources categorized into ten main types (waste, emissions, food, nature, industry, metro, animals, cleaning, tobacco, and synthetic) as shown as Fig1. As it is clarified in Fig 1, the largest smell detection issued by the waste that includes different kinds causing unpleasant odors. As well as each type includes its own kinds, as emissions caused by traffic, fuel, or dust that in turn caused by car, exhaust, gasoline, petrol, dust, and mold. This figure shows the detailed types of each category.
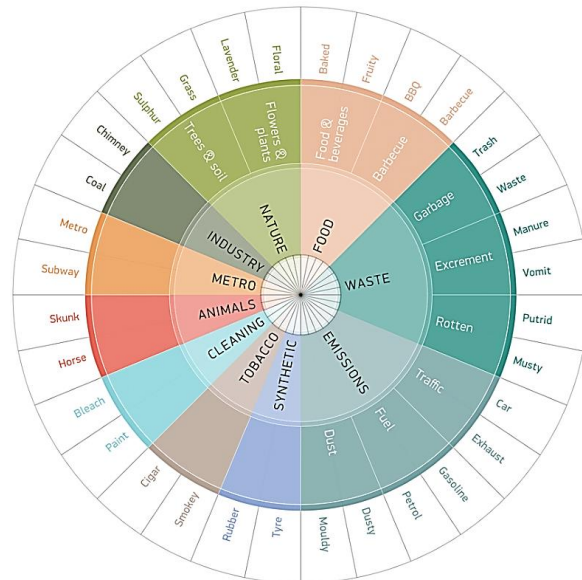

Fig.1: Urban smell taxonomy. Source: (Schifanella & Aiello, 2016)

2. FACTORS AFFECTED ODOR DISPERSION

The dispersion of odor is affected by numerous components according to (Xiao, 2018) that are: smells and smell sources, physical environmental settings, time and weather, human perception, characteristics of a place, unpredictable environmental issues, and other sensory mediation. The importance of wind factor in smelling different odors is mentioned in various previous studies as in (Brancher, Piringer, Grauer, & Schauberger, 2019) that explains the necessity of studying wind direction to assess the separation distance for a particular site from the odor source. As well the research of (Piringer, Knauder, Pertz, & Schauberger, 2016) that provides models of separation distances calculated depending on wind speed and direction to help avoiding odor disturbance on two different sites. In addition to the previous researches, (Eltarkawe & Miller, 2019) presents a study of odor issues in different locations with wind study consideration.

The focus of this paper is on one factor that is the weather in specific the wind as an influenced factor that affect the odor dispersion.

3. DATA VISUALIZATION FRAMEWORK

The concept of visualizing the odors in the city in smellscape is not an innovative idea, however previous research in meteorology and chemical fields applied this step using different techniques to measure data then visualize these data in a map.

The previous researches presented various tools that help in measuring the odor intensity in the area, the most used is the electronic nose (e-nose) that can recognize a complex mixture of odors, in addition to various other methods that measure odors like: Citizen Science, Field Olfactometry, Field Inspection, Chemical Analysis, Gas Chromatography-Olfactometry, Chemical Analysis with Speciation, and Dynamic Olfactometry. All these tools are used as odor measurement techniques. As an example, the research of (Kitson , Leiva , Christman, & Dalton, 2019) applied a method that includes using two of odor measurement tools (citizen science, and field olfactometry), then mapping the location information and recorded observations in ArcGIS software for the purpose of presenting smellscape study.

In addition to studies in the chemical field, research belongs to meteorology field have studied the odor dispersion in coordination with environmental effects to help visualize data on a smellscape map.

The application of these methods helps in the upcoming study of the affected area in odor pollution, as the previous methods are applicable in the chemical and meteorology fields and there is a new approach to make it valid in the architectural field.

As it is noticed from previous studies, the odor could be visualized as a smellscape that indicates the odor affected areas, and with the help of wind study, a better smellscape could be presented as a reference for the city to highlight the best urban areas for new residential constructions.

4. VISUALIZING ODOR POLLUTION IN TRIPOLI CITY

The smellscape in Tripoli city is an innovative concept, and as this research focuses on studying the odor pollution in residential areas and the effect of wind factor in odor dispersion, that will help in the future to draw an innovative architectural smellscape for Tripoli city. This study benefits from various previous odor studies in the meteorology and chemical field to try to put these studies in the architectural field to benefit from the study of odor. As an example, (Brancher, Piringer, Grauer, & Schauberger, 2019) used the wind rose to visualize the wind affected separation distance for odors. In addition, this study benefits from (Leem, 2017) that visualize the odor spots on the map of London city to show the affected areas by odors. Also, (Eltarkawe & Miller, 2019) used the wind rose as an affected factor on the odor source and drew it on a map. This study profits from all the previous studies of odors and wind. The case study includes three different residential locations in Tripoli city (Al Mina, Al Meetein, Bahsas) as shown as Fig 2. These areas have been selected as residents in these areas reported about the unpleasant odors in their places, this problem affects the inhabitants' lives, health, comfort, and in many cases could force the people to leave their places looking for a better clean area. The ArcGIS software is used as an initial step to locate the affected areas by odor, next this software is valuable in adopting new method (for the thesis) to provide a new approach in analyzing and visualizing odor data as in architectural smellscape.
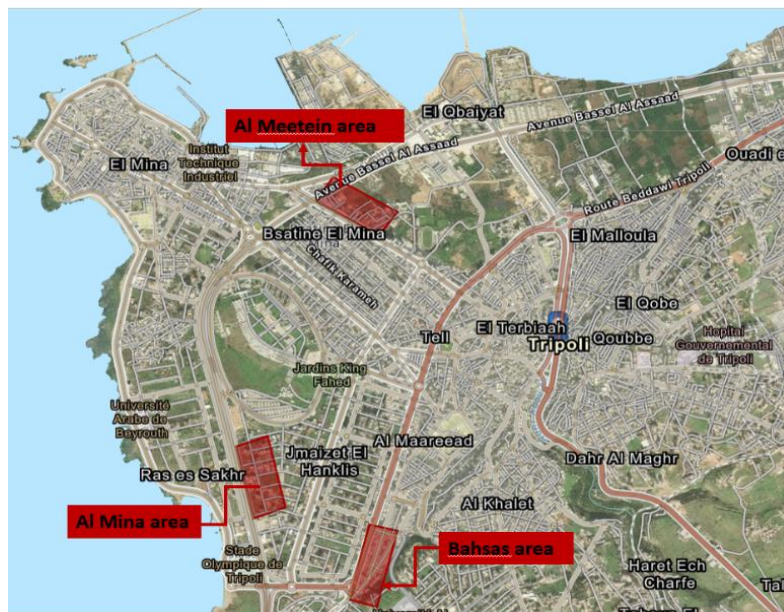
Fig.2: ArcGIS map clarifies the three selected residential areas.
Source: Arc GIS map modified by the author.

4.1. Defining Odor Sources and Affected Areas

The three selected areas are affected by different odor sources, the three odor sources are in three different areas in Tripoli city. These areas are identified depending on official reports issued by the city, or published in formal articles as clarified in (Deeb, 2017) that shows the odor source that affects the area of Bahsas is located in the area of Koura causing the bad smell because of the sewers works in this area. According to NNA, ministry info (Salloum, 2017) Al Mina area is affected because of the sewage flows into the sea causing the unpleasant odor in this area. Depending on (Al-Chamal, 2017) the problem of landfill that is located in an area far from the residential areas, threats the people health and affect a wide area up even Al Meetein area producing the bad smell. As shown as Fig 3.
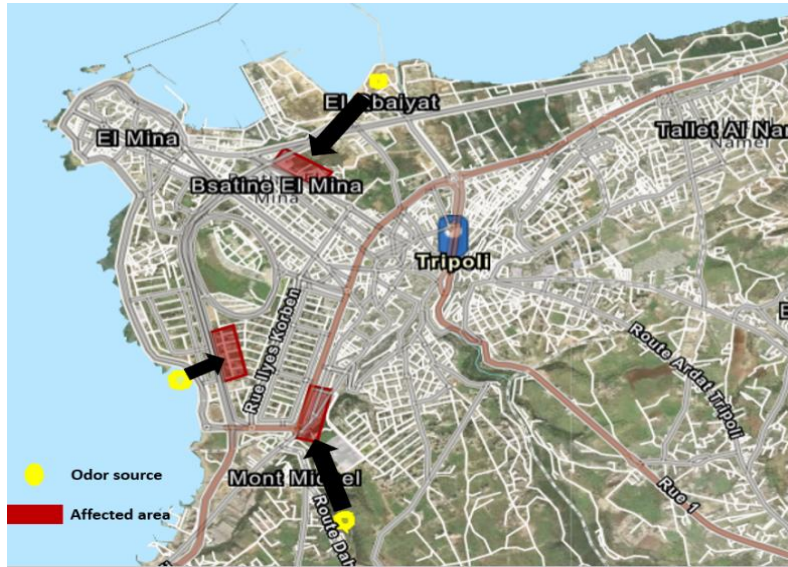
Fig.3: ArcGIS map clarifies odor different sources and the affected areas.
Source: Arc GIS map modified by the author.

4.2. Wind Direction Analysis

As it is clarified previously, the wind factor plays a major role in the odor dispersion. Depending on the weather reports provided by (Windfinder, 2020) all the weather information, including wind is available, and help to achieve adequate wind data (direction, speed and so on), the forecast information is based on GFS model that is a global forecast system provides a weather forecast model. The wind data collected from the website will be analyzed on excel, to provide a wind rose in Tripoli city, then put it into a pivot table and use a radar chart, to help find out the dominant wind in the city in specific times and how it affects the dispersion of odor in each of the selected areas. As indicated in figures 4, 5, and 6.

Fig.4: Dominant wind direction in Tripoli city. Source: (Windfinder, 2020)

Fig.5: Average wind speed in Tripoli city. Source: (Windfinder, 2020)

Fig.6: Wind direction and strength distribution in Tripoli city. Source: (Windfinder, 2020)

According to wind data collected in Tripoli city, a wind rose will be provided for a period from 21st until 31st of May, as the detailed wind data is available on the website during this time, and help to provide a wind rose for each of these days that will clarify the dominant wind in the area. As indicated in Table 1.
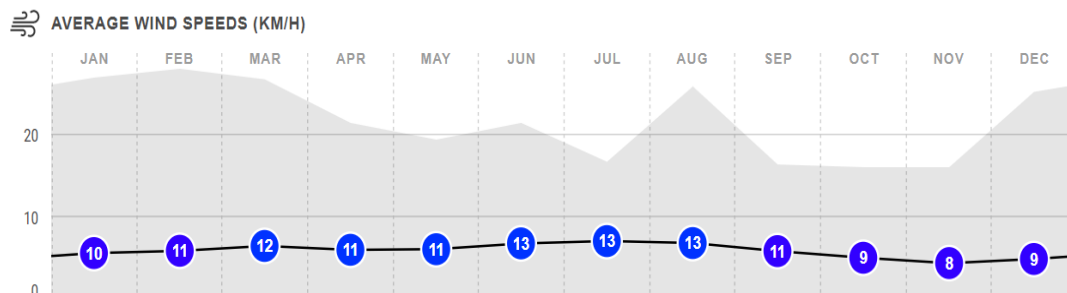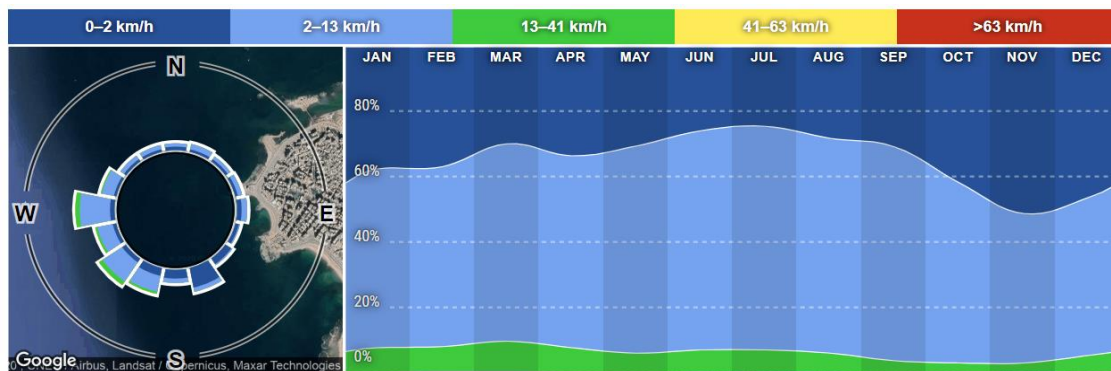
Table 1: Wind data from 21st till 31st of May. Source: The author.

Start time	Wind-dir	Wind direction	Wind speed/km/h
21/05/202000:00	350	N	7
21/05/202003:00	68	ENE	7
21/05/202006:00	34	NE	7
21/05/202009:00	55	NE	6
21/05/202012:00	294	WNW	9
21/05/202015:00	347	NNW	7
21/05/202018:00	290	WNW	6
21/05/202021:00	109	ESE	2

Start time	Wind-dir	Wind direction	Wind speed km/h
22/05/202000:00	73	ENE	6
22/05/202003:00	94	E	6
22/05/202006:00	234	SW	11
22/05/202009:00	222	SW	19
22/05/202012:00	229	SW	30
22/05/202015:00	227	SW	31
22/05/202018:00	216	SW	37
22/05/202021:00	227	SW	37

Start time	Wind-dir	Wind direction	Wind speed km/h
23/05/202000:00	228	SW	37
23/05/202003:00	225	SW	37
23/05/202006:00	216	SW	31
23/05/202009:00	222	SW	39
23/05/202012:00	229	SW	39
23/05/202015:00	227	SW	39
23/05/202018:00	225	SW	41
23/05/202021:00	215	SW	43

Start time	Wind-dir	Wind direction	Wind speed km/h
24/05/202000:00	216	SW	44
24/05/202003:00	226	SW	37
24/05/202006:00	215	SW	39
24/05/202009:00	312	NW	28
24/05/202012:00	324	NW	19
24/05/202015:00	285	WNW	15
24/05/202018:00	185	S	22
24/05/202021:00	211	SSW	35

Start time	Wind-dir	Wind direction	Wind speed km/h
25/05/202000:00	285	WNW	28
25/05/202003:00	264	W	17
25/05/202006:00	204	SSW	30
25/05/202009:00	201	SSW	46
25/05/202012:00	230	SW	41
25/05/202015:00	216	SW	28
25/05/202018:00	216	SW	24
25/05/202021:00	246	WSW	13

Start time	Wind-dir	Wind direction	Wind speed km/h
26/05/202000:00	345	NNW	6
26/05/202003:00	36	NE	9
26/05/202006:00	52	NE	11
26/05/202009:00	28	NNE	9
26/05/202012:00	332	NNW	11
26/05/202015:00	350	N	11
26/05/202018:00	357	N	9
26/05/202021:00	21	NNE	7

Start time	Wind-dir	Wind direction	Wind speed km/h
27/05/202000:00	21	NNE	13
27/05/202003:00	12	NNE	11
27/05/202006:00	17	NNE	11
27/05/202009:00	14	NNE	11
27/05/202012:00	354	N	15
27/05/202015:00	226	NNW	11
27/05/202018:00	336	NNW	6
27/05/202021:00	263	W	6

Start time	Wind-dir	Wind direction	Wind speed km/h
28/05/202000:00	240	WSW	6
28/05/202003:00	225	SW	9
28/05/202006:00	205	SSW	17
28/05/202009:00	226	SW	26
28/05/202012:00	240	WSW	29
28/05/202015:00	239	WSW	30
28/05/202018:00	236	SW	28
28/05/202021:00	231	SW	26

Continue Table 1

Start time	Wind-dir	Wind direction	Wind speed km/h
29/05/202000:00	246	WSW	24
29/05/202003:00	232	SW	22
29/05/202006:00	225	SW	24
29/05/202009:00	227	SW	31
29/05/202012:00	220	SW	39
29/05/202015:00	228	SW	41
29/05/202018:00	225	SW	39
29/05/202021:00	214	SW	37

Start time	Wind-dir	Wind direction	Wind speed km/h
30/05/202000:00	216	SW	33
30/05/202003:00	216	SW	28
30/05/202006:00	211	SSW	28
30/05/202009:00	218	SW	28
30/05/202012:00	230	SW	26
30/05/202015:00	237	WSW	20
30/05/202018:00	242	WSW	15
30/05/202021:00	227	SW	9

Start time	Wind-dir	Wind direction	Wind speed km/h
31/05/202000:00	208	SSW	4
31/05/202003:00	144	SE	2
31/05/202006:00	167	SSE	4
31/05/202009:00	227	SW	6
31/05/202012:00	264	W	11
31/05/202015:00	251	WSW	15
31/05/202018:00	245	WSW	17
31/05/202021:00	223	SW	13

These tables show the wind direction (in degrees), and speed (in km/h) in a pattern of eight times a day begins at 12 in the morning till 12 of the next day. It is noticed that the wind speed and direction differ on the same day and from a day to the next.

4.3. Wind Rose Analysis

Depending on the previous data, a wind rose is available according to wind speed categorized into six groups. The first wind rose is provided according to the study conducted in Tripoli city, the wind speed is between 2-5 km/h is visualized in pivot table to show that this wind is mostly coming from the south east and rarely from the south west. The second wind rose is for wind speed between 6-9 km/h that shows the variation of wind direction from the north east, north west, and southwest. The third wind rose for wind speed between 10-13 km/h is quite close from the previous wind rose as the wind direction varies between north east, north west, and southwest. The fourth wind rose is for wind speed between 14-17 km/h shows that the wind comes from north east and north west, and more from the southwest than the previous wind rose. The fifth wind rose is for wind speed between 18-21 km/h shows that the wind is more common from the south west, in addition from the north west and north east. The last wind rose is for the wind speed more than 21 km/h when the wind speed could achieve 41 km/h, shows that the wind direction is dominant from the south west in most. As shown as Figure 7.
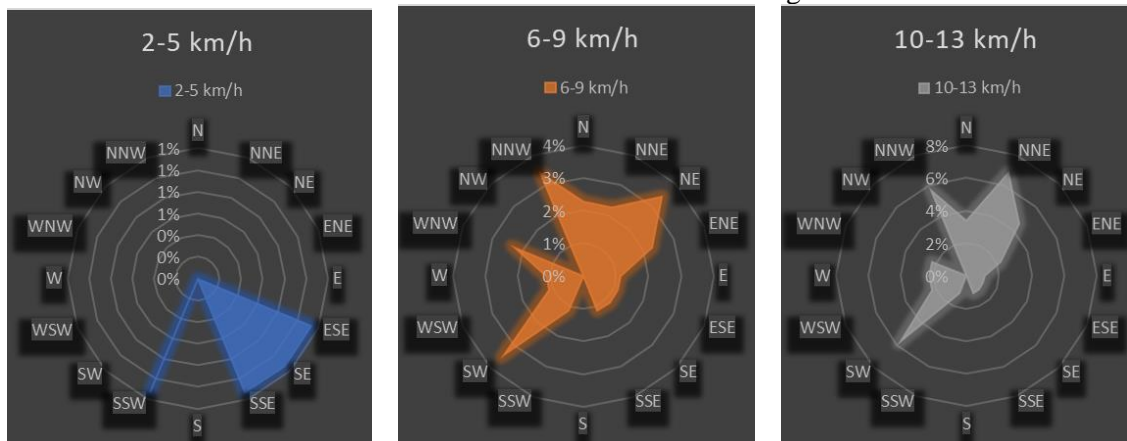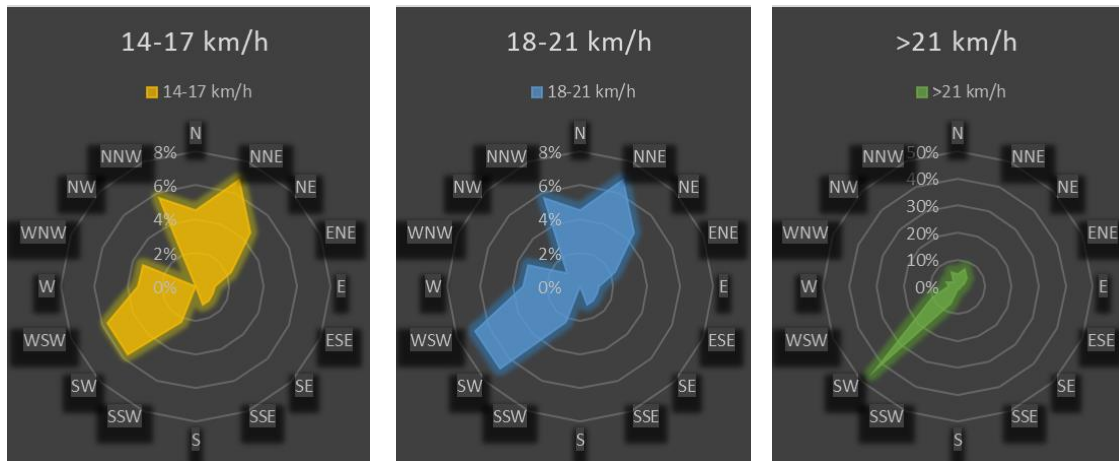
Fig.7: Wind rose clarifies the dominant wind direction according to wind speed. Source: The author

The wind rose helps in visualizing the wind direction and finding out the most dominant wind, according to its speed and direction in the studied area. As clarified in the wind rose for Tripoli city in Fig 4 the most dominant wind in the city comes from the west and southwest, and the study conducted proves that this wind is the most common in most days.

5. RESULTS AND DISCUSSION

According to the wind rose in the period from 21st to 31st of May, the results are shown on separated maps as shown in Fig 8, that clarifies the odor sources, affected area by odor, wind rose according to wind speed and direction, and the most affected area by odor and wind. As shown as Fig. 8, the map (a) shows that the wind speed between two to five km/h comes usually from the southeast and rarely from the southwest, which make the wind that affect the odor dispersion comes from the southeastern side. By comparing this result on the odor affected areas in Tripoli city, it is found that the wind in this case could mostly affect the odor dispersion in Bahsas area as the odor source that affects this area is located in the southeastern side to Bahsas. The map (b) shows that the wind speed between six to nine km/h comes usually from north-northwest, northeast, and less from west-northwest and southwest, which make the wind that affect the odor dispersion comes from the northeastern to northwestern and southwestern sides. By comparing this result on the odor affected areas in Tripoli city, it is found that the wind in this case could mostly affect the odor dispersion in Al-Mina and Al-Meetein areas as the odor sources that affect these areas are located in the northwestern and southwestern sides to Al-Mina and Al-Meetein. The map (c) shows that the wind speed between 10-13 km/h comes usually from north-northeast, north-northwest, and less from the southwest, which make the wind that affect the odor dispersion comes from the northeastern to northwestern and southwestern sides.

By comparing this result on the odor affected areas in Tripoli city, it is found that the wind in this case could mostly affect the odor dispersion in Al-Meetein area as the odor sources that affect this area is located in the northeastern side to Al-Meetein, and the wind affect less the odor dispersion in Al-Mina area as the odor sources that affect this area is located in the southwestern side to Al-Mina. By comparing the maps (d) and (e), it is noticed that the dominant wind is quite similar with a slight difference. The map (d) presents wind speed between 14-17 km/h comes from the north northeast, north north-west, west south-west, and southwest. This makes the affected areas by wind and odor are Al-Mina as the odor source is located in the southwest side, and Al-Meetein area as the odor source affects this area is located in the northeast side in this area. The map (e) presents wind speed between 18-21 km/h comes from north, northeast, north north-west, and much more than the map (d) from west south-west, and southwest. This makes Al-Mina area is more affected by wind and odor as the wind speed and direction are more dominant and the odor source is on the southwest side. Also, Al-Meetein area as the odor source affects this area is in the northeast side of this area. The map (f) presents wind speed more than 21km/h comes from the southwest side. This makes the affected area by wind and odor is Al-Mina as the odor source is located in the southwest side.
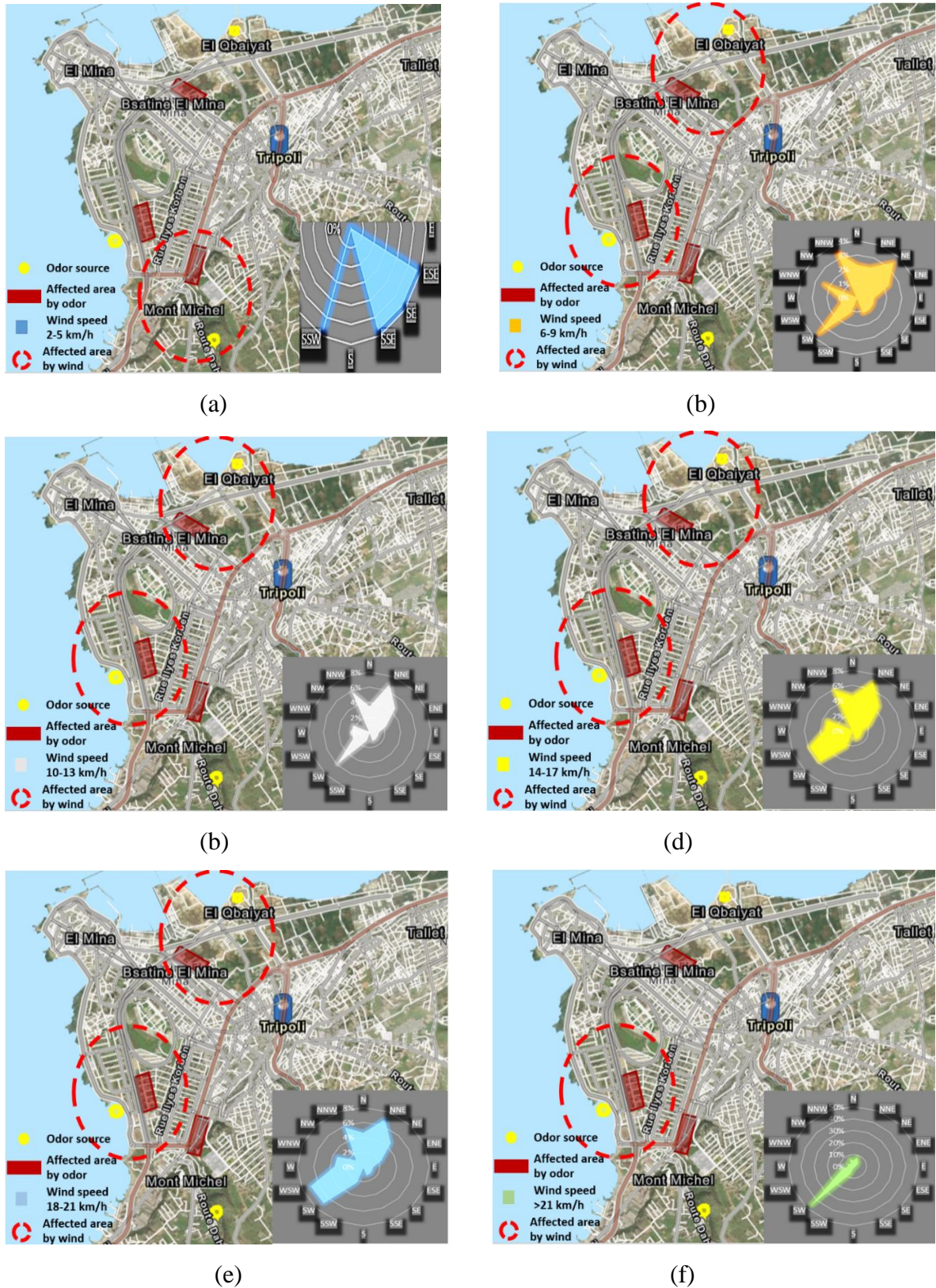
Fig.8: Maps shown the affected area by odor with the factor of wind. Source: The author.

The circles provided on the maps are mainly to define the affected residential areas by odor considering the factor of wind, these circles do not have adequate measurements as this step could be provided in the future work.

As a result, the data collected from wind speed and direction that visualized in pivot tables helps in conducting the influence of wind in spreading the odor in the selected residential areas in Tripoli city.

The dominant wind in Tripoli city comes usually from south and southwest as presented in (Windfinder, 2020), the analysis done in this research for the period between 21st to 31st of May clarifies that the wind speed and direction vary in each day with ensuring that the southwest wind is the most dominant. The outcome of this study is to benefit from the wind study to define one of the factors that influence the odor dispersion in each area and according to the different odor sources.

6. CONCLUSION

The research intended to highlight the importance of odor in controlling peoples 'lives, in the residential areas. The odor dispersion is affected by various factors that are mentioned previously, the factor of wind is conducted in this research to find out the role of wind in distributing the odor between areas. The study of wind has been conducted in Tripoli city for 11 days in May and the results show that the wind speed and direction differ from day to another and vary between 2- 43 km per hour as a speed, and from northeast to northwest to southwest as a direction. These results could prove that the problem of the odor dispersion in different residential areas in Tripoli city is continuously affected by the various wind speed and direction that play a major role in spreading odor, in addition the odor sources are different and surround Tripoli city so the affected areas will suffer in different times from the odor dispersion as the wind differs in its speed and direction during close periods. The research includes three different residential areas in Tripoli city (Al Mina, Al Meetein, Bahsas) each of these areas is affected by a different source of odor that cause a real problem for the inhabitants in their places. To find out the odor dispersion in the city, the concept of smellscape was adopted as to locate the odor sources and affected areas using an ArcGIS map. The second step was to discover the factors influence the odor dispersion and adopt one factor that is the wind speed and direction, the wind study depends on data provided by forecast information based on GFS model for Tripoli city that help in visualizing these data as wind rose to find the most dominant wind direction and speed affect the odor diffusion. It is found that the wind differs in its direction and speed from day to another which play a major role in spreading the odor particles in different directions and distances. The research benefits of the wind study to explain one of the factors that impact the odor dispersion in each of the selected areas that differ in the odor sources which help in evaluating the odor pollution in each area. The results show that visualizing the data in pivot tables helps in conducting the influence of wind in spreading the odor in the selected residential areas in Tripoli city.

Future Work

This research is an initial step in providing a new method of visualizing data as to be conducted as a future Ph.D thesis, to achieve an innovative method of smellscape not limited to chemical and meteorology fields, but also comprise the architectural field that will benefit from these maps in designing new areas or protecting existing areas from possible odor pollution.

Study limitation

As the odor dispersion is located on maps with the odor source and affected area, the distance of this dispersion is not calculated, it is only assumed as a location at this stage, and it should be considered in future work. Another factor plays a major role in odor dispersion is the temperature that should be considered as important as the wind factor that influence the odor dispersion in further work.

Acknowledgments

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