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DIRECTIONAL ASSESSMENT OF AIR POLLUTION ON DISPOSAL SITES AT HEBBAL AREA USING GEOINFORMATICS

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Abstract

A location for a dump must be chosen after consideration of air, water, and soil. Similarly, environmental resources need to assess for the open dumped disposal sites. The wind movement carries the odor's from the disposal sites, and it has a big influence on the people who live nearby. Additionally, anthropogenic activity at disposal sites such as leaching and sporadic fires promote the release of organic contaminants that drift with the wind. It is vital to understand the spatial distribution of pollution using GIS in order to calculate the possible danger from open dumping. Data on population density and weather observations were gathered for the current study area from a census database and the few areas with monitoring stations, respectively. varied places have varied meteorological features, including various patterns of wind speed and direction. A windrose plot that examines patterns of wind speed and direction is typically created to assess the danger of air pollution. The distribution of wind speeds in various directions is seen on the windrose plot. The windrose chart analyzed for three years data suggest the directional flow of wind movement is from southwest to northeast varying with speed and the frequency rate shows a decreasing percentage year wise. The study of spatial distribution maps of the windspeed and direction gives an idea about the air movement and helps to correlate with spreading of the dry waste in the surrounding. The integrated map reveals that the bigger arrows indicate the high movement of wind blow and vice versa with small arrows.

Keywords: *Windspeed, Windrose, GIS, Odor, Unsanitary*

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INTRODUCTION:

A relation between some types of meteorological conditions and odor complaints at solid waste facilities has been noticed (Blumberg et al., 2001; Capelli et al., 2008; Epstein, 2011). The wind is responsible for moving the air contaminants; wind direction affects where they end up, and wind speed determines how far they can spread. As Thanh and Lefevre noted, the amount of health effects brought on by air pollution varies greatly depending on on the wind speed and direction. Even though disposal facilities are often found in low-density locations relative to dense populations, the air pollutants they produce can be carried by the wind and have an impact on high density areas downwind of the disposal site [8]. For instance, Sengupta et al. produced an air quality index map by combining an air quality map with a land-use map made using data on air pollution. It is vital to understand the spatial distribution of pollutants in order to calculate the possible risk from open dumping [9]. By examining the local population along with the air pollution concentration, the effect of air pollution on any given location may be evaluated. For the purpose of assessing the threat, Beer and Ricci (1999) also took into account the population structure and concentration distribution. In general, seasonal, or temporal variations can be found in the wind's direction [10] and speed across time. The wind direction with the highest frequency of occurrence is called the prevailing wind direction. No predominant wind directions, however, may frequently also have significant far dissemination and have a significant impact on densely populated places. Thus, it may not be suitable to evaluate the danger of air pollution only based on the direction of the prevailing wind. Varying wind directions and speeds will have varying effects on the amount of air pollution in downwind locations, even with the same emission rate. Therefore, the air movement posed by an open disposal site is measured in this study. It is inappropriate to base threat assessments exclusively on the direction of the dominant wind, especially in regions with significant seasonal wind direction fluctuation. The wind rose diagram is plotted by wind data, spatial distribution maps are plotted for population density and waste generation to eradicate the above problems by identifying suitable locations for open dumpsites which does not affect the community. For example, preventing the spreading of waste, control the pollution effect on the community, to promote the social awareness and suggestion of decentralized techniques for solid waste.

1.1Geographical Information System

A computer system known as a GIS is used to gather, store, analyze, and present information on the location of the earth's surface (Dharek et al.,2020; Vengala et al., 2021). Any information that contains a location can be used by GIS. There are numerous ways to provide the location, including using latitude and longitude, an address, or a zip code. Data on population, population density, area, and solid waste generation may be included in the system (Rao et al., 2020; Sunagar et al., 2020) [11]. It contains information about the locations of streams, various types of soil and vegetation, factories, farms, and schools as well as information about storm drains, highways, and electricity lines [12].

2.0 Background and study area

Bangalore, which is in the Karnataka state, has a mild and healthy environment and is located at 12.98°N and 77.58°E. It is 9oo metres above sea level. Bangalore has had the reputation of being one of the Asian cities with the fastest rate of growth since the 1980s. The Bangalore Metropolitan area is the fifth largest metropolitan area in India and comprises an area of 1258 sq.km. The generation rate of MSW in metropolitan centers, however, is accelerating due to an increased population level, a quicker economic process and improving community living standards. The below figure 1 shows the chosen study areas, which comes under Yeshwanthpur, Hebbal and Yelahanka.

At a typical generation rate of 0.5 kilograms per person per day (kg/capita/d), the Bangalore Urban, which has an area of 2196 km^2 and a population of around 14.30 million, produces about 5000 metric tonnes of waste daily. The open garbage in the town's expanding area causes serious problems for the buildings built on these old dumps. over 6o unlicensed disposal sites are confirmed to exist in Bangalore. The Karnataka State Pollution Panel (KSPCB) and the BBMP have closed these dumpsites, but new ones have appeared elsewhere, posing health dangers to the inhabitants [Sasikumar, et al., 2012].

Wind data is used for various research works like solid waste management department, for determining suitable locations for dumpsites supported wind speed, direction, etc. The wind information is collected from Indian Meteorological Department for various stations in Bangalore like Hindustan Aeronautics Limited (HAL), Kempegowda International Airport, and Majestic City. Wind rose diagrams are drawn using wind data to determine the direction in which the heaviest wind is blowing. To stop garbage from spreading and to lessen the impact of pollution on the neighbourhood, wind speed and direction are important considerations when identifying open dumpsites [Krˇcmar, D.; Tenodi, S. et al., 2018]. The study regions' data layers are created using the available information in the form of a spreadsheet or table, and ArcGIS is used to plot the spatial distribution of maps, zoning maps, and maps relating to wind speed and direction.

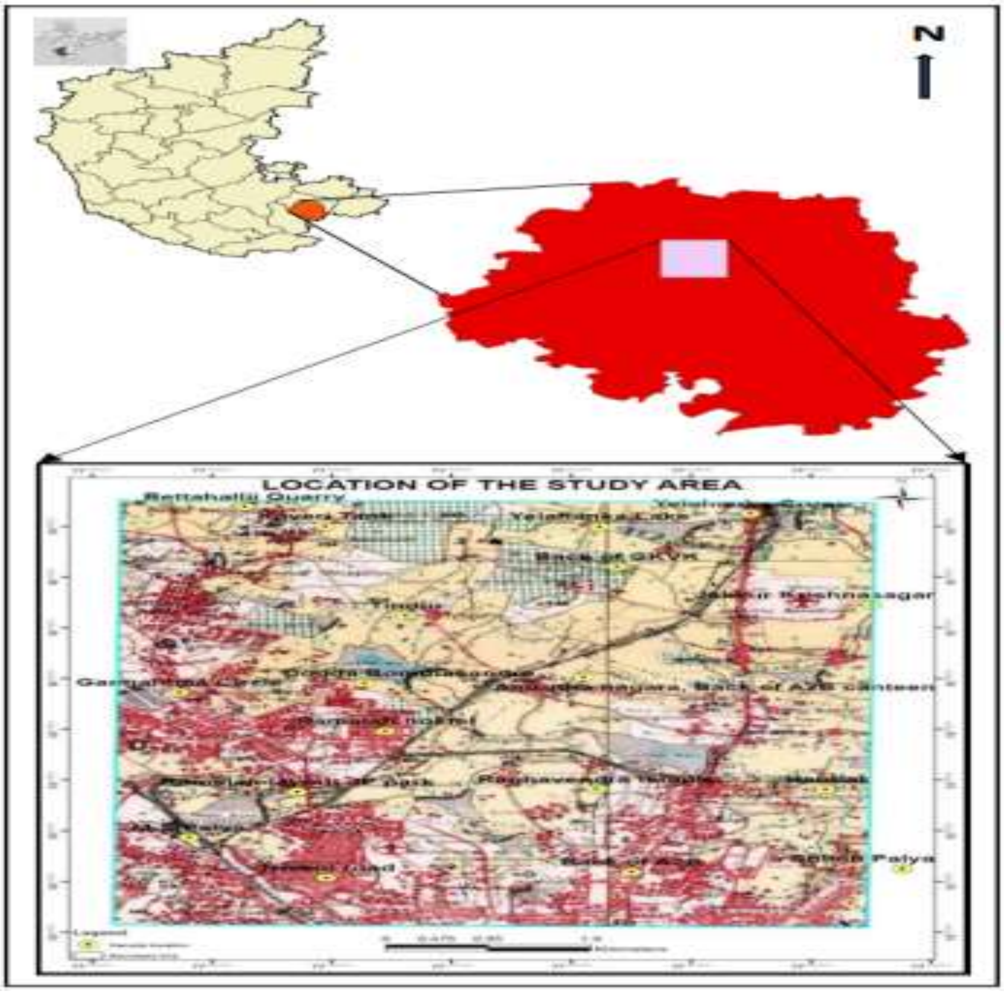


Fig.1: Location of the study areas

3.0 Methodology

The steps for carrying out an air quality risk assessment are shown in Fig. 2

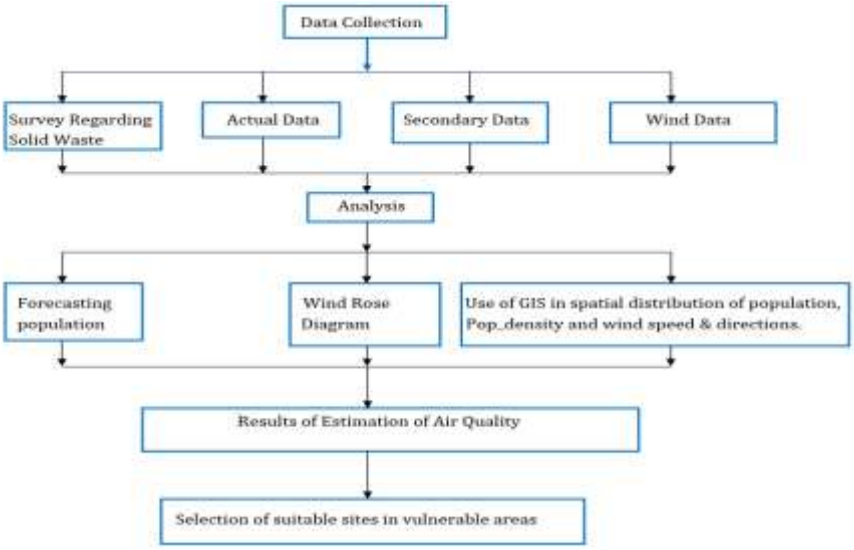


Fig.2: Flow chart showing the methodology adopted

This study evaluates the air pollution based on wind directions and speeds using GIS and windrose plots using data received from the Indian Meteorological Department.

The wind rose diagrams are constructed by using majestic wind data as Majestic is closest to study area and covers area about 20 km^2 radius. station and the research area is 13.5 km to 38.3 km, as illustrated in Figure 3.

Table 1: Locations of meteorological stations of the Bangalore			
STATION	S. NAME	LATITUDE	LONGITUDE
S1	MAJESTIC	12°34’48”	77°20’60”
S2	HAL	12°34’12”	77°22’48”
S3	BIA	13°06’36”	77°25’12”

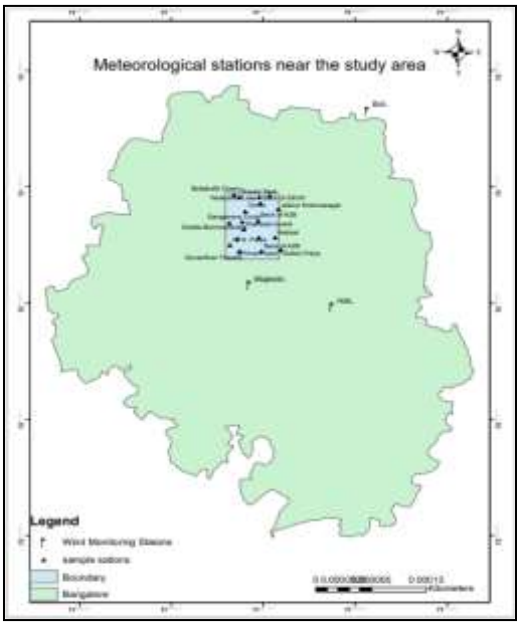


Fig.3: Metrological Stations in the vicinity of the Study Area

Data on the study area's wind direction and speed that is both temporal and geographic are needed to complete the investigation. The majority of research sites, however, do not have a meteorological observation station nearby to give the data. Data on wind speed and direction gathered from nearby observation sites.

For data collecting, there are two different types of methodologies: analytical methods and predictive methods. Predictive approaches can't be used in the study area since they are too expensive and sophisticated. The study area can instead employ an analytical method. Based on a site's distance from observation stations, an analytical method calculates the wind directions and speeds at that location.

one observation station provided the hourly weather data. i.e., S1 which is near to study area. With relevant to the collected data of three years (2018, 2019, 2021), a windrose is been plotted by dividing the direction into several cardinal w.r.t North, South, East & West for the three years data of S1 to detect the directional flow of movement is high or low. Tables 2, 3, and 4 provide analysis and illustrations of the wind directions for N (north), NNE (north-northeast), NE (north), ENE (east- northeast), S (south), SSW (south-southwest), SW (southwest), SW (west), W (west), WNW (west-northwest), NW (northwest), and NNW (north-northwest). As depicted in Figs. 4, 5, and 6, a wind speed of 2-2.5 m/sec was considered to be a calm wind.

on the basis of a year's worthof daily wind data, a wind rise for the research region has been determined according to the 2018(one hour of the day). Each spoke is divided into distinct frequency categories that represent the proportion of time that the wind blows in various directions and speeds. These 14 cardinal directions are used in all of the wind roses. This rose demonstrates that the study location's predominant wind direction for the time period is the southwest. In actuality, the three spokes of east, southwest, and west (E, SW, and W) account for 49% of daily wind directions. By adding the frequencies of each of these directions (18+12+19=49%), this may be rapidly computed. This further demonstrates how the wind primarily blows from the NNE and SSW. The information about wind speeds from various directions is also provided by these wind roses. one can estimate that 8% of the time the wind blows from the southwest at speeds between 6 and 8 kilometer per hour by looking at winds from the southwest (the longest spoke). Similar to the previous spoke, it can be determined that winds blow from the southwest on this spoke o.3% of the time, 7% of the time at velocities between 12 and 14 km/hr, and 1% of the time at speeds between 18 and 2o km/hr.

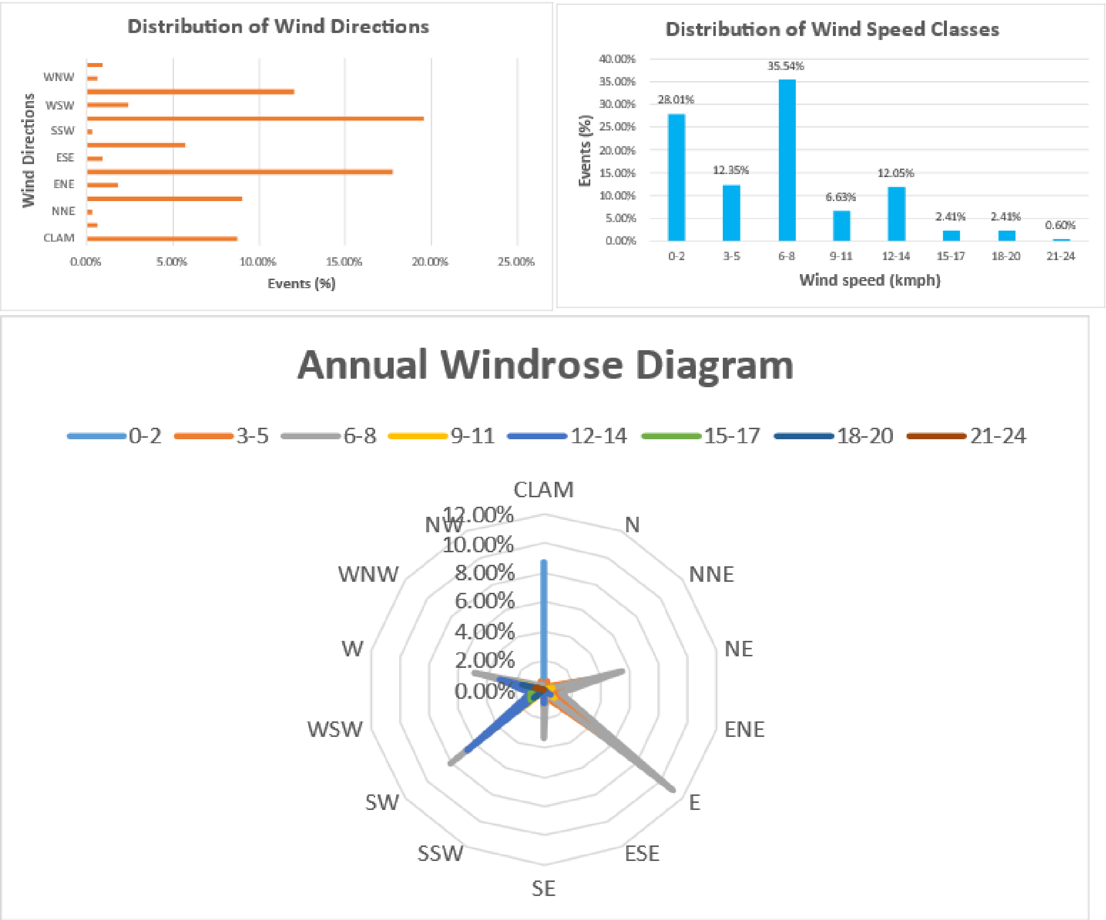
All of the windrose depicted below employ the ten cardinal directions in 2019. These windroses demonstrate that the predominant wind direction at the research location throughout the time period is the southwest. In actuality, 59% of hourly wind directions fall into the three spokes of Northeast, East, and Southwest (NE, E & SW). By adding the frequencies of each of these directions, this may be rapidly determined (14+15+30 = 59%). This further demonstrates how infrequently the wind comes from the South (S) and East Southwest (ESW), with frequency of 0.6% for each. These windrose additionally offer information about speed coming from various angles. one can estimate that 14% of the time the wind blows from the southwest at speeds between 6 and 8 kmph by looking at wind from the southwest (the longest spoke). Similarly, it can be determined that wind blows from the southwest on this spoke at speeds between 3 and 5 kmph about 6% of the time, between 12 and 14 kmph approximately 6% of the time, and between 18 and 20 kmph approximately 0.3% of the time.

All of the winds shown here use the 14 cardinal directions in 2021. These windroses demonstrate that the predominant wind direction at the research location throughout the time period is the southwest. In actuality, 49% of hourly wind directions fall into the three spokes of Northeast, East, and Southwest (NE, E & SW). By adding the frequencies of each of these directions (15+7+27 = 49%), this can be rapidly estimated. Additionally, this demonstrates that the wind rarely blows in the west-northwest (WNW), with frequencies of these directions being 0.3%. These windrose additionally offer information about speed coming from various angles. one can estimate the percentage of time the wind blows from the southwest at speeds between 6 and 8 kmph by looking at wind from the southwest (the longest spoke). Similarly, it can be determined that wind blows from the southwest on this spoke at speeds between 3 and 5 kmph approximately 8% of the time, between 12 and 14 kmph approximately 2% of the time, and between 15 and 17 kmph approximately

Table 2: Details of wind direction and speed calculation for the year 2018

	CLAM	N	NNE	NE	ENE	E	ESE	SE	SSW	SW	WSW	W	WNW	NW	Grand Total
0-2	8.73%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	28.01%
3-5	0.00%	0.60%	0.30%	3.01%	0.60%	5.12%	0.60%	1.20%	0.00%	0.30%	0.00%	0.00%	0.00%	0.60%	12.35%
6-8	0.00%	0.00%	0.00%	5.42%	1.20%	11.14%	0.30%	3.31%	0.00%	8.13%	0.30%	4.82%	0.60%	0.30%	35.54%
9-11	0.00%	0.00%	0.00%	0.60%	0.00%	0.90%	0.00%	0.30%	0.30%	2.41%	0.30%	1.81%	0.00%	0.00%	6.63%
12-14	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%	0.00%	0.90%	0.00%	6.63%	0.90%	3.01%	0.00%	0.00%	12.05%
15-17	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.20%	0.90%	0.30%	0.00%	0.00%	2.41%
18-20	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.90%	0.00%	1.51%	0.00%	0.00%	2.41%
21-24	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%	0.00%	0.00%	0.60%
Grand Total	8.73%	0.60%	0.30%	9.04%	1.81%	17.77%	0.90%	5.72%	0.30%	19.58%	2.41%	12.05%	0.60%	0.90%	100.00%

Fig.4: Distribution of wind speed and direction with windrose chart for the year 2018 near to the



study area

Table 3: Details of wind direction and speed calculation for the year 2019										
	E	**ESE**	**NE**	**NW**	**S**	**SE**	**SW**	**W**	**WSW**	**Grand Total**
0-2	0.30%	0.00%	0.30%	0.30%	0.00%	0.30%	0.00%	0.00%	0.30%	27.11%
3-5	8.13%	0.00%	8.43%	0.90%	0.00%	1.81%	6.33%	3.61%	0.00%	29.22%
6-8	5.72%	0.60%	4.82%	0.90%	0.60%	0.00%	14.16%	3.31%	0.00%	30.12%
9-11	0.00%	0.00%	0.00%	0.30%	0.00%	0.00%	3.01%	0.60%	0.30%	4.22%
12-14	0.60%	0.00%	0.30%	0.00%	0.00%	0.00%	5.72%	1.51%	0.30%	8.43%
15-17	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%	0.00%	0.00%	0.60%
18-20	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.30%	0.00%	0.00%	0.30%
Grand Total	14.76%	0.60%	13.86%	2.41%	0.60%	2.11%	30.12%	9.04%	0.90%	100.00%

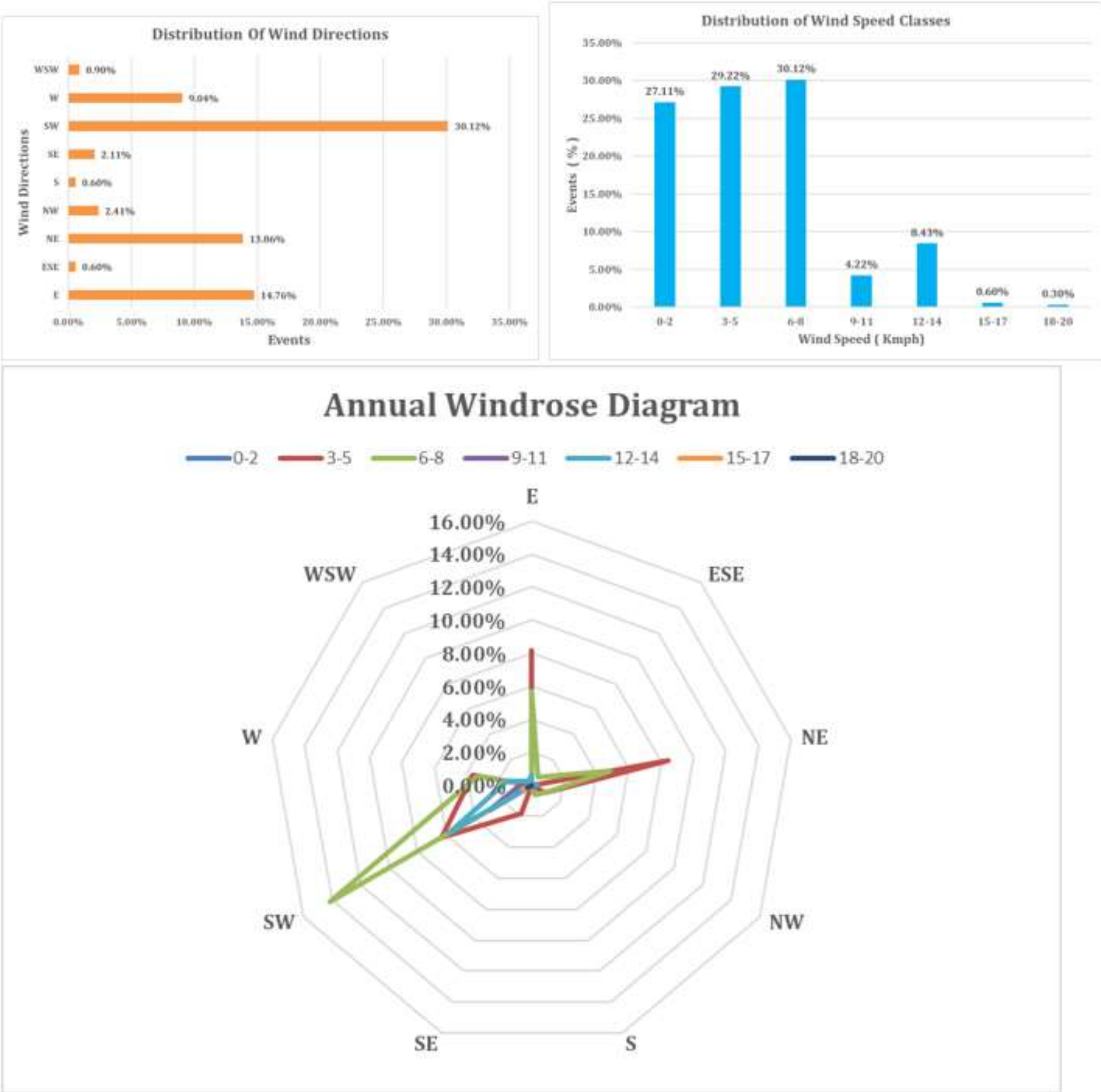


Fig.5: Distribution of wind speed and direction with windrose chart for the year 2019 near to the study area

Table 4: Details of wind direction and speed calculation for the year 2021

	N	NNE	NE	NE	ENE	E	SE	SSW	SW	WSW	W	WNW	NW	GrandTotal
0-2	0.00%	0.00%	0.00%	0.00%	0.00%	0.30%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	25.30%
3-5	0.60%	0.30%	6.02%	1.51%	3.92%	2.41%	0.30%	0.00%	7.53%	0.00%	1.51%	0.00%	0.30%	26.20%
6-8	0.90%	0.90%	6.93%	1.81%	2.11%	3.92%	0.60%	0.90%	12.95%	0.30%	3.92%	0.30%	0.30%	35.84%
9-11	0.00%	0.00%	0.90%	0.00%	0.00%	0.30%	0.30%	0.00%	3.31%	0.30%	0.30%	0.00%	0.30%	5.72%
12-14	0.00%	0.00%	0.90%	0.30%	0.00%	0.30%	0.60%	0.30%	2.41%	0.30%	1.20%	0.00%	0.00%	6.33%
15-17	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%	0.00%	0.00%	0.00%	0.00%	0.60%
Grand Total	1.51%	1.20%	14.76%	3.61%	6.02%	7.23%	1.81%	1.20%	26.81%	0.90%	6.93%	0.30%	0.90%	100.00%

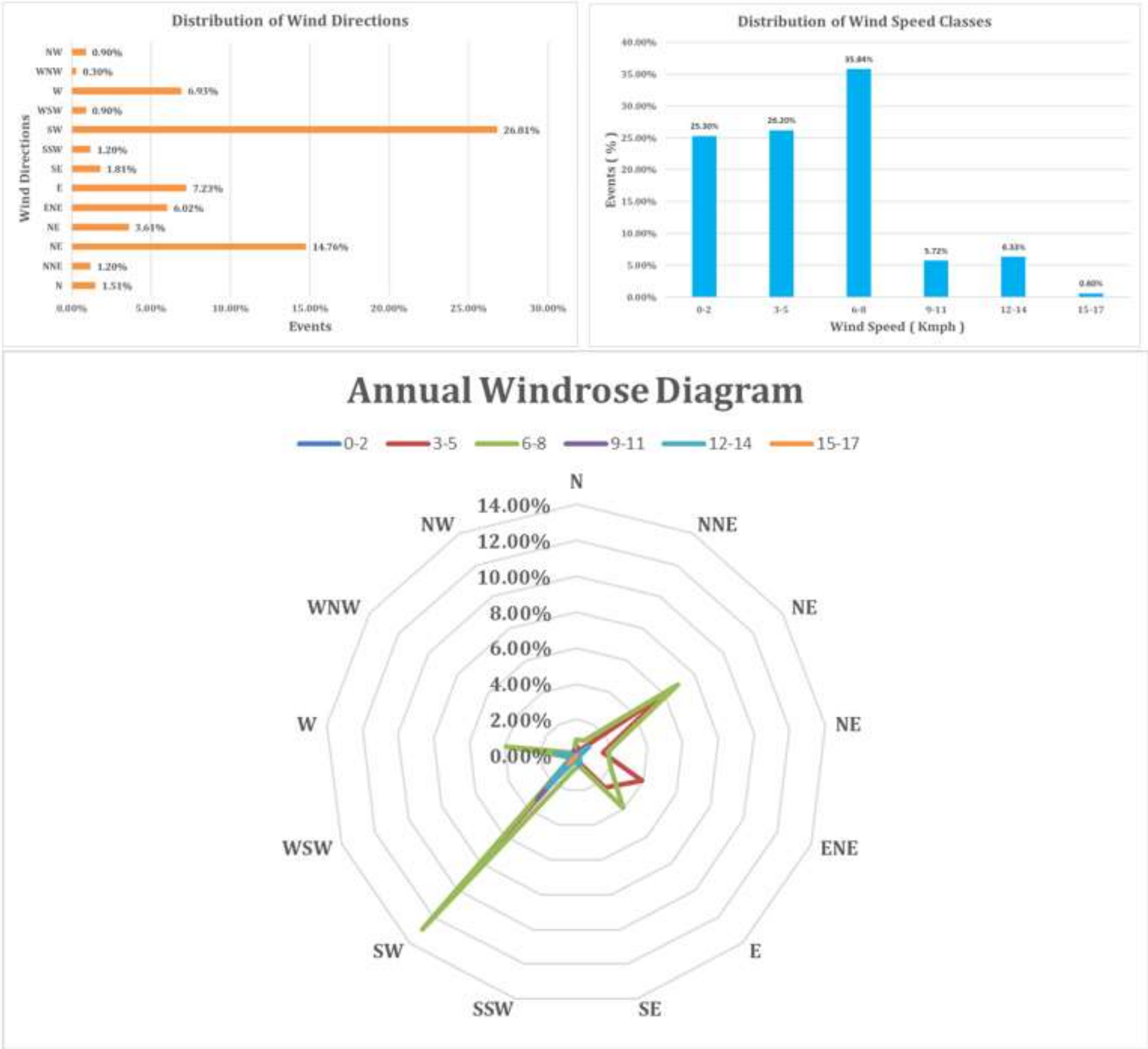


Fig.6: Distribution of wind speed and direction with windrose chart for the year 2021 near to the study area

The windrose chart analyzed for three years data suggest the directional flow of wind movement is from southwest to northeast varying with speed and the frequency rate shows a decreasing percentage year wise.

The area of wind stations S1, S2, and S3 having Lat and Long of 12°34’48”, 77°20’60”;12°34’12”,77°22’48”&13°06’36”, 77°25’12”consist of wind speed of 6.85, 20&16.67along with wind direction of 16.18, 25 & 25 for the current year 2022 as shown in Table 5.

Table 5: Wind speed and direction for the current year 2022

STATION	S. NAMES	LATITUDE	LONGITUDE	WIND SPEED Km/hr	WIND DIRECTION
S1	MAJESTIC	12°34’48”	77°20’60”	6.85	16.18
S2	HAL	12°34’12”	77°22’48”	20	25
S3	BIA	13°06’36”	77°25’12”	16.67	25

To determine the air pollution effect, it is important to assess the potential impact of pollution on the vicinity of open dumpsites. So, a spatial pollution distribution was therefore mapped for further understanding. The study of spatial distribution maps of the windspeed and direction gives an idea about the air movement and helps to correlate with spreading of the dry waste in the surrounding. The maps of pollution movement spatial variation in the study area have been plotted with the help of ArcGIS software as shown in Fig. 7 (a & b).

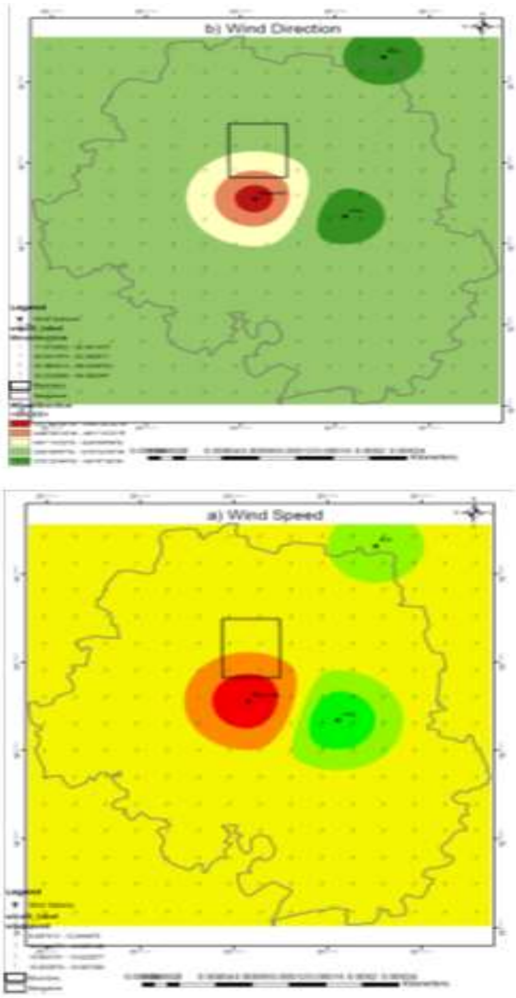


Fig. 7: Movement of (a) Wind Speed (b) Direction of the study area

4.2Combined wind speed and direction

Both these maps Fig. 7 (a & b) of wind speed and direction are merged for better understanding of wind movement w. r. t solid waste dumped sites. This map signifies the positions of wind stations and location of study areas along with speed and directions of wind.

The Fig. 8 of merged map reveals that the bigger arrows indicate the high movement of wind blow and vice versa with small arrows. The length of the arrow represents the wind speed from low to high and arrow head represents the direction in which the maximum wind is blowing i.e. from southwest to northeast direction.

In map we can see that near to the study areas or majestic the size of the arrow is small that is due to the urbanization, the wind is obstructed comparing it with the BIA wind station. There we can see that the size of arrows large which indicates that wind speed is high due to more opens sites and agricultural lands towards Yelahanka lake and Yelahanka cross.

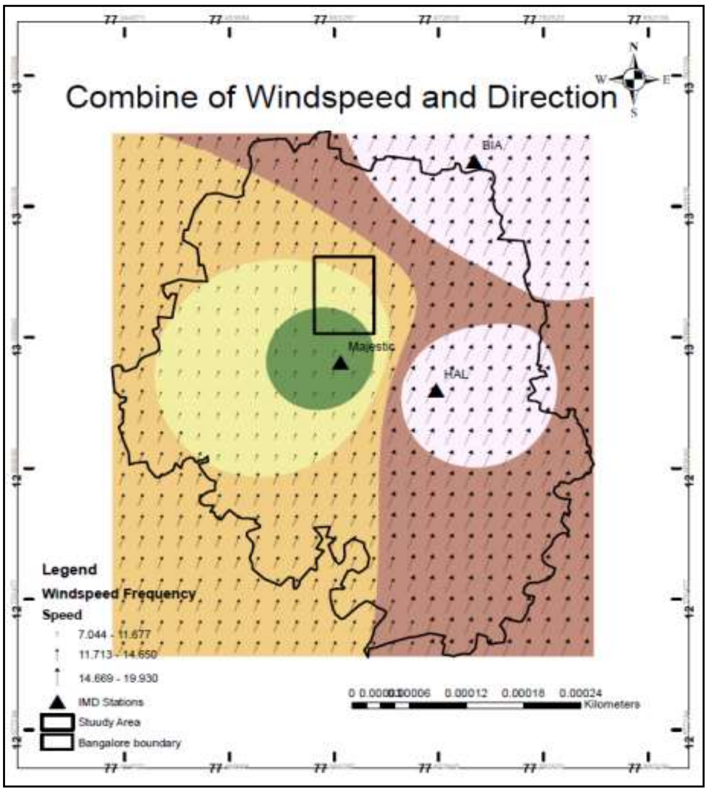


Fig. 8: Combination of wind speed and direction of the study area

odor complaints tend to occur with no or very weak wind (Epstein, 2011). Precipitation also contributes for a strong impact on the strength of odor. The rate of decomposition of the waste is affected by the amount of moisture available, which results in gas production rates (ATSDR, 2016) and thus waste dumps have adverse impacts on the environment and public health.

5.0 Conclusions

The wind speed and direction map shows that the wind is blowing from south west to north east. The larger arrow shows movement at the highest wind speed, while the smaller arrow shows movement at the average to lowest wind speed.

The wind speed maps illustrate that the small arrow of the southwest region of the study area has slow movement along with the direction. This signifies solid waste pollution spreading from the air is less towards the northern part as the wind direction blows and this leads to odor and pathogenic disease accumulating in and around the corners of dump site areas. The small arrow of the slow wind movement could be one of the reasons for high rise of buildings from the southern part and this is vice versa w.r.t the northern part.

The most pressing concern is towards residents living in the vicinity of illegal dumping sites, and there is an urgent need to regulate and monitor the ambient air quality in Bangalore, particularly around open dumping sites of the estimated pollution movement in the usual wind direction.

once this been determined, open dump sites should be located where the least amount of wind is blowing.

The current open dumping is contaminating air quality as well as creating unsanitary health conditions for the public.

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