Assessment Of Air Pollution Vulnerability And Its Impact In Jaipur City

Submitted by Auther :

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AIR POLLUTION

- Contamination of the indoor or outdoor environment by any chemical, physical or biological agent *that modifies the natural characteristics , concentration* .

- Industrial pollution accounts for 51% of pollution, followed by automobile pollution (27%), agricultural burning (17%), and miscellaneous causes (5%) comprising CO (Carbon Monoxide), Sox (Oxides of Sulphur), Ozone, NOx (Oxides of Nitrogen), Unburnt hydrocarbons, PM (Particulate matters).Other pollutants released are C4H6 (Butadiene), Photochemical oxidants, aldehydes, lead etc.

- According to a recent research,13 cities were listed in to of the most polluted 20 cities of the with the worst yearly levels of air pollution are in India, And at least 140 million people there breathe air that is *10 times or more over the WHO acceptable limit.*

Major Causes of pollution

Growth of vehicles

- Jaipurhas the highest number of vehicles in Rajasthan.

- As per the report of Transport department (Government of Rajasthan) the Maximum Share of registered vehicles in Jaipur was 14.74% in the year 2020-21 followed by Udaipur (10.74%) and Ajmer (9.92%).
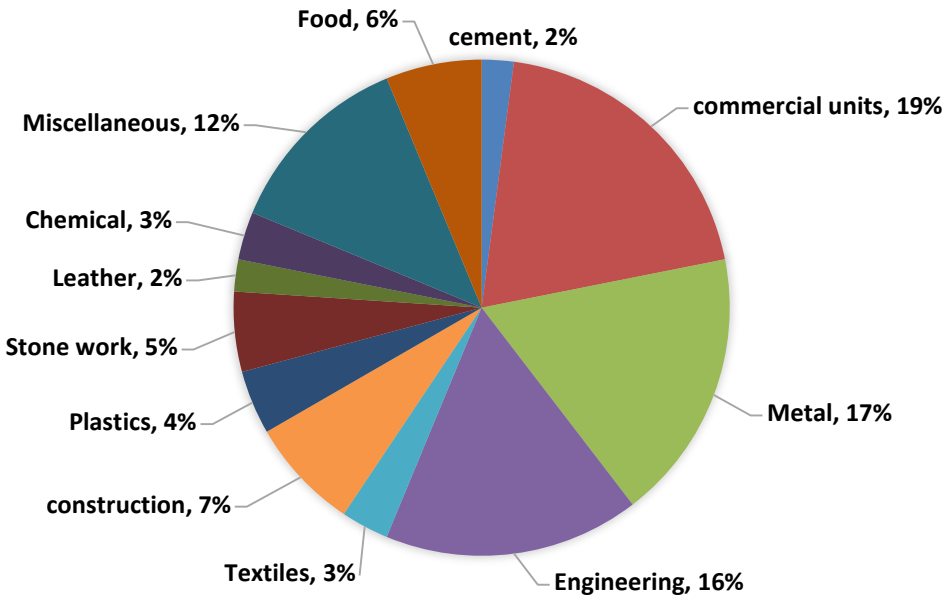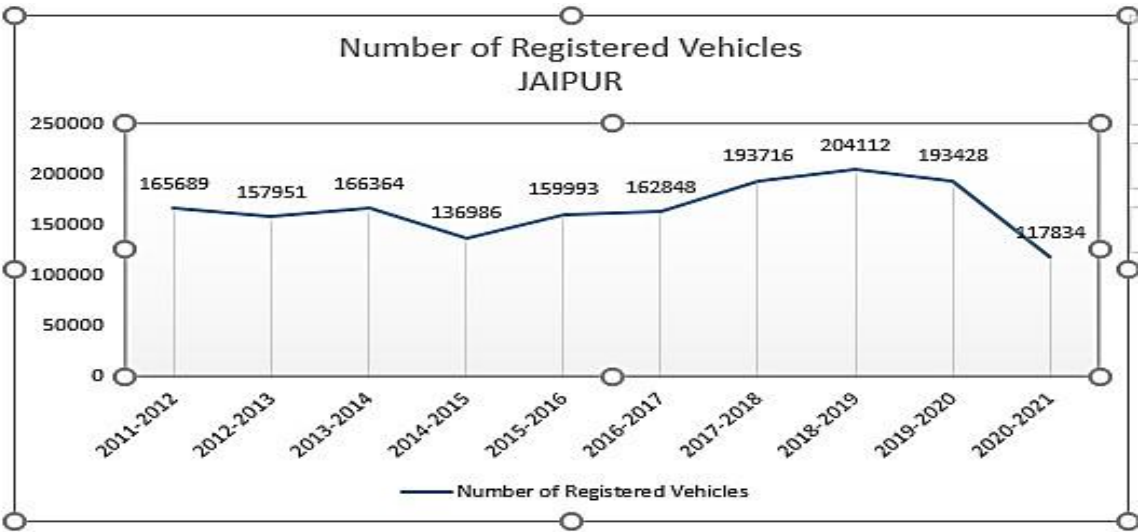
Industrial Growth

- According to the Ministry of Micro, Small and Medium Enterprises (MSME), there are more than 37,756 registered large, medium, and small-scale industrial units in Jaipur district, spread across 48 designated industrial areas.

- It is observed that the Metallics industries, Engineering industries are the major industries in the district. These industries are the major sources of various toxic air pollutants.

PROBLEM STATEMENT

1)The growing trend of pollution in the Jaipur from the above studies indicates that there is a need of extensive monitoring and

Share Of Industrial Sectors In Jaipur

Number of Registered Vehicles JAIPUR

165689, 157951, 166364, 136986, 159993, 162848, 193716, 204112, 193428, 117834

Number of Registered Vehicles

Food, 6% — cement, 2% — commercial units, 19% — Miscellaneous, 12% — Metal, 17% — Chemical, 3% — Leather, 2% — Stone work, 5% — Plastics, 4% — construction, 7% — Textiles, 3% — Engineering, 16%

locating the sites that are more vulnerable to be affected by emission.

2)The measures needed for the mitigation of emission needs to be area specific as at some areas vehicular pollution is prominent and industrial at others.

3) The study will also introduce that management measures that could help to reduce pollutant load from the atmosphere.

plains

OBJECTIVE OF STUDY

1) Perform the vulnerability analysis of different sites in Jaipur city using vulnerability scores for year 2021 and 2022

2) Analyze the impact of air pollutants (RSPM, SO2 NO2) emission at the various sites selected.

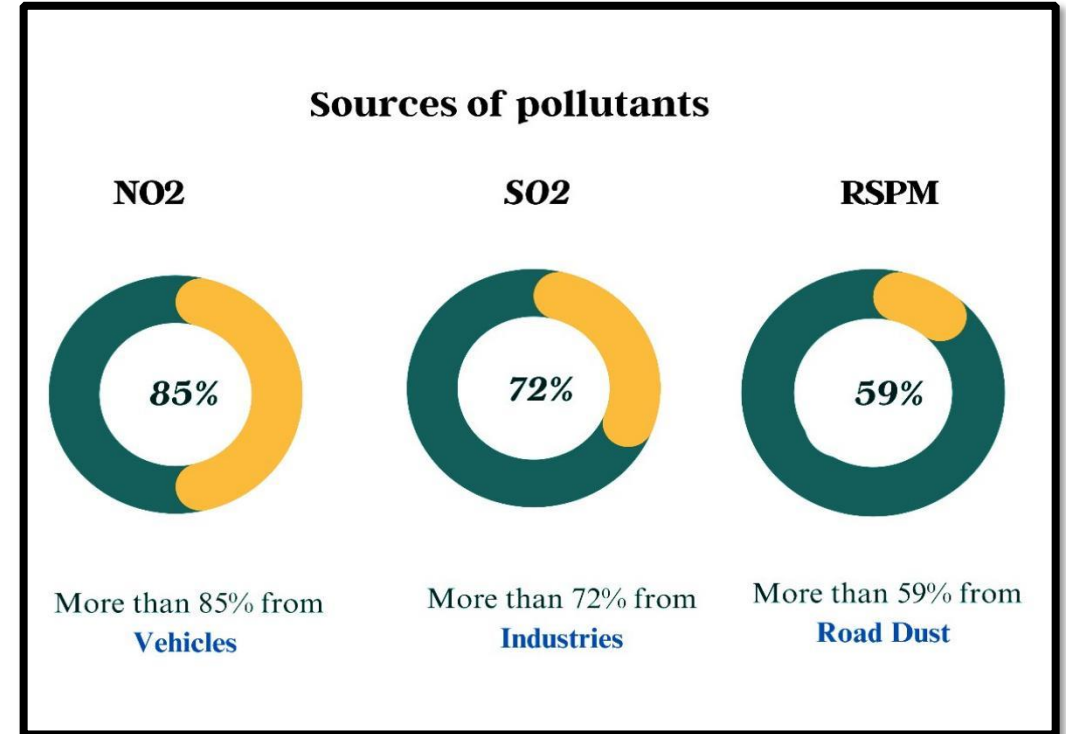3) Analyze the various factors affecting the level of pollution in the selected areas and depict the trend.

5)Create the map of the spatial distribution of each pollutant in the Jaipur city using ARC GIS

6)Suggest the management steps and remedial measures which are needed to be taken for the reduction in pollution levels based.

LITERATURE REVIEW

- **Mukesh Sharma(2020)** carried out an extensive study on the air quality of the Jaipur city. It was found in the study that more than 85% of nitrogen is released in Jaipur's atmosphere from vehicular emission. More than 72 % of Carbon Monoxide was released from vehicular emission Industries contributed more towards release of SO2

- **Suresh Jain and Mukesh Khare (2007)** carried out a case study of the Delhi city using vulnerability analysis. The vulnerability index for different cities was calculated. The vulnerability index indicates the stress on particular site selected due to the air pollution load

Sources of pollutants

NO2 — 85% — More than 85% from **Vehicles**
SO2 — 72% — More than 72% from **Industries**
RSPM — 59% — More than 59% from **Road Dust**

- **S. Norela, A. Maimon, B.S. Ismail and S. Al-Bateyneh (2010)**carried out a study on Concentration of Air Pollutants During Working and Non-Working Days in the Kuala Lumpur City Centre, Malaysia. Vulnerable analysis (VA) was carried out to evaluate the air pollution stress at the different locations. The toxicity weighing factors in this analysis as stipulated by the World Bank for the pollutants such as NO , SO and CO were 4.5, 1.4 and 0.004 respectively were taken

- **Sridevi Jena(2016)** carried out a study on impacts of vehicular emission on ambient air quality along the National Highway-32 at Dhanbad.In order to examine the stress levels on the

environment as Well on human beings due to atmospheric pollution,Vulnerability analysis was carried out.

- **Dr. K.L Sridaran , Shikha Gupta and Indraj Gujar (2017)**carried out the analysis of relation between transportation and Air Pollution in Jaipur city . The study showed that out of all the selected sites congestion at transport nagar was highest . Also the level of NOx was found to be the highest at this site. It was suggested that the use of public transport, use of cleaner fuels, promoting hybrid vehicles are some of the solutions to curb vehicular emission. The study also emphasized on use of non motorized vehicles

DESCRIPTION OF THE SITE SELECTED

Jaipur city lies on the geographical coordinate of 26.9124° N, 75.7873° E with 470 people per Km² average population density. The study will be conducted at several locations of Jaipur city to analyze the level of emissions
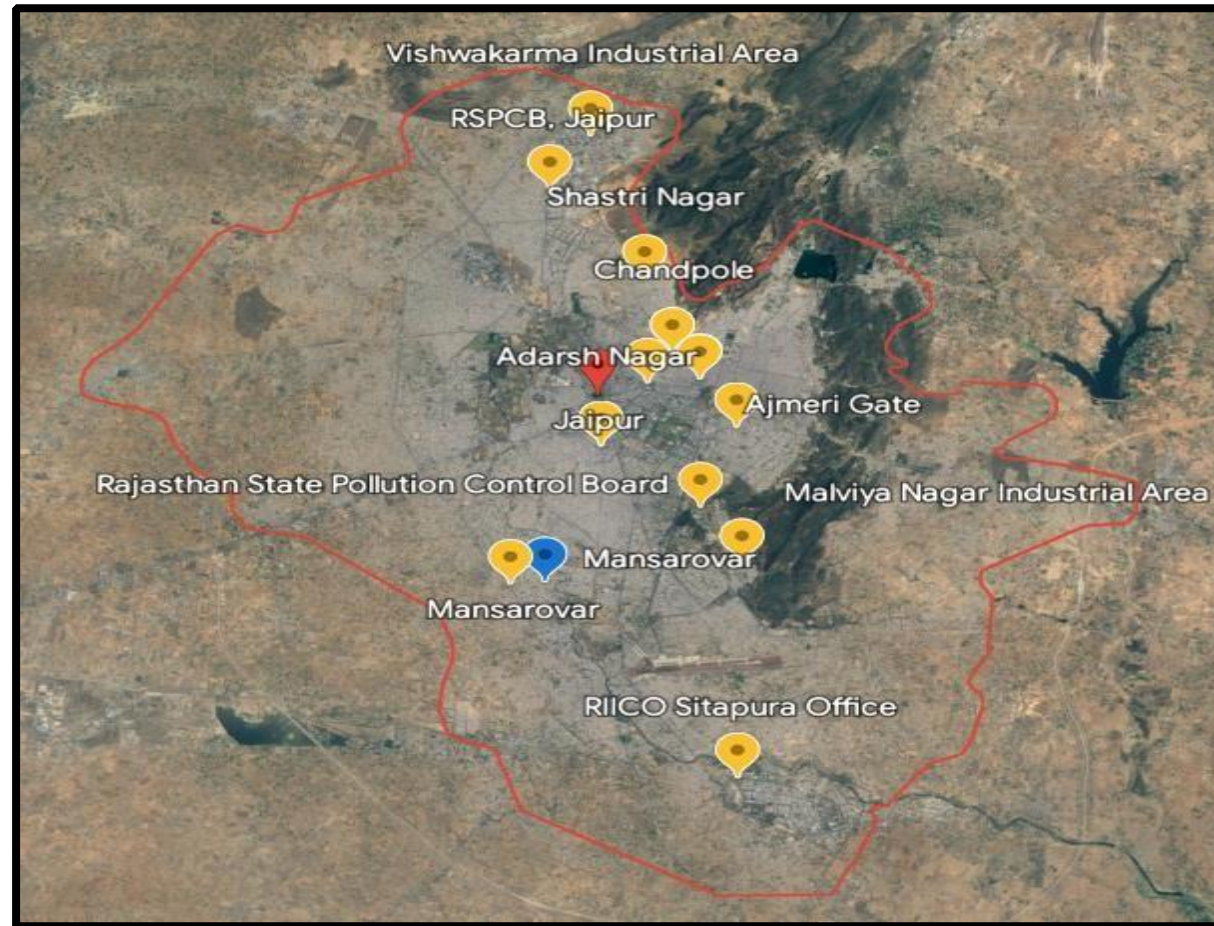
SITES	CODE	CO-ORDINATES	Remarks
• Police Commissionerate	PC	26°54'12"N 75°48'2"E	Residential Cum Commercial
• Adarsh Nagar	AN	26°54'07"N 75°49'37"E	Residential
• Mansarovar	MAN	26°53'20"N 75°49'03"E	Residential
• Sitapura	SIT	26°47'16"N 75°49'38"E	Industrial
• VKI Area	VKI	27°0'09"N 75°46'59"E	Industrial
• Sikar Road(RSPCB OFFICE)	SIKR	26°58'48"N 75°46'25"E	Industrial
• Malviya Nagar	MLN	26°52'36"N 75°50'49"E	Industrial

• Shastri Nagar	SN	26°57'34"N 75°47'53" E	Residential Cum Commercia
• Ajmeri Gate	AJG	26°54'21"N 75°49'07"E	Residential Cum Commercia
• Chandpole	CHP	26°54'49"N 75°50'26"E	Residential Cum Commercia
• Baees Godam	BAEG	26°54'2"N 75°48'14"E	Industrial
• Jhalana Doongri	JHD	26°52'50"N 75°49'29"E	Residential

METHODOLOGY

- The various parameters analyzed for the study are Sulphur Dioxide (SO_2), Oxides of Nitrogen as NO_2, Respirable Suspended Particulate Matter (RSPM/PM10). The data

is collected for the annual average value of various pollutants on the 12 sites for year 2021 and 2022.

- As per the guidelines of CPCB, annual average concentration is the Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval. The limits set by CPCB for these pollutants are as follows

> **Exceedance Factor (EF) -**

$$EF = \frac{\text{Observed annual mean concentration of criteria pollutant}}{\text{Annual standard for the respective pollutant and area class}}$$

Annual standard for the respective pollutant and area class The four air quality categories are:

Pollution	EF
Critical pollution (C):	> 1.5
High pollution (H):	1.0 - <1.5
Moderate pollution (M):	0.5 - <1.0
Low pollution (L):	< 0.5

Pollutant	Time Weighted Average	L (Ind Resi
RSPM (µg/m3)	Annual	60
Nitrogen Dioxide (NO2) µg/m3	Annual	40
Sulphur Dioxide (SO2), µg/m3	Annual	50
Carbon Monoxide (CO), mg/m3	Annual	60
Lead (Pb) µg/m3	Annual	0.50

> Vulnerability Score and Index analysis

$$VS_T = \sigma_{ni=1} X_i T_i$$

where, X_i is the concentration of *ith* air pollutant, T_i, the toxicity weighing factors for *ith* air pollutant, and n, the number of air pollutants. The toxicity weighing factors in this analysis as stipulated by the World Bank for the pollutants is given below
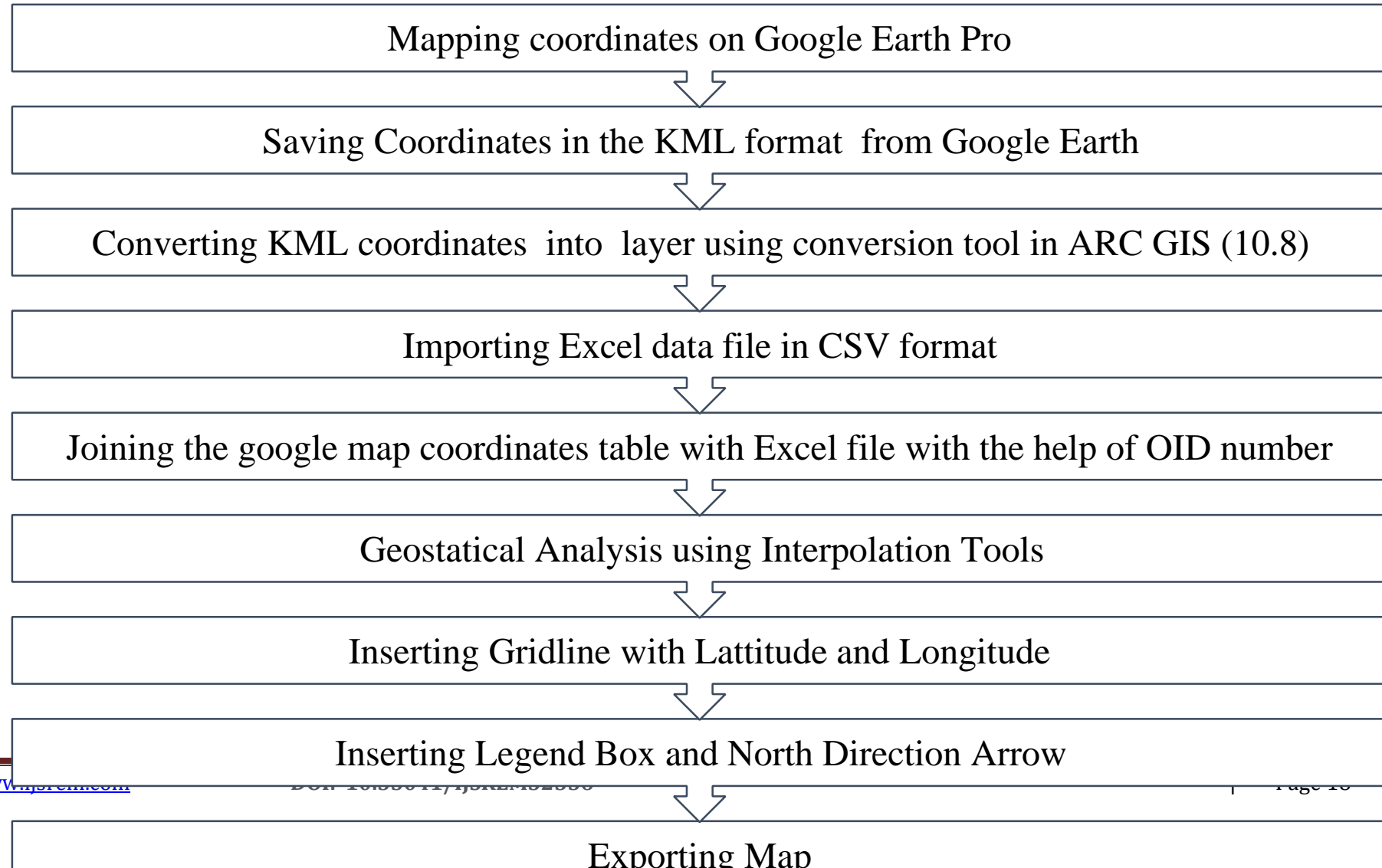
Pollutants	Relative Weight
Lead	85
NOx	4.5
RSPM	2.3
SO2	1.4
CO	0.04

Total Vulnerability Score (VST)	Vulnerability Index (VI)
>4420	Very High
4420–3315	Medium High
3315–2210	High
2210–1661	Medium High
1661–1113	Medium
1113–517	Low
<517	Very Low

Arc GIS \ (defines most) (Visual

➤ Arc GIS

Mapping coordinates on Google Earth Pro

Saving Coordinates in the KML format from Google Earth

Converting KML coordinates into layer using conversion tool in ARC GIS (10.8)

Importing Excel data file in CSV format

Joining the google map coordinates table with Excel file with the help of OID number

Geostatical Analysis using Interpolation Tools

Inserting Gridline with Lattitude and Longitude

Inserting Legend Box and North Direction Arrow

Exporting Map

YEAR	SITES	VS RSPM	VS NO2	VS SO2	VS CO	VS Pb	VST	VI
	Police Commissionerate	315.79	249.57	17.70	48	95.2	708.56	Low
	Adarsh Nagar	244.95	158.94	17.63	33.6	96.8	551.92	Low
	Mansarovar	285.20	97.69	8.47	34	95.2	520.56	Low
	Sitapura	271.4	105.48	9.07	32	96.8	514.75	Very Low
	VKI Area	374.9	121.275	11.07	35.6	110.5	653.34	Low
2021	Sikar Road	345	109.86	8.96	36	102	601.82	Low
	Malviya Nagar	234.6	98.50	8.57	30.4	85	457.07	Very Low
	Shastri Nagar	273.7	94.12	19.02	44	93.5	524.34	Low
	Ajmeri Gate	342.7	138.46	9.81	39.6	102	627.17	Low
	Chandpole	338.1	124.96	9.11	48.4	102	622.57	Low
	Baees Godam	328.9	103.90	8.68	34.8	94.35	570.63	Low
	Jhalana Doongri	246.1	82.98	7.56	21.6	51	409.54	Very Low
	Police Commissionerate	326.14	251.77	19.32	47.2	102	746.43	Low
	Adarsh Nagar	251.04	183.15	16.66	34	96.8	581.65	Low
	Mansarovar	372.6	108.04	7.88	36.8	110.5	635.83	Low
	Sitapura	384.1	120.73	8.4	44	110.5	667.73	Low
	VKI Area	512.9	122.49	9.29	47.2	127.5	819.41	Low
2022	Sikar Road	531.3	126.3	9.6	62.4	96.8	826.4	Low
	Malviya Nagar	269.1	100.03	8.17	34.8	93.5	505.6	Very Low
	Shastri Nagar	309.51	208.71	21.30	32	102	673.52	Very Low
	Ajmeri Gate	322	130.05	8.77	33.2	102	596.02	Low
	Chandpole	391	126.22	8.07	34.8	110.5	670.59	Low
	Baees Godam	388.7	121.59	7.67	34.8	102	654.79	Low
	Jhalana Doongri	246.1	105.93	7.56	30.4	93.5	482.56	Very Low

Relative vulnerability at sites

SITE / YEAR	PC	AN	MAN	SIT	VKI	SIKR	MLN	SN	AJG	CHP	BAEG	JHD
2021	708.56	551.92	520.56	514.75	653.34	601.82	457.07	524.34	627.17	622.57	570.63	409.54
2022	746.43	581.65	635.83	666.73	819.41	826.4	505.6	673.52	596.02	670.59	654.79	482.56

🟥	Most Vulnerable Site
⬜	Least Vulnerable Site

- The following table shows that highest vulnerability score of 708.56 is found at the site PC in year 2021 which makes it the most vulnerable site in the year. In the year 2022 most, vulnerable site is Sikar Road area.

- Jhalana (JHD) is found to be the least vulnerable site in year 2021 as well as in 2022 which makes it the least polluted site

Vulnerability Score Comparison

Vulnerability Score Comparison

- Vulnerability score at all the sites is more in the year 2022 in comparison to its previous year except at Ajmeri gate..
- Distinction between the pollution levels
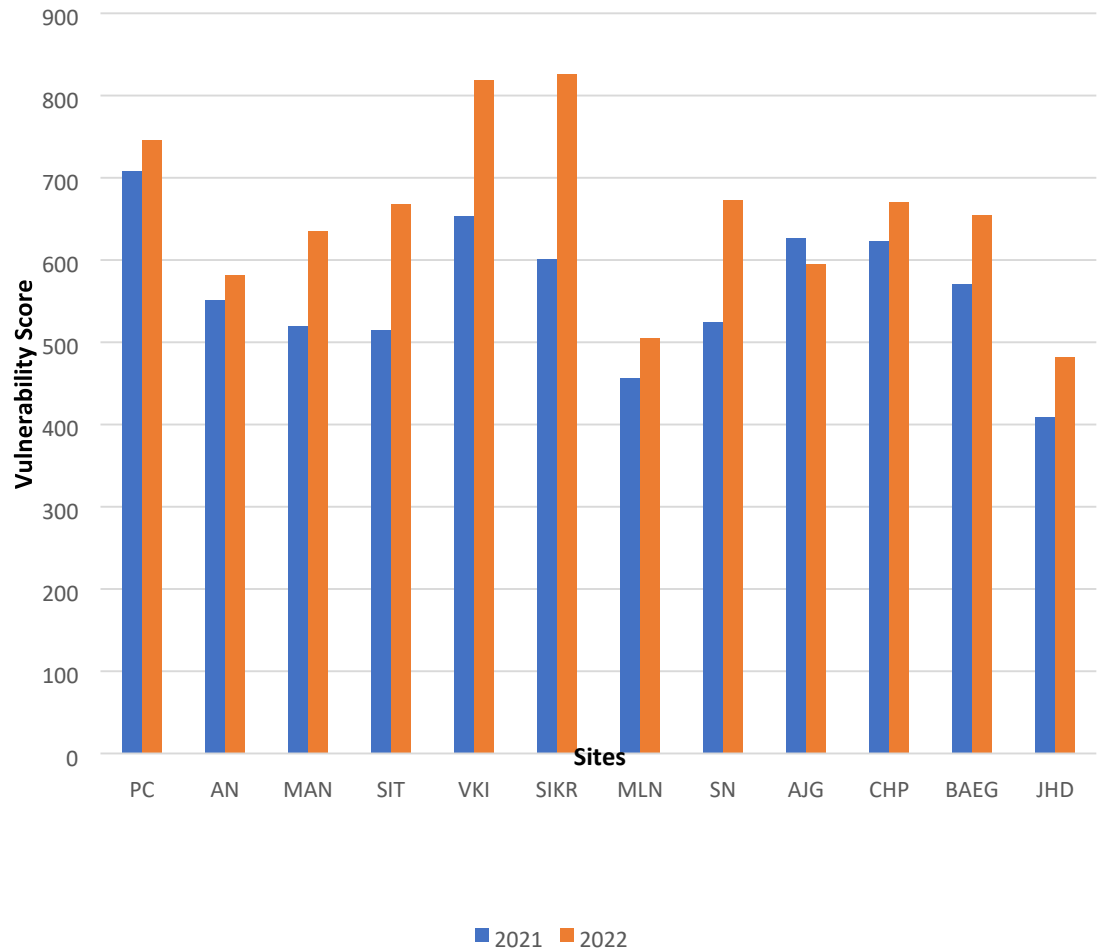
in residential areas, such as Mansarovar, and industrial areas compared to the industrial areas. Commercial areas like Malviya Nagar, Jhalana Doongri reflects least amount of pollution.

• Industrial areas like VKI and nearby areas have the maximum amount of pollution.

- Highest change in vulnerability score (37%) was recorded at the site Sikar Road (RSPCB Office). This finding suggests that the vulnerability level at the Sikar Road site has undergone a

% Change In VS from 2021 to 2022

substantial shift. The site is located near various clusters   of industries   and these industries

40.00release various pollutants in the environment.

Moreover, there is high traffic near the Sikar
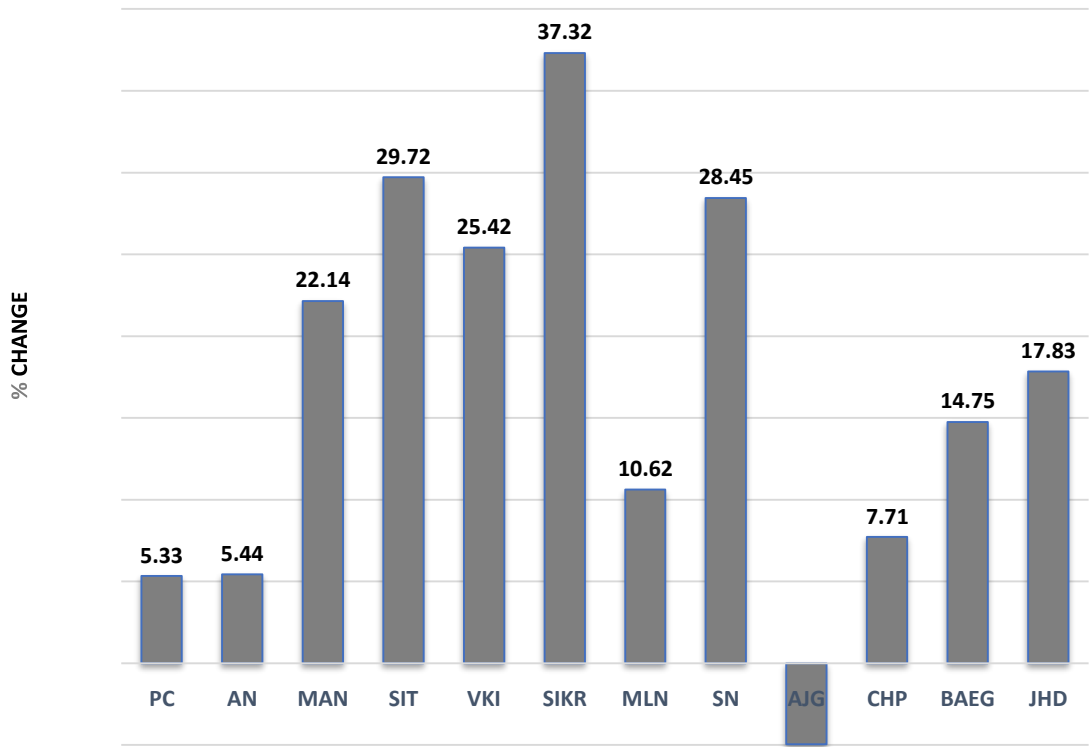
35.00 road area which is part of NH52.

30.00 • The Sitapura Industrial Area has experienced a 25.00 significant increase in its vulnerability score, with a notable jump of 29%. The area is situated 20.00 along National Highway (NH) 12 or the Tonk

Road. There are about 74 air polluting industries 15.00 operating in the Sitapura Industrial Area, out of 10.00 which 35 per cent fall in the miscellaneous

sector, mostly jewelry but also some automobile 5.00 units (CSE report).

0.00 • There is drop in VS at the Ajmeri Gate area (-

Chart values (% CHANGE):
- PC: 5.33
- AN: 5.44
- MAN: 22.14
- SIT: 29.72
- VKI: 25.42
- SIKR: 37.32
- MLN: 10.62
- SN: 28.45
- AJG: (negative)
- CHP: 7.71
- BAEG: 14.75
- JHD: 17.83

-5.004.97%) is a good indicator. Although the drop in

-4.97 vulnerability score suggests a

slight

■ % CHANGE

10.00enhancement in the resilience of the Ajmeri

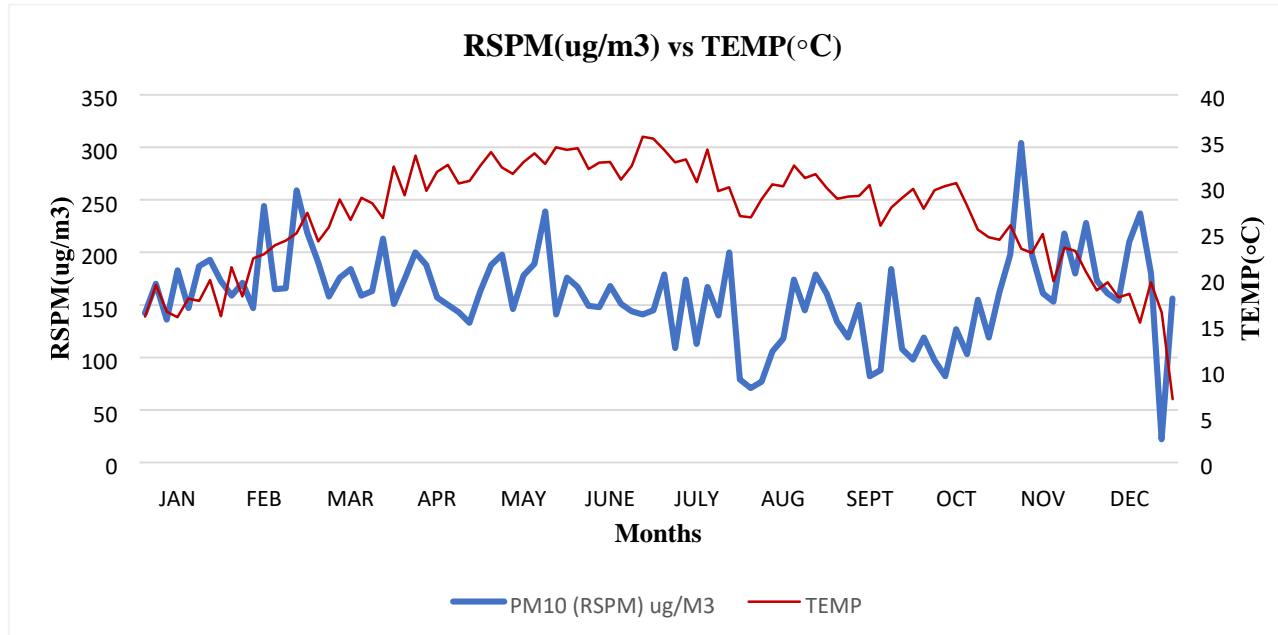Gate area, it may not be sufficient to yield tangible and noticeable positive outcomes
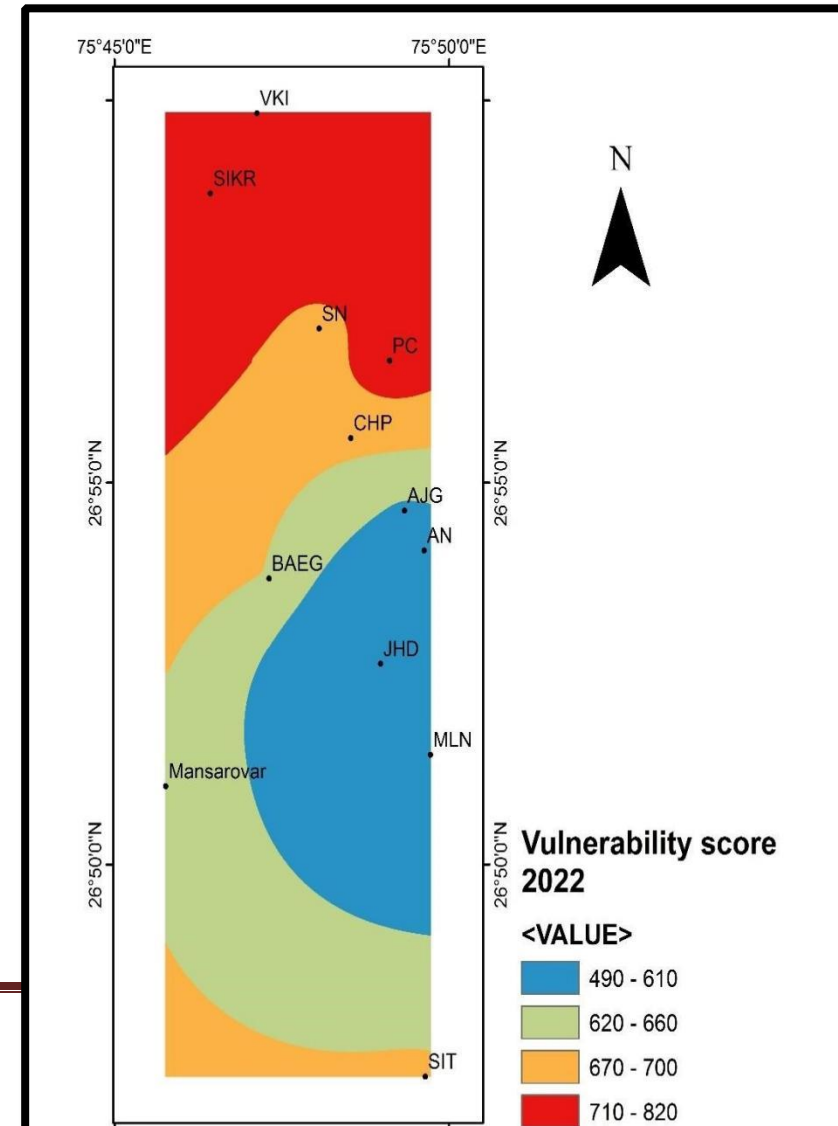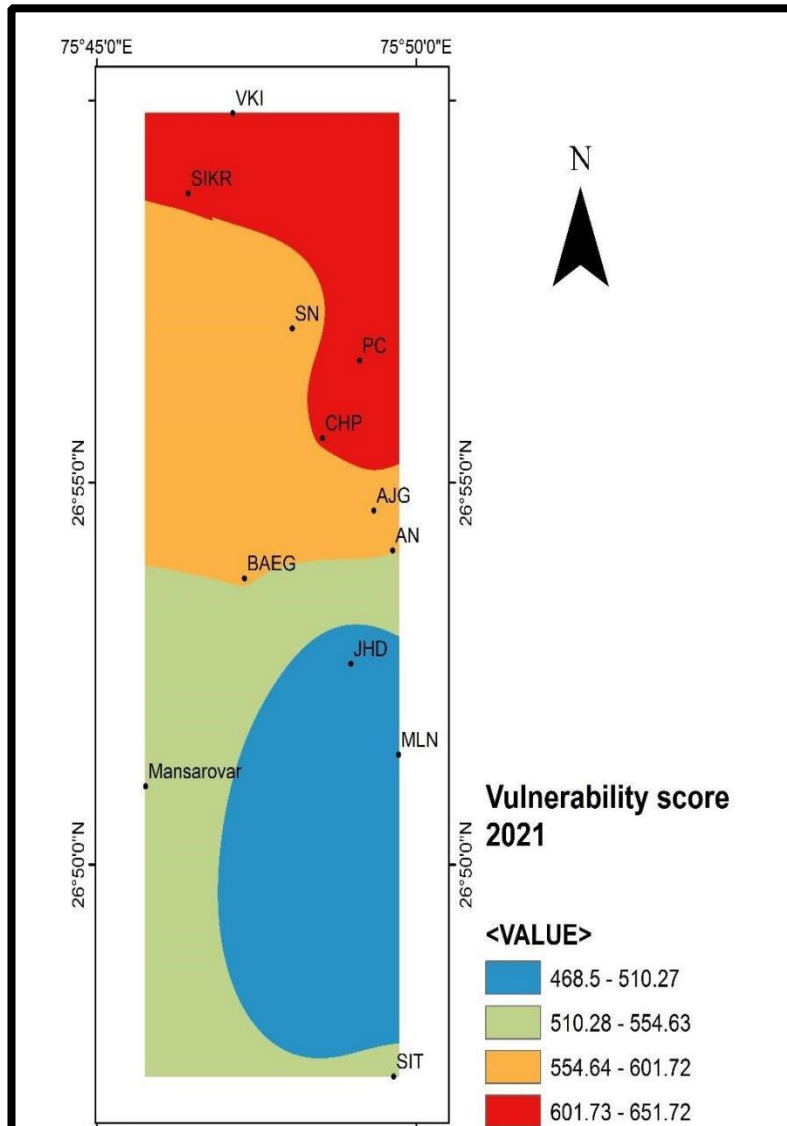
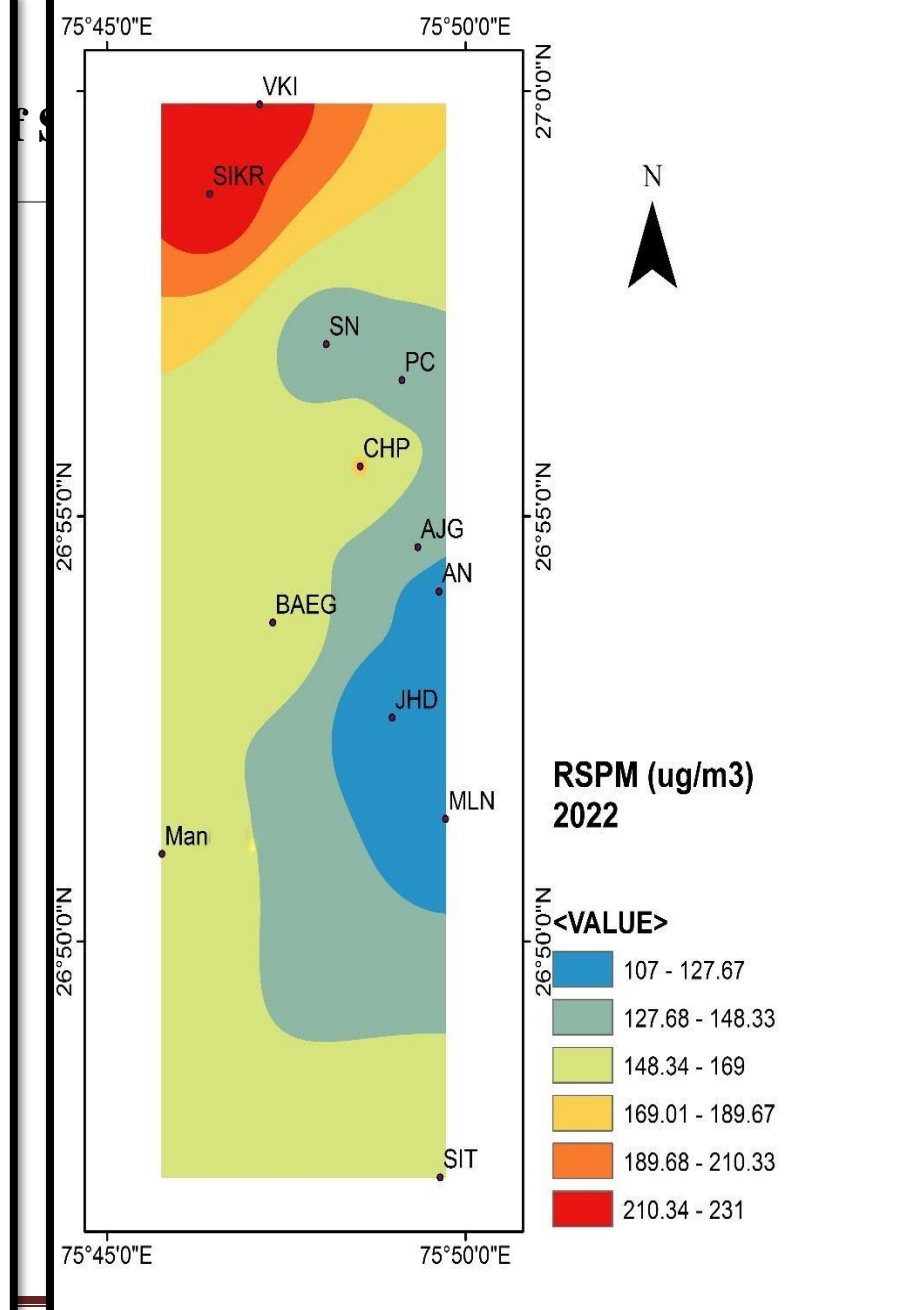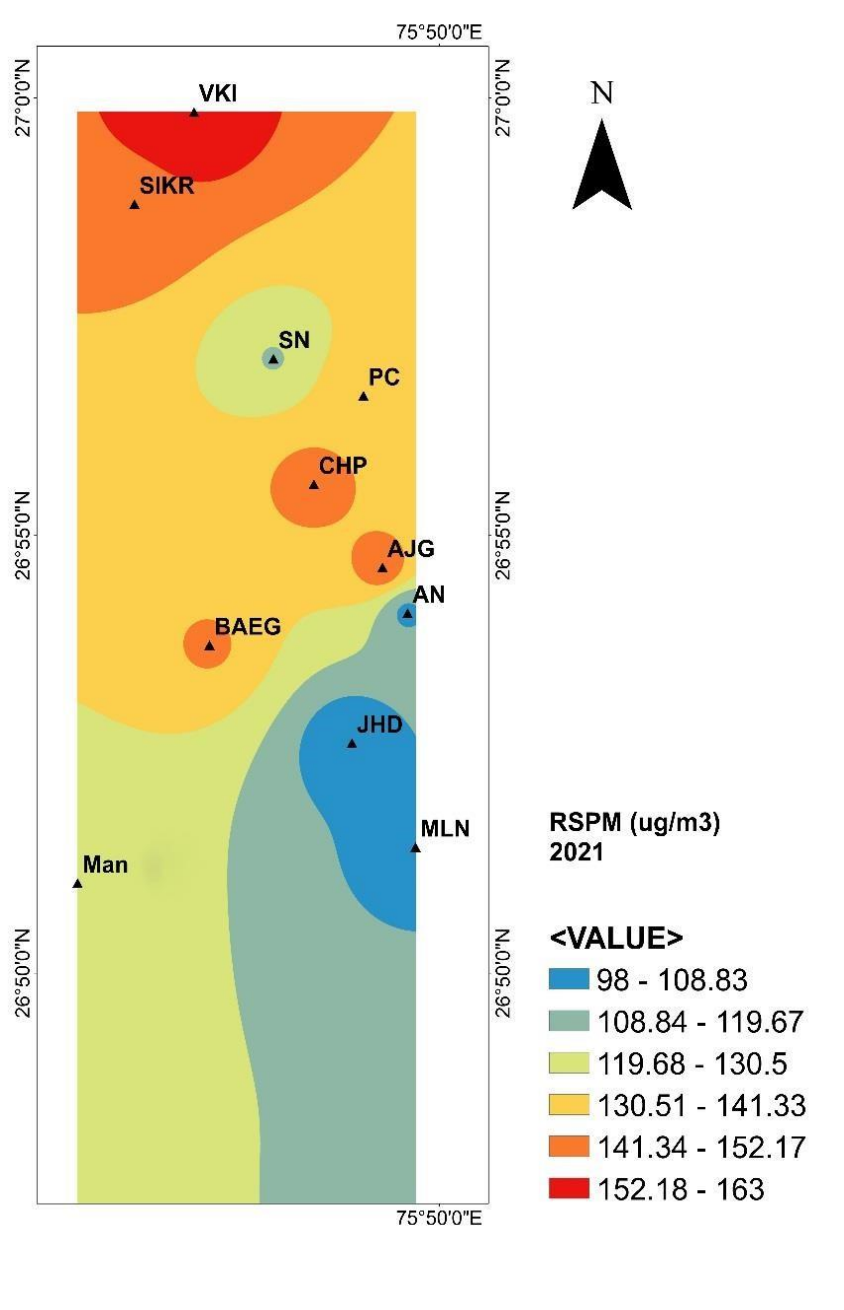# Variation of pollutants in 2021 and 2022

RSPM(2021) vs RSPM(2022)

SITES

Nitrogen Dioxide (NO2) ug/M3

PC	AN	AJG	CHP	VKI	SKR	STP	BSG	MALN	MAN	SN	JHD

0

●── 2021   ── Limit   ●── 2022

SO$_2$ (ug/m3)

It can be observed that high values of RSPM
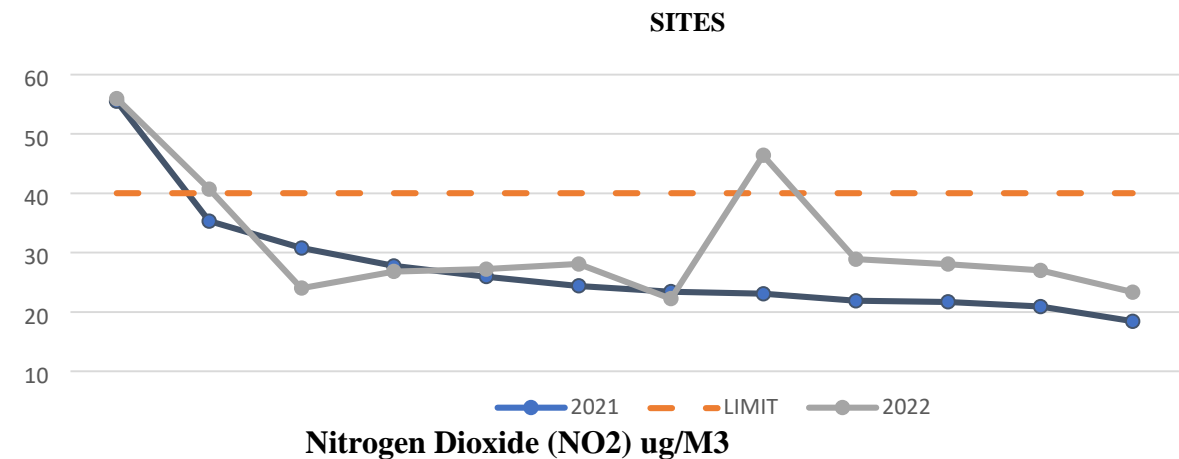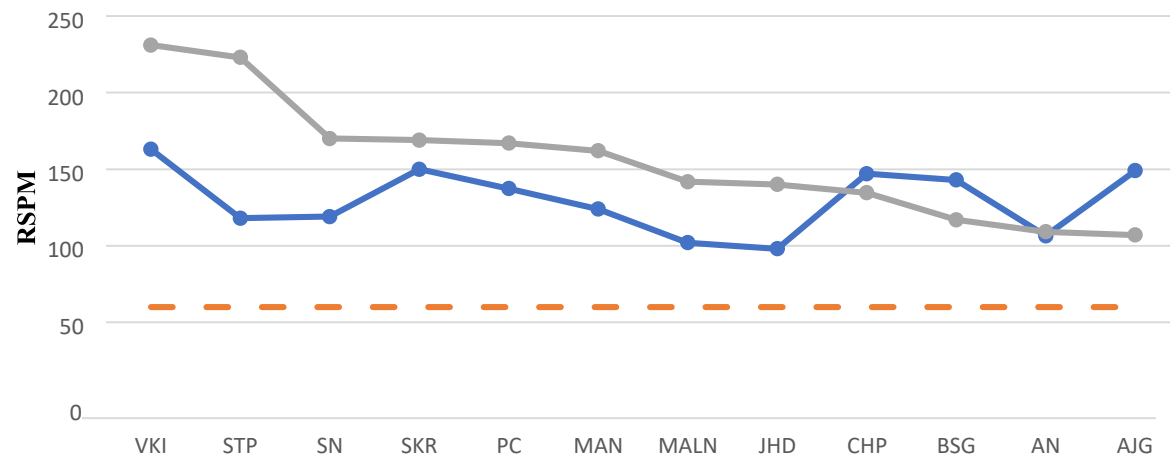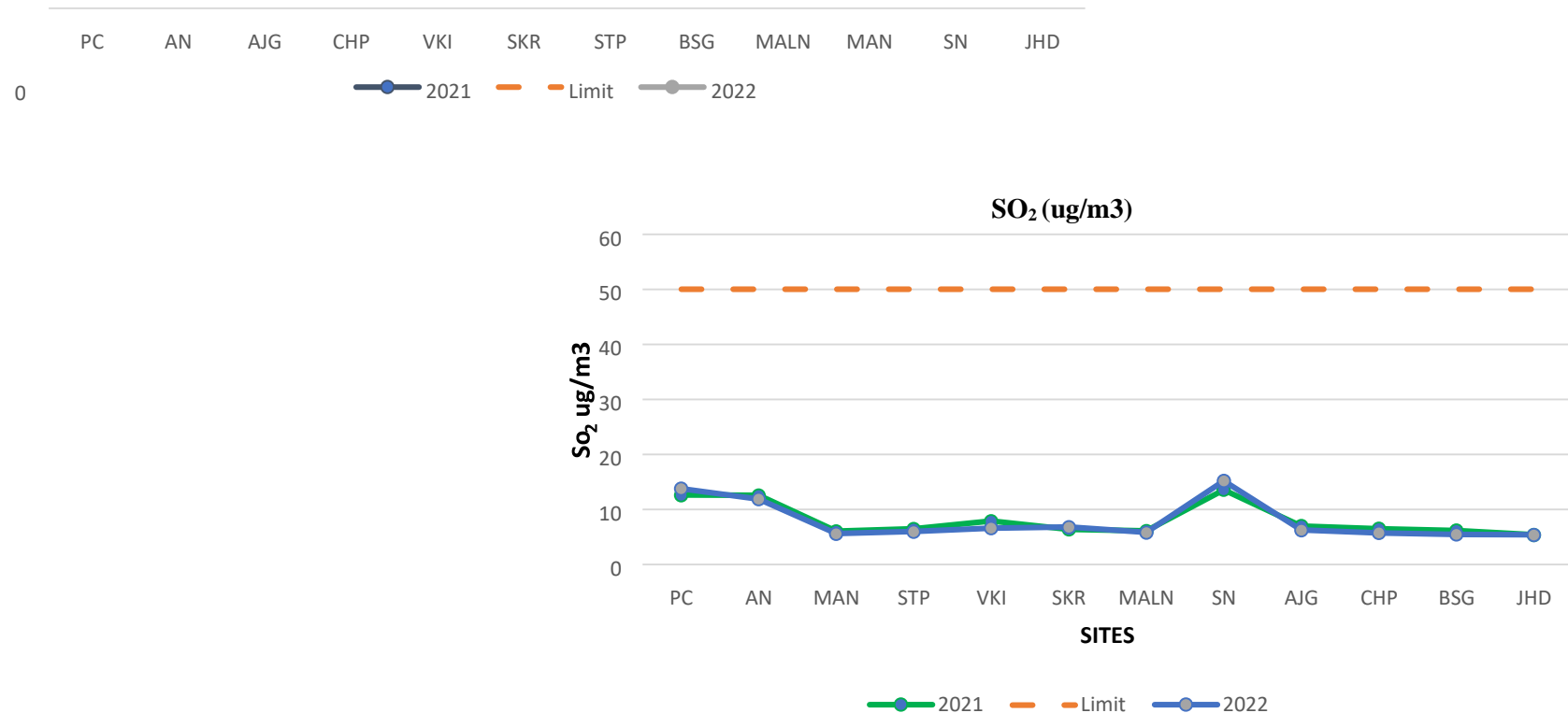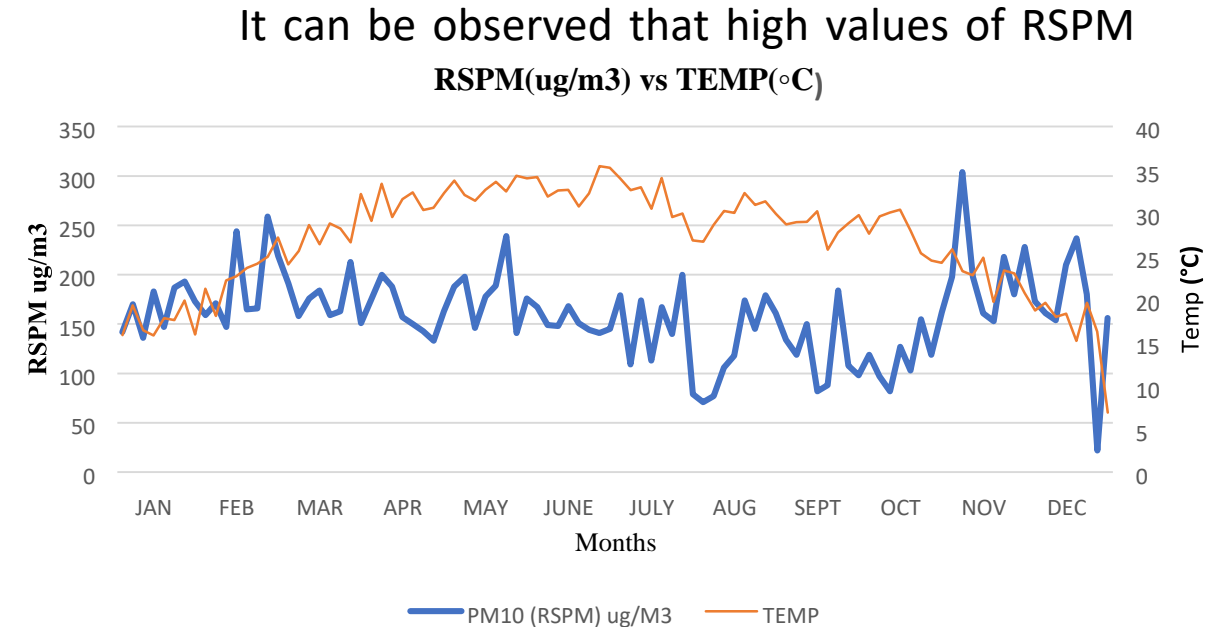
RSPM are seen in the winter season which is in the months of January October November.

During rainy season in the month of July-August there is considerable improvement in

the air quality of the site **(VKI).** Rain eases air pollution problem by forcing down the particulate matter and pollen down which clearly reflects the best air quality in the month of August of the given year 2021.

The following graph represents the variation of RSPM with Temperature **at RSPCB regional office Sikar road** throughout the year 2022. It can be observed that high values of RSPM are seen in the winter season which is in the months of January October and November in comparison to summer season. In the month of November and starting of December there is observed to be a drop in the values of RSPM. Month of July August during rainy season reflects the best quality

RSPM (ug/m3)
2021

<VALUE>
98 - 108.83
108.84 - 119.67
119.68 - 130.5
130.51 - 141.33
141.34 - 152.17
152.18 - 163

RSPM (ug/m3)
2022

<VALUE>
107 - 127.67
127.68 - 148.33
148.34 - 169
169.01 - 189.67
189.68 - 210.33
210.34 - 231

The VKI industrial area is prominently depicted in red, indicating a high level of RSPM impact in the region. Northern part of Jaipur city is more severely impacted by RSPM compared to the southern part. Jhalana and Malviya Nagar areas are have the least impact by RSPM. These areas are also surrounded by the Jhalana ForestArea,

Consistent with the previous year, the VKI industrial area remains a high contributor of RSPM in the city.Sikar road area long with VKI are marked in red color which denotes highest level of pollution. The pollution in Mansarovar, Baes godam, Chandpole lies in the same range. The jhalana doongri area along with Malviya Nagar remains the least impacted area in the entire city

NO2

- Maximum value of NO2 observed at Police Commissionerate at both 2021 and 2022

- high values of NO_2 are seen in the winter season which is in the months of January October and November in comparison to summer season. There is high fluctuation in the values on pollutant in the summer with decreasing trend till the month of September. During rainy season in the month of July-August there is considerable improvement in the NO_2


SO2

- The highest value of SO_2 (2021) and (2022) was observed in Shastri Nagar

- Monitoring stations are checked for observations at least twice per week therefore to draw the plot 8 sampling days are observed at uniform interval in a month i.e., is twice per week and plotted in a graph
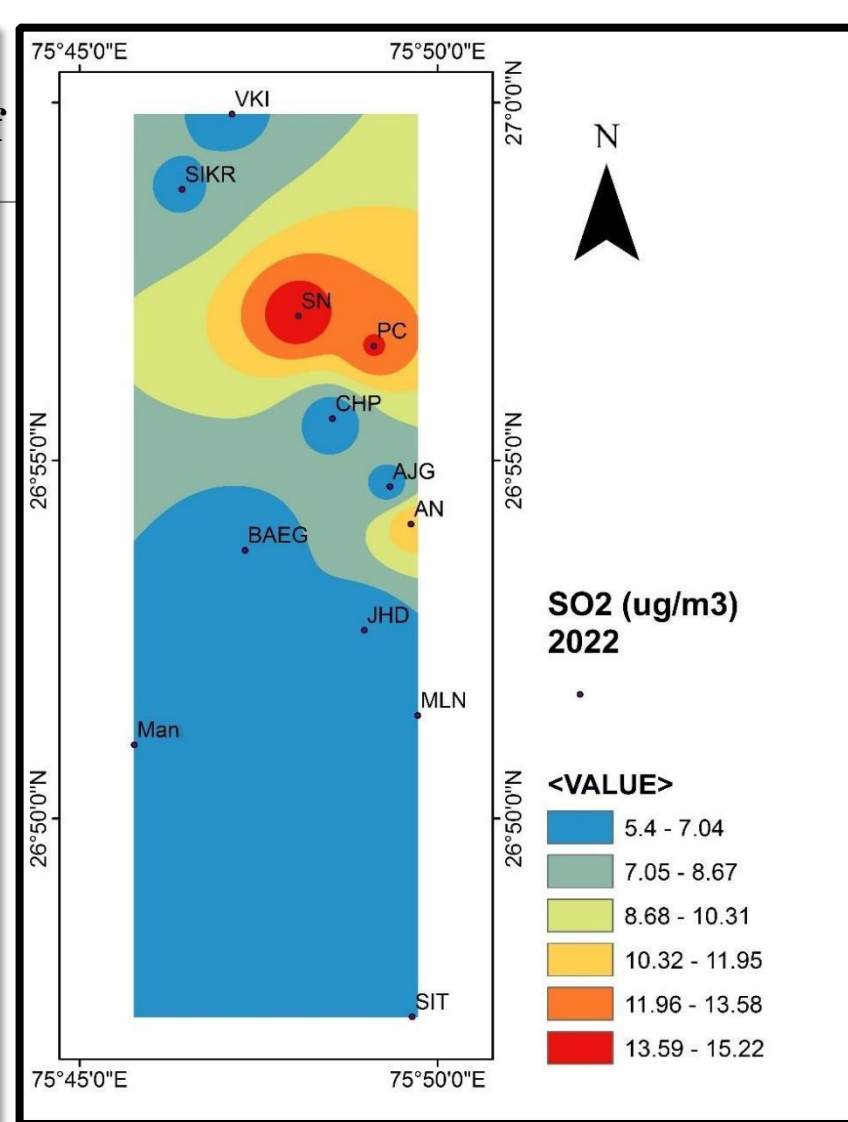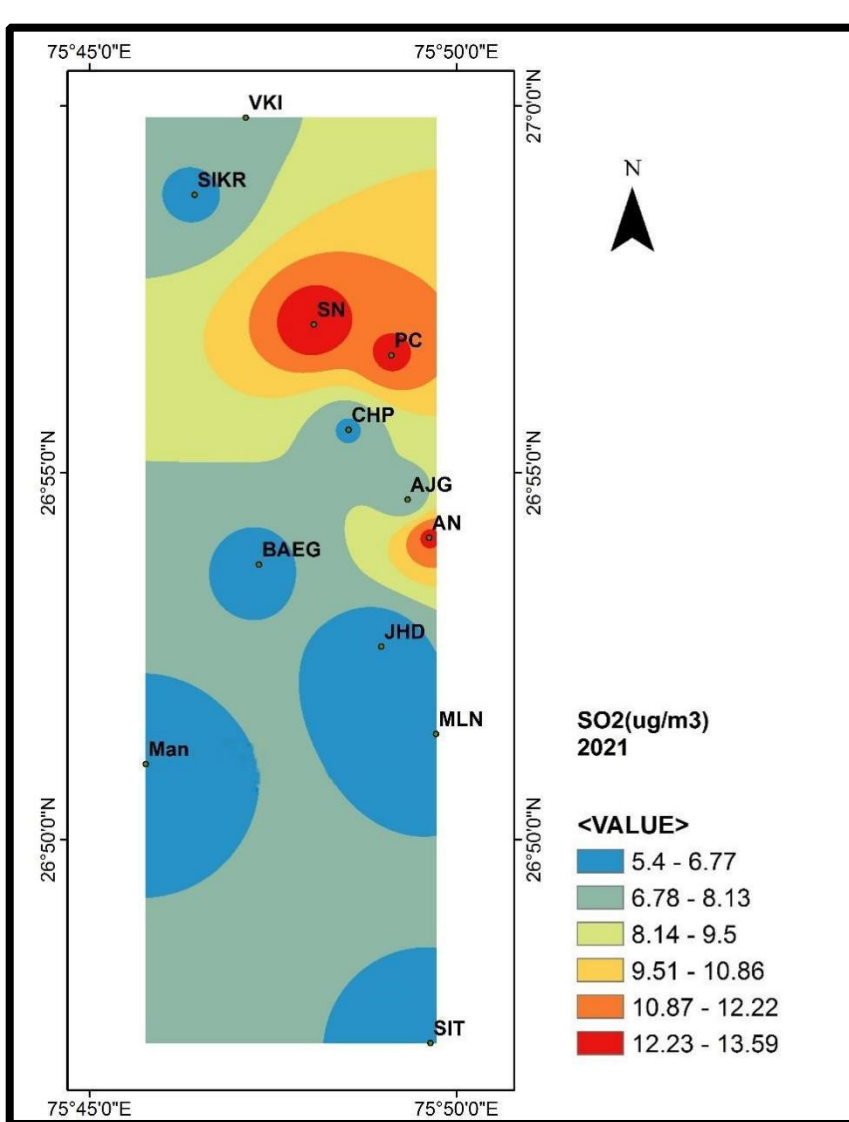
- During the colder months, there is a higher demand for heating, which results in increased combustion of fossil fuels and the release of SO2 emissions. Winter meteorological conditions, such as stable atmospheres and reduced wind speeds, impede the dispersion of pollutants.

- During the summer season, as the demand for heating decreases, there is a corresponding reduction in SO2 emissions from residential heating sources.. Summer meteorological conditions, characterized by higher wind speeds and increased atmospheric mixing, facilitate the dispersion and dilution of pollutants, including SO2.

- There is drop in concentration in rainy season in the month of July August. Rainfall has a purifying effect on the atmosphere, effectively removing and reducing the concentration of sulfur dioxide (SO2).
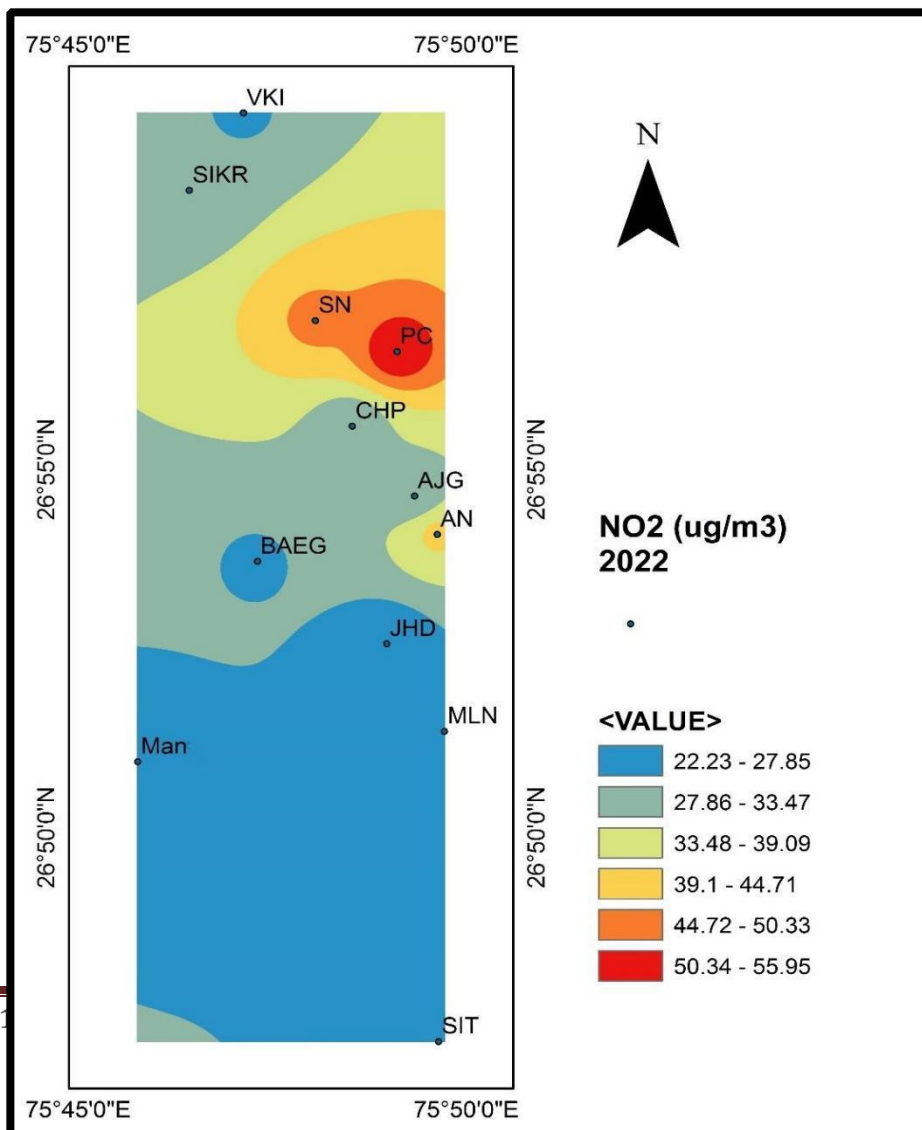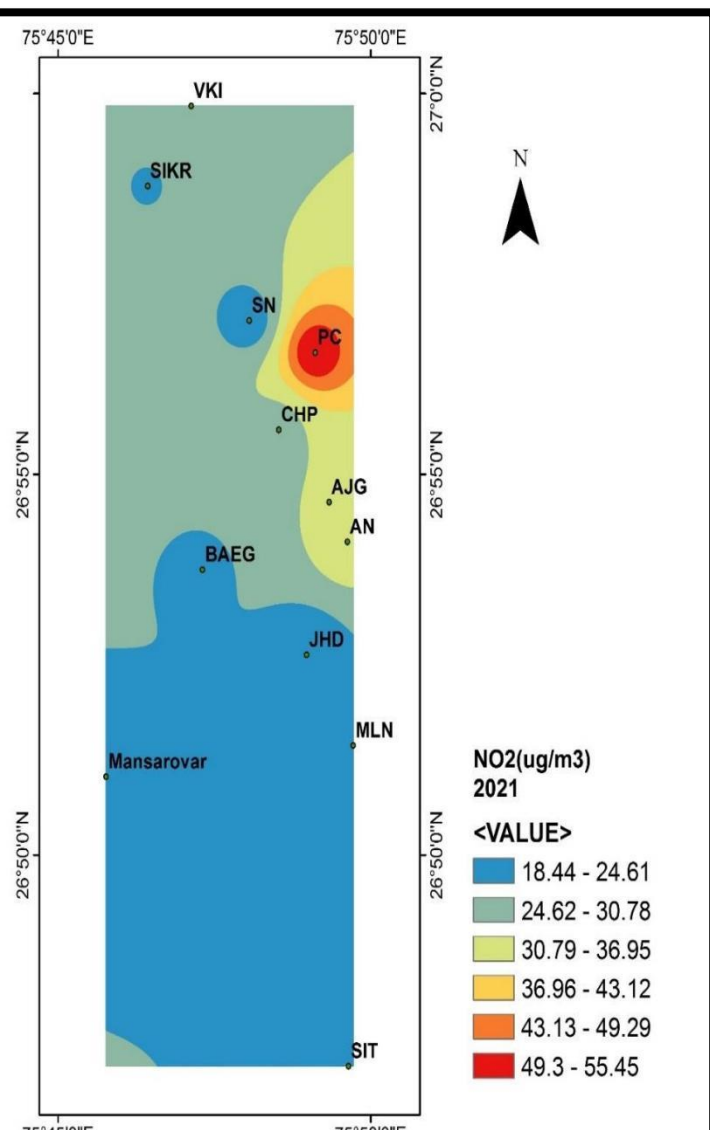
2021 The region with blue color signifies locations with the lowest levels of NO_2 pollution which are namely Mansarovar, Malviya Nagar, Jhalana Doongri, Baes Godam and Sikar Road area. The NO_2 concentration is evidently high in the police Commissionerate area. Adarsh Nagar and Ajmeri Gate area marked with light green color are also contributing significantly in the pollution.

2022 Police Commissionerate area shows similar trend as the last year by falling in the category of highest pollution marked as red. It can be observed that pollution impact in Shastri Nagar area is also marked as red. Jhalana Doongri, Malviya Nagar and Mansarovar indicated by blue still

SO2(ug/m3) 2021

<VALUE>
- 5.4 - 6.77
- 6.78 - 8.13
- 8.14 - 9.5
- 9.51 - 10.86
- 10.87 - 12.22
- 12.23 - 13.59

SO2 (ug/m3) 2022

<VALUE>
- 5.4 - 7.04
- 7.05 - 8.67
- 8.68 - 10.31
- 10.32 - 11.95
- 11.96 - 13.58
- 13.59 - 15.22

2021 Areas marked with red color, namely Shastri Nagar, Police Commissionerate, and Adarsh Nagar, are identified as having the highest concentration of SO2. Several blue spots on the map indicating Mansarovar, Malviya Nagar, Jhalana Doongri, Baees Godam and Sikar road are the areas of least concentration

2022. In the map, Shastri Nagar and the Police Commissionerate area are marked with red color, indicating the highest concentration of SO2 pollutant in these locations. Furthermore, the identification of areas with lower SO2 concentrations, such as Mansarovar, Malviya Nagar, Jhalana Doongri, Baees Godam, and Sikar road, emphasizes their relatively better air quality marked in Blue color.
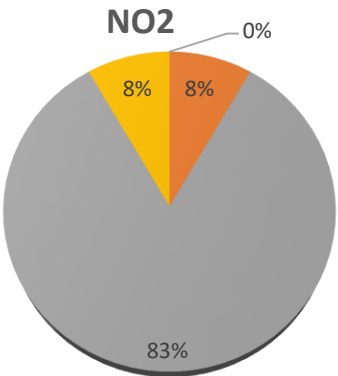
PERCENTAGE OF SITES WHICH ARE CRITICAL , HIGHLY , MODEATELY OR LEAST POLLUTED
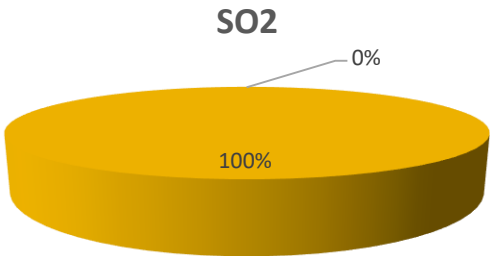
2021
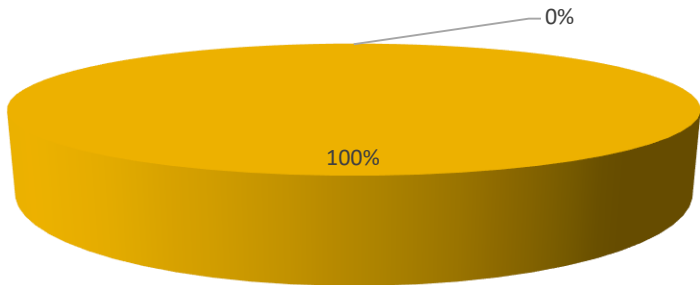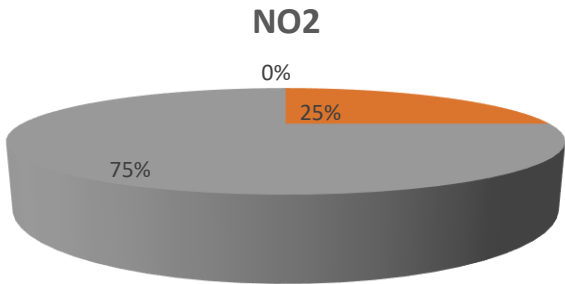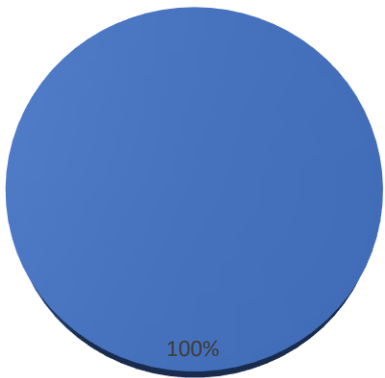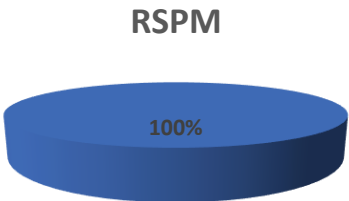
NO2

2022

RSPM

SO2

Conclusion

- The vulnerability index of the city lies in the range of "Low" to Very Low" and trends in change in Vulnerability score indicates the progression of Index towards medium. It has been found that most vulnerable area is the year 2021 is police Commissionerate Jaipur which is located near high density traffic area shaheed Smarak traffic intersection. In the following year 2022 the score indicates that most vulnerable area is Sikar road area (RSPCB office) which is located near various clusters of industries and NH52.

- Least Vulnerable area in the year 2021 is Jhalana Doongri followed by the Malviya Nagar Industrial Area in the year 2022. Both these areas are located near well maintained forest cover of Jhalana forest area. Even though there are various commercial units in MNI area most of them are well maintained. It should also be noted that most of the commercial units are hotels and hospitals.

- Green Area of Jhalana needs to be preserved to maintain the low pollution levels

- Spatial distribution of Vulnerability Score indicates the Northern Part of Jaipur is relatively more vulnerable

- RSPM and NO_2 are the main pollutants which are matter of concern.

- RSPM concentration at all the sites for 2021 and 2022 were much above standard limits. An increasing trend was observed in the concentration at most of the sites. Spatial analysis indicates that the Maximum concentration of RSPM is seen at Northern part of the city mainly at VKI area and Sikar road.

- NO_2 concentration showed an increasing trend with increase from 8.33% sites at high pollution (EF) to 25% Sites at high. It is found that Police Commissionerate and Shastri Nagar are the most impacted area.

- SO_2 Concentration are found to be in the safe range with highest concentration at Shastri Nagar. SO_2 is a highly toxic pollutant

- The study emphasizes on the need to take necessary steps to curb increasing rate of pollution in the Jaipur city.

Management Steps

CONSTUCTION ACTIVITIES

✓ Water Suppression

✓ Wind speed reduction (for large construction site)

✓ Upgradation of Machinery

ROAD DUST

✓ Regular sweeping of the road with vaccum

✓ Needs to be adopted at areas with high RSPM concentration

✓ Increasing the plantation in the nearby areas

✓ Maintainance and upgradation of the roads on a regular basis

✓ Moistioning the road

   Deliquescent salts can be used which are directly applied on the roads like calcium chloride or magnesium chloride absorb water from the atmosphere ✓   Wind Breakers

INDUSTRIES

✓ Flue-gas desulfurization (FGD) :

✓ PNG (Piped Natural Gas) : VKI industrial area is seen to be the one contributing maximum to the pollution . Most of the industries are still dependent on conventional methods for power generation in VKI area.

✓ Fumes exhaust systems :. Its purpose is to effectively capture and contain these emissions, ensuring the safety of the environment and individuals involved.

Green wall trapping the pollution
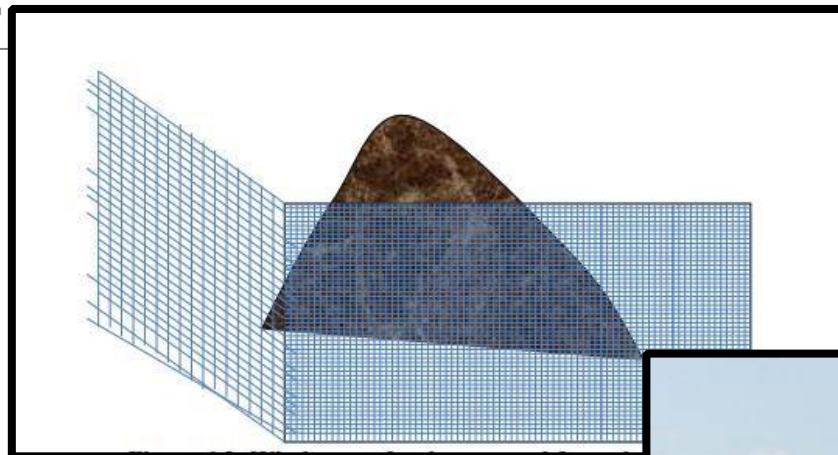
VEHICLES

✓ Diesel particulate filter (DPF)

✓ Scrapping out of old vehicles

✓ Alternative cleaner fuels and Improving public transport

✓ Fast implementtion the upcoming stage of Bharat Standards

✓ Removal of free parking zones : The commercial areas like Malviya Nagar , Old city Chandpole and others should have paid parking system .

✓ Roadside Filters

✓ Vegetation barriers

✓ Active air filtration systems like HEPA

- ✓ Photocatalytic filters : Photocatalytic filters utilize materials like titanium dioxide (TiO2) to react with pollutants when exposed to light, breaking them down into harmless compounds. Applied to building facades or other roadside structures, these filters offer self-cleaning capabilities when exposed to sunlight.

- ✓ Green walls : green walls, also known as living walls or vertical gardens, which provide vertical air purification similar to vegetation barriers while enhancing aesthetics and offering insulation and noise reduction benefit

- ✓ Vehicle Speed : Emission increases with increase in speed

SITE	MAJOR POLLUTANT	SUGGESTIONS
Police Commissionerate	RSPM, NO_2	Traffic control mechanism needed to control heavy traffic flow near shaheed Smarak intersection which will control NO2 emissions
		Roadside filters can be installed to regulate RSPM pollution
		Vehicle speed regulations near intersection , idling banned
Adarsh Nagar	RSPM, NO_2	Intelligent traffic control systems near Adarsh nagar circle
		Elimination of free parking near commercial places
Mansarovar	RSPM	Improvement in quality of roads as poor road quality contribute to RSPM
		Large scale constructions are frequent in the area so there is need to control emissions from the sites Construction wastes should be handled carefully and methods like Wet suppression can be used
		Decongestion of roads is needed as the area still has inactive traffic lights which leads to disturbances

Sitapura	RSPM	Environment friendly fuels need to be adopted in textile industries and other major industries
		Regulation of industries and proper monitoring
VKI Area	RSPM	Flue-gas desulfurization to regulate industrial SO2 Emission
		Industrial Emission control technologies like Fumes exhaust systems
		LPG and liquid fuuel should be replaced by PNG (Piped Natural Gas)
		Regulation of industies and proper monitoring
		There is a significant movement of large trucks that transport raw materials and finished products.
Sikar Road	RSPM, NO$_2$	Moistening the road using Deliquescent salts to control dust particles
		Wind breaks can be installed along the road
		Site is situated near VKI so the industries nearby needs effective management

SITE	MAJOR POLLUTANT	SUGGESTIONS
Malviya Nagar	RSPM	Introduction of paid parking system
		Industries in Malviya nagar industrial area should be encouraged to use cleaner fuels
		Preserving the green area
Shastri Nagar	RSPM	Located several kilometers away from sewapura landfill where solid waste burning contributes to pollution therefore proper solid waste management strategies are needed
		Improvement of public transport a decrease the vehicular load in area
Ajmeri Gate	RSPM	Roadside filters
		Increasing green cover area

Chandpole	RSPM	Roads in the area are congested which leads to congestion and pollution therefore separate parking space should be provided
		Public transportation should be encouraged
Baees Godam	RSPM	Management and monitoring of industrial emissions
		Increasing the plantation in the nearby areas
		Traffic management near 22 Godam Circle
Jhalana Doongri	RSPM	Green Area of Jhalana needs to be preserved
		Restricting movement of heavy vehicles as they contribute more to pollution