Study of Environmental Profile Around Industries in the Lind-Bohanon Neighborhood Area

Conducted on behalf of
Lind Bohanon Neighborhood Association

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Introduction

It has generally been seen that businesses prefer setting up their production facilities near big cities. This gives them proximity to the consumer market, labor, low cost raw material and various other benefits. There has been a large increase in industrial development around the Twin Cities Metropolitan Area in Minnesota in the past few years. Emissions from these industries are a concern to neighboring residents in many locations as emissions contain hazardous compounds that may cause potential health risks. Most people, regardless of where they reside, desire a living environment free of pollution.

As industrial development encroach on traditional residential regions, the potential for conflicts between industry owners and their neighbors increases. This leads to increased complaints and calls for government regulation. County offices and other local units of government are being asked to make land use decisions to reduce the impact of pollution from industrial operations, but with little or no scientific information and few tools on which to base their decisions. (Nangia, 2000)

The Minnesota Pollution Control Agency (MPCA) monitors air quality from its many stations across the state. Many times the data gathered by these stations does not represent air quality for the entire state/region. There are pockets where air quality is very poor because of the stations proximity to industrial plants.

Geographic Information Systems (GIS) are powerful tools commonly used for presenting spatial data, including setback distances. Setback is distance that one needs to travel away from the source to diminish its effect. GIS software can be used to capture, store, and check, integrate, manipulate, analyze and display data related to positions on the Earth's surface. Setback distances represented in tables are difficult to understand. Maps with setbacks drawn on them using GIS can more easily convey such information. (Nangia et. al., 2001)

In the past researchers at the University of Minnesota have tried to map the emissions for Toxic Release Inventory (TRI) and study the demography of populations at risk. McMaster et al (1998) have used the ALOHA dispersion model and Monte Carlo techniques to study the TRI and its impact. ALOHA is a dispersion model that predicts the spill of hazardous chemicals in case of an accident. Nangia (2000) has used INPUFF-2.0, another EPA dispersion model, to study odor dispersion from livestock facilities in Carver county, MN. The results give a broad picture and are a reliable source of information at large-scales. Wind-frequency, direction, and velocity for a location are used to determine the approximate frequency with which odors could occur in a worst case scenario (prevailing wind direction).

Researchers at the EPA have developed a model named Industrial Source Complex 3.0 (ISC-3.0) for determining short (durations as small as hourly) and long-term (seasonal or annual) pollutant concentrations in rural and urban settings using average emission rates from point and area sources and a joint frequency distribution of wind direction, wind speed, and stability. The short duration variant of the model is called ISC-ST, ST standing for short term. And the long duration simulation model is called the ISC-LT. The advantage of using ISC-3.0 rather than another dispersion model is that based on annual emissions it can model the air quality, for a smaller area. It gives better estimates of pollutants than measured by an EPA monitor located distant away.

The Lind-Bohanon Neighborhood Area (LBNA) is located north of Minneapolis, MN along I-94. (Figure 1). According to 1990 census data, it has a total population of 4,500. (http://freenet.msp.mn.us/nhoods/censusdata/mpls/LINDBOHN.html) The LBNA has seen an explosion of industrial development and is home to many production and utility companies. It is an area with few resources and a small population. Many LBNA residents now commute to jobs in Minneapolis or its suburbs. The closest weather monitoring station is at the Minneapolis-St. Paul (MSP) International Airport.

The Lind Bohanon Neighborhood Association wanted to investigate the environmental emissions imposed on the Lind Bohanon neighborhood from the Camden and Humboldt Industrial areas. The research will help residents to make decisions about the health and actions of residents in regards to environment management. (http://www.npcr.org/whatsnew.html)

The purpose of this part of the project was to demonstrate the use of GIS to map ISC-3.0 results for the Lind Bohanon Neighborhood Area. Maps were produced and overlaid with different setback distances. The maps produced will be easy to understand by diverse audiences. Interviews with residents will help validate the results of the model.

Intended Audience

The goal of this project was to map the emissions from the industrial plants and identify the populations at risk. It should help determine if the schools and other recreational facilities are at a safe distance. Unlike many other studies, demography of populations at risk is not within scope in this project. This is due to the small population sample (4,500 people). The maps will also aid the community in determining safe areas for recreational purposes and future development. These maps can be used in public meetings and community gatherings to generate awareness.

It has been seen that people prefer to look at graphics to spreadsheets. (Nangia et al, 2001) Maps serve as an effective means of communication to the masses. Once drawn, these maps can be put on the web using Map Server software. This will give the public free access to the results of the study.

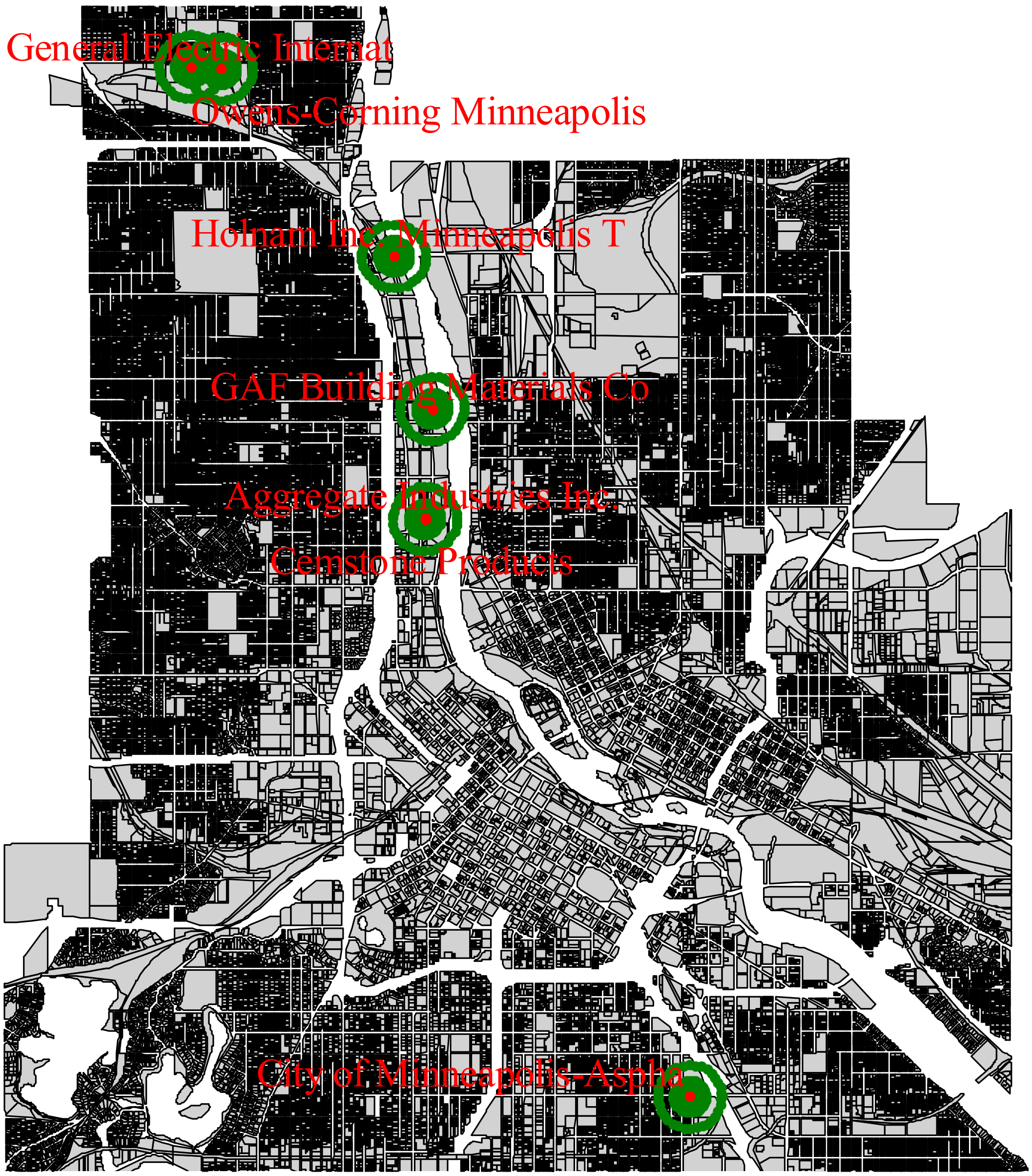

Figure 1: Map of the Twin Cities Metropolitan Area and industrial facilities in LBNA vicinity considered for the study.

Materials and Methods

Industrial Source Complex-3.0 (ISC-3.0) was used for estimating setback distances from industrial plants for different levels of emissions. The algorithm used by ISC-3.0 is based on Gaussian plume assumptions and is thus subject to the limitations of non-reactive pollutants and a homogeneous wind field. Terrain in the modeling region is assumed to be level or gently rolling. Computations can be made for up to 200 point sources and 2500 area sources and an unlimited number of receptor locations. There are two basic types of inputs that are needed to run the ISC models. They are:

(1) Input run stream file, and
(2) Meteorological data file.

The run stream setup file contains the selected modeling options as well as source location and parameter data, receptor locations, meteorological data file specifications and output options. The ISC models offer various options for file formats of the meteorological data.

Usage of the ISC dispersion model is taught in undergraduate environmental and civil engineering courses at various universities. A Graphical User Interface (GUI) with GIS compatibility is also available by a private vendor. (http://www.beeline-software.com/) Literature available on the web indicates that researchers in the US, Canada and Korea have used ISC in the past for various studies. The results have been reported as "satisfactory".

ISC-3.0 is an enhanced version of ISC. The enhancements of ISC-3.0 give the user added flexibility to tailor technical features of the model to particular source-receptor configuration and locales. The joint-frequency function describing the meteorology can be specified using either a 16-point or a 36-point compass for the wind sectors. ISC-3.0 requires data on user options, grid dimensions, sources, meteorology, receptors, and model calibration constants. The user must indicate whether the following options are to be employed for point source calculations:

- Initial dispersion and/or buoyancy-induced dispersion
- Stack-tip downwash and
- Gradual plume rise

Also to be indicated is whether the stability array data is divided into 16 or 36 wind-direction sectors. Information required for each source includes the following:

- Location (user units)
- Area-source side length (m)
- Average emission rate (g/sec.) for each pollutant
- Daytime and nighttime emission rate ratios
- Source Height (m)
- Stack Diameter (m)
- Stack gas exit velocity (m/sec.)
- Stack gas temperature (^oF, ^oC, or K) and
- Decay half-life (hr.)

Area-source side length is required for area sources. Stack diameter, exit velocity and exit temperature are pertinent to point sources only. Meteorological data needed for the computation are:

- Joint frequency function of wind direction, wind speed, and stability category
- Average wind speed (m/sec.) representing each of six wind-speed categories
- Mean atmospheric temperature (^{o}C)
- Mixing heights (m) for each of six stability classes and
- Wind-profile exponents for each stability class

Suggested values and suggested values needed for computation is available in the ISC-3.0 (Industrial Source Complex) User's Guide Appendix A. The meteorological data available at EPA's website needs to be run through a software called PCRAMMET, available for free download, to convert text file into ASCII format. Once processed through PCRAMMET the meteorological data file is ready to incorporate in ISC-3.0. Figure 2 describes the process adopted for this study.

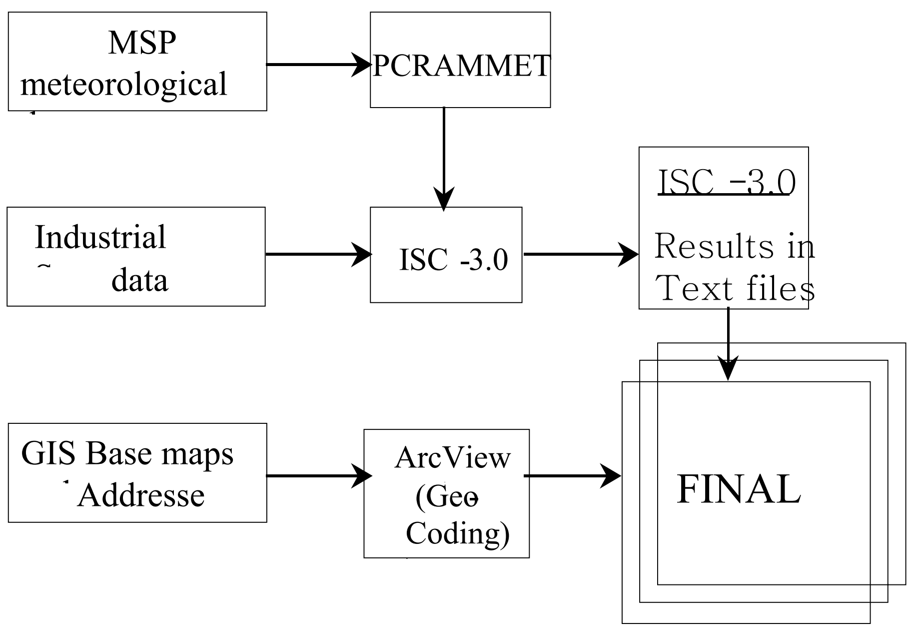

Figure 2: A flow diagram of the process used in this study for making the maps from the data generated by the model

Limitations of ISC-3.0

According to the (Industrial Source Complex) User's Guide, the limitations of ISC-3.0 are that:

- Source emissions and meteorology should be uncorrelated
- Variation in emission rate between adjacent area sources is assumed to be negligible
- Terrain should be flat to gently rolling
- No consideration of chemical reactions or removal other than that which can be handled as a simple exponential decay

It is assumed that one wind vector and one stability category are representative at any given time of the area being modeled.

Data Sources

The Center for Urban & Regional Affairs (CURA) at the University of Minnesota, MN provided base maps for this project. These maps are in Universal Transverse Mercator (UTM) projection and include address and parcels. No information on the associated errors was provided. The maps included address and parcels. The base maps are part of research done by Matson (former MGIS student at the University of Minnesota) for his unpublished capstone project report.

Hackle (2001) collected data for emissions from industrial facilities in the LBNA vicinity during the summer of 2001. The facilities (Table 1) reported are the ones that are needed by MPCA to report their emissions. The data is reported for the annual emission is in tons per annum (Tons/Yr.). The data reported was for years 1990 through 1998. The 1998 data was used for analysis in this project. Unfortunately, the data is incomplete. Values are not available for many years. The meteorological and wind direction data is available from the work done by Nangia (2000).

Table1: Pollution data available at MPCA's website for 1998 (as reported by Hackle).

Polluter	Carbon Monoxide (CO) (Tons/Yr.)	Nitrogen Dioxide (NO_2) (Tons/Yr.)	Sulfur Dioxide (SO_2) (Tons/Yr.)
Aggregate Industries Inc. Yard	0.01	-	-
Cemstone Products	0.03	0.15	-
City of Minneapolis-Asphalt Plant	16.04	1.47	0.24
GAF Building Materials Co.	2.43	4.41	3.86
General Electric International	0.01	0.04	0.07
Holnam Inc. Minneapolis Terminal	-	-	-
Owens- Corning Minneapolis Plant	48.89	15.46	70.38

Limitations and Constraints of the Data

The emission data available for analysis is based on the annual emissions. There are seasons when the production (and emission) was at its peak, but the annual emissions average out the trend. The maps give a broader picture and the boundaries will be "fuzzy". They will not be helpful for small-scale decision-making.

There was not much information available about the base map dataset generation and meteorological data collection. Though researchers at CURA have used these data sets for various purposes in the past, quality of these datasets is questionable.

Geographical Information Software and Analysis

The base maps and emission information were accessed and displayed using Arc View (ESRI Press) software. The software was used to draw contours around each industrial facility in the area for the corresponding emission levels.

Dispersion modeling of available data was done using the ISC-3.0. Levels of Carbon Monoxide (CO), Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2) were calculated at setback distances of 50, 100, 150, 200, 250, 300, 500 and 1000meters. Although the data was available, PM-10 levels were not calculated because they were very low. According to MPCA, PM-2.5 levels are harmless in Minnesota.

The 360^o area around each source was divided into thirty-six 10^o sectors. The ISC-3.0 model, when run, gave 3hr., 24 hr. and annual concentrations of pollutants in 36 different directions. The results shown in this report are for the highest 3-hr. average concentrations. The concentration levels were then incorporated into the database files of the base map for the neighborhood. Using GIS software, contours were drawn for the available data. Contours at an interval of 0.5m with a base at 0m were drawn for the seven facilities considered for this study.

Results and Discussion

Carbon Monoxide (CO)

Figure 3 shows the contours for the Carbon monoxide levels around General Electric (GE) and Owens-Corning (OC) plants. GE had a negligible emission of 0.1ton for the considered year (1998). Thus, contours were plotted for OC only in this case. The levels are for the first highest 3 hrs average concentrations. An interesting thing to note here is that according to National Ambient Air Quality Standards (NAAQS) the permissible level considered safe is 10,000 $\mu g/m^3$. The levels are low compared to standards. Table 2 summarizes the NAAQS.

Table 2: National Ambient Air Quality Standards

Pollutant	Standard Value
Carbon Monoxide (CO)	10,000 $\mu g/m^3$ (3-hr. average)
Nitrogen Dioxide (NO_2)	100 $\mu g/m^3$ (Annual Arithmetic Mean)
Sulfur Dioxide (SO_2)	1300 $\mu g/m^3$ (3-hr. average)

Figure 4 shows levels of concentration of CO around the GAF Building Material Co. (GAF). The contours are drawn taking the 1998 emission data of 2.43 tons. As seen in the figure, the concentration levels are very low compared to standards listed in Table 1.

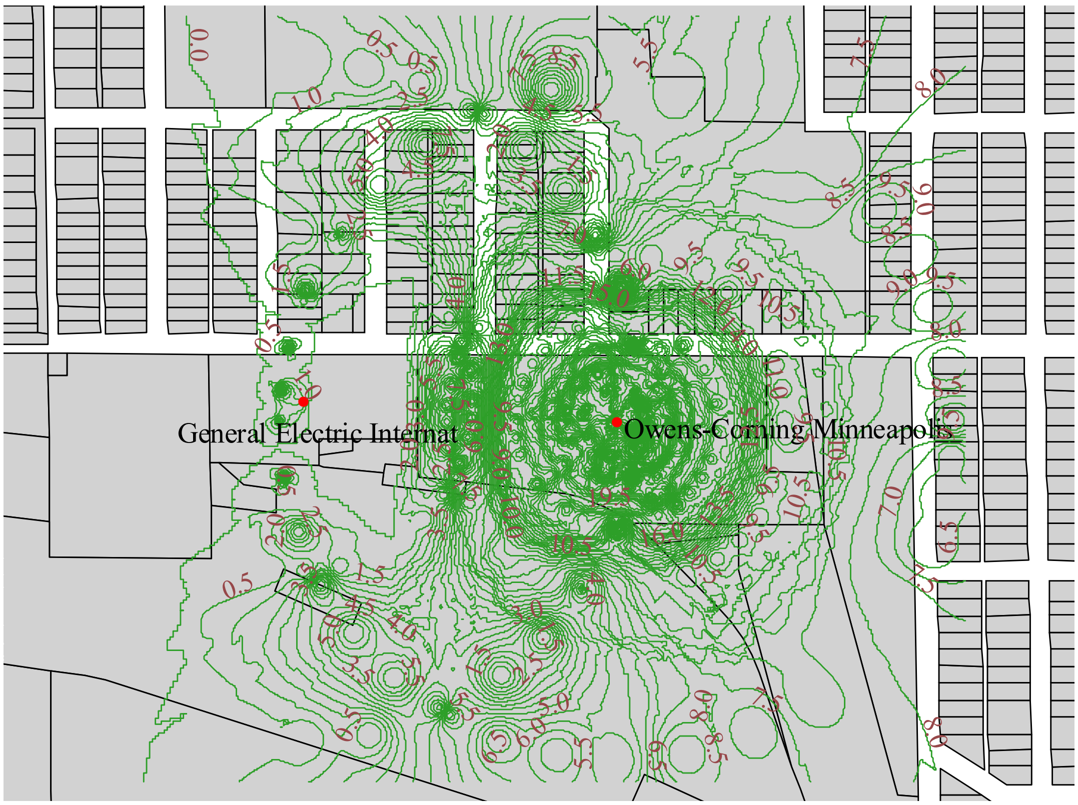

Figure 3: Concentration levels (in μg/m^3) of CO around the Owens-Corning Plant. Contours are at an interval of 0.5m with base of 0m.

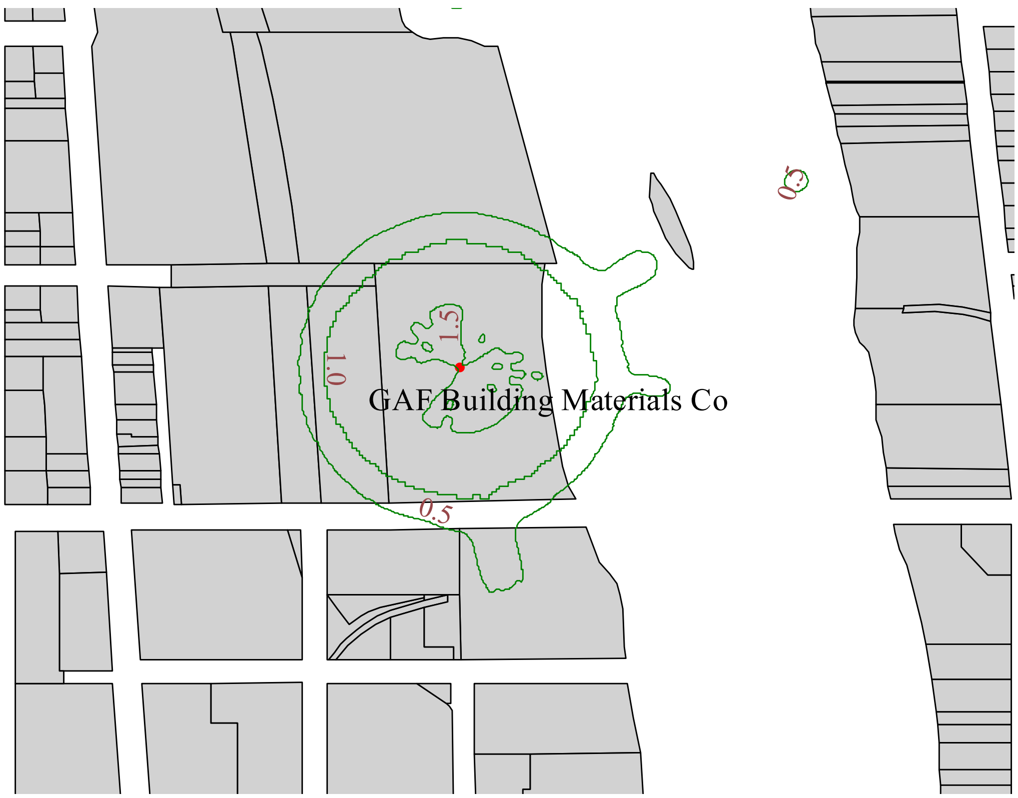

Figure 4: Concentration levels (in µg/m^3) of CO around the GAF Building Material Co. Contours are at an interval of 0.5m with base of 0m.

Emissions could not be calculated and plotted for Aggregate Industries inc. Yard and Cemstone Products because of low reported levels of emission.

Figure 5 has contours plotted for the City of Minneapolis-Asphalt Plant. Reported level is 16.04 tons. The standard level acceptable is 10,000µg/m^3. The levels reported here are low compared to the standard.

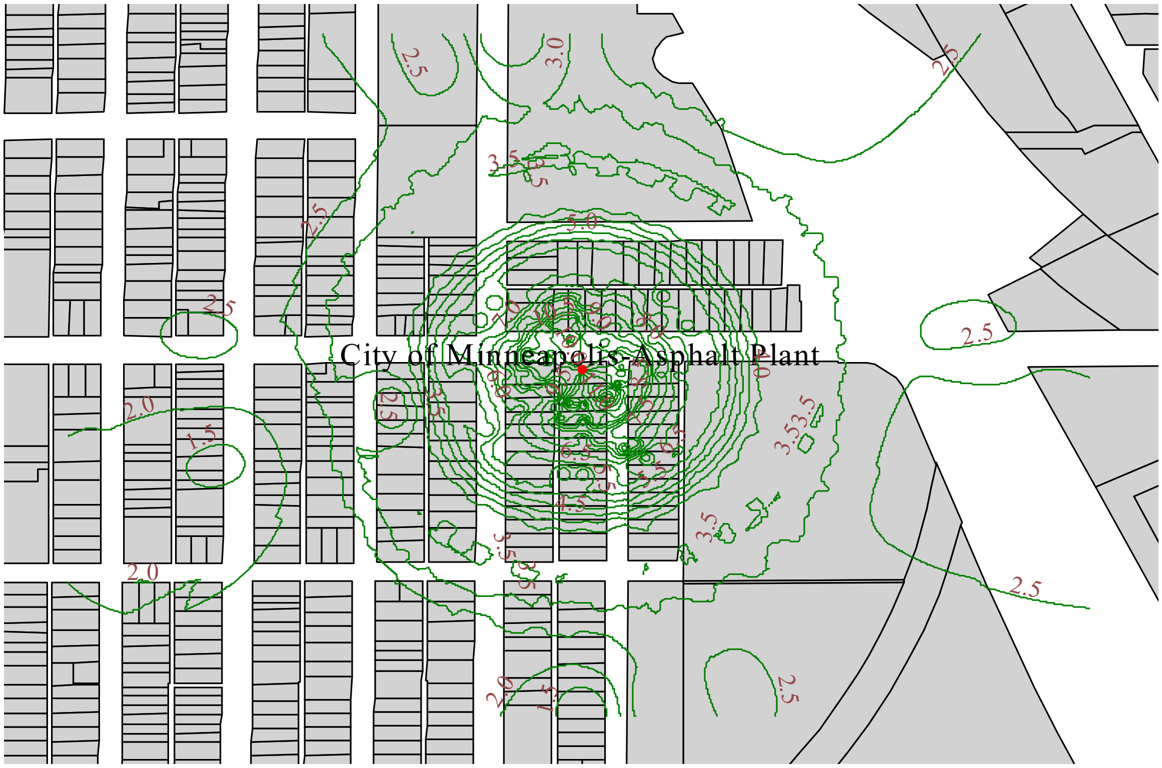

Figure 5: Concentration levels (in µg/m^3) of CO around the City of Minneapolis-Asphalt Plant. Contours are at an interval of 0.5m with base of 0m.

Nitrogen Dioxide (NO_2)

Figure 6 has contours plotted for NO_2 levels for OC and GE facilities. OC has a high level of emission (15.46 tons) compared to GE (0.04 tons). The highest annual average concentration, for OC, was found to be 12.06µg/m^3. This is very low compared to the standard set by NAAQS of 100µg/m^3.

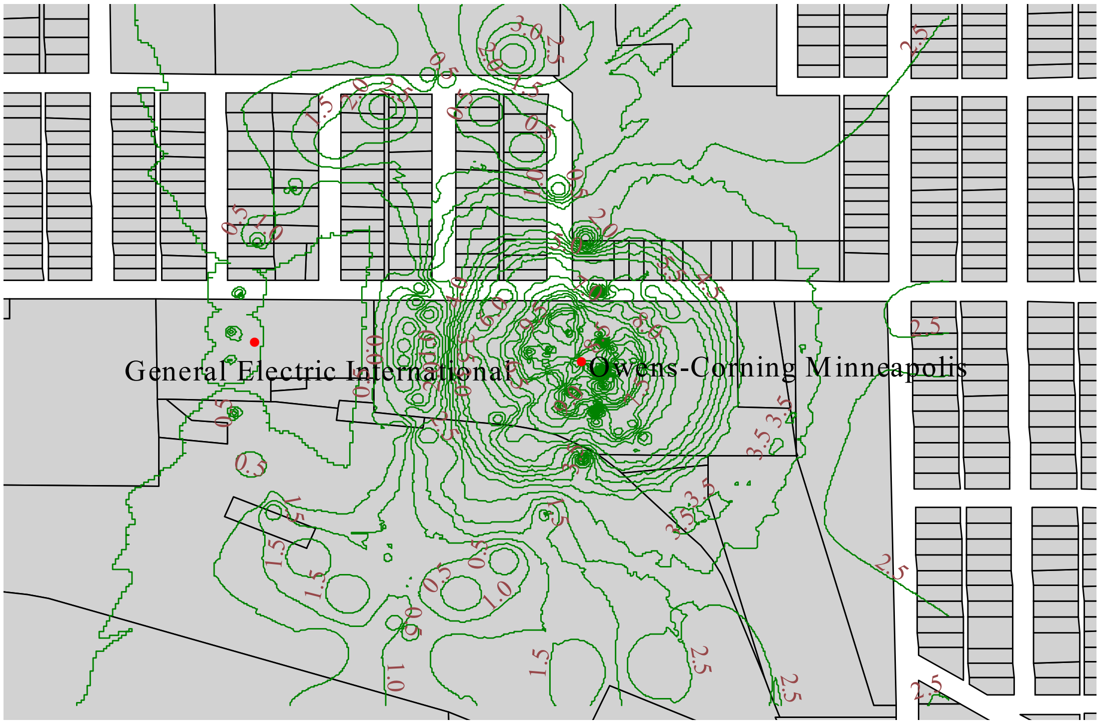

Figure 6: Concentration levels (in µg/m^3) of NO_2 around the Owens-Corning Plant. Contours are at an interval of 0.5m with base of 0m.

Figure 7 is a plot of contours around the GAF Building Materials Co. for NO_2 concentrations. The annual emissions considered for this study were 4.41tons as reported in 1998. The emission caused an annual maximum concentration to be 3.8µg/m^3. This again is well within the limit (100µg/m^3) set by NAAQS.

Figure 8 plots NO_2 emissions for the City of Minneapolis-Asphalt Plant.

Figure 7: Concentration levels (in µg/m^3) of NO_2 around the GAF Building Material Co. Contours are at an interval of 0.5m with base of 0m.

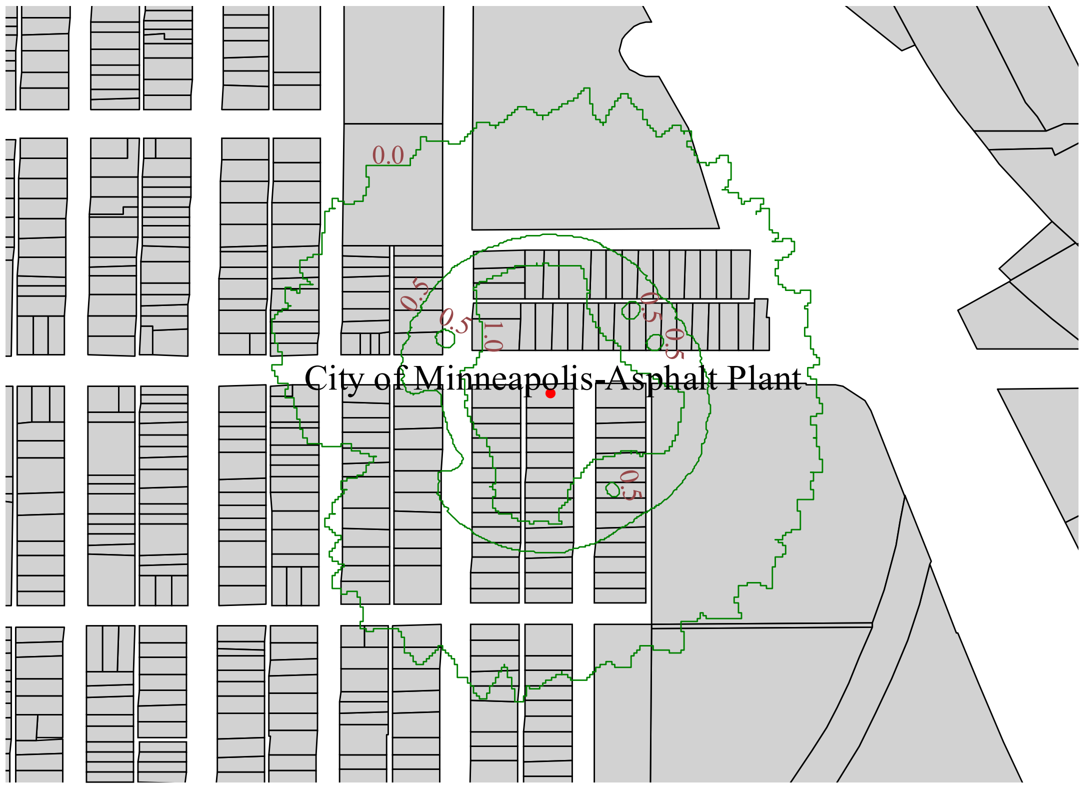

Figure 8: Concentration levels (in µg/m^3) of NO_2 around the City of Minneapolis-Asphalt Plant. Contours are at an interval of 0.5m with base of 0m.

Sulfur Dioxide (SO_2)

Figure 9 and 10 are plots of emission data of Sulfur Dioxide (SO_2) for the General Electric, Owens-Corning and GAF plants. Holnam, Cemstone and the City of Minneapolis-Asphalt Plants did not report or have significant enough levels of SO_2 to analyze. Owens Corning had the highest emission amongst the 7 facilities. Owens reported 70.38tons in the year 1998. GE reported 0.07

tons and GAF had 3.86tons of SO_2 Emission. The limit set by NAAQS is 1300μg/m^3 for a 3-hr.average. All the emission values reported are well within the limits.

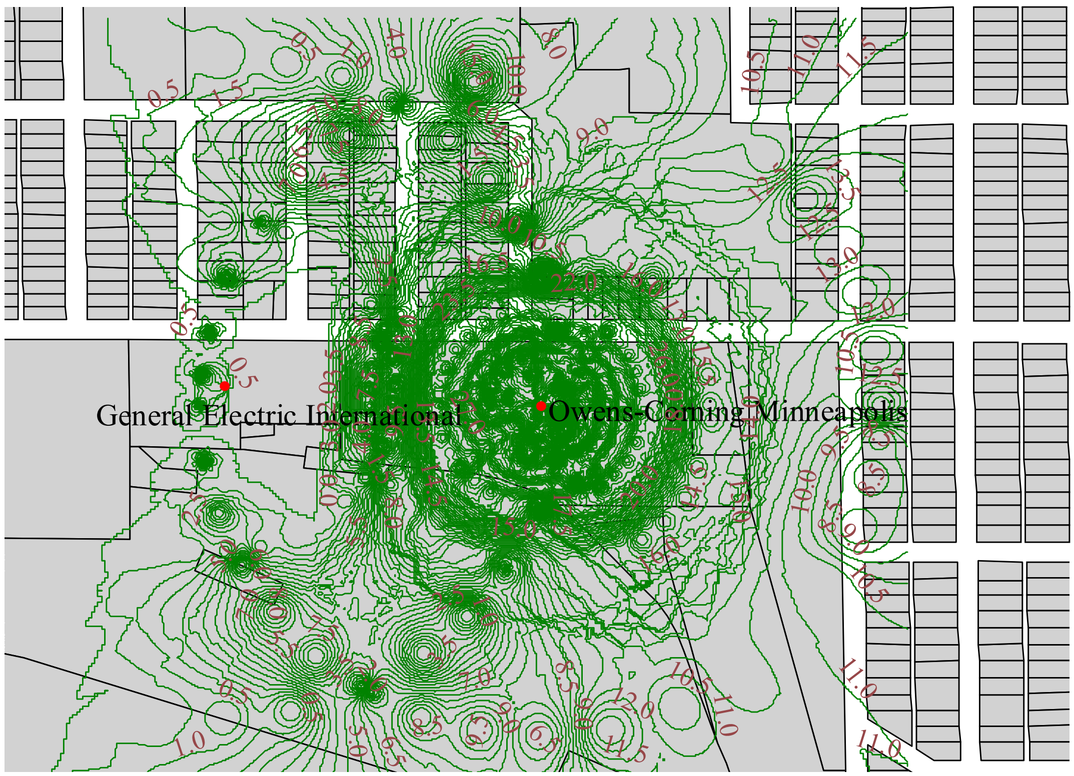

Figure 9: Concentration levels (in μg/m^3) of SO_2 around the GE and OC plants. Contours are at an interval of 0.5m with base of 0m.

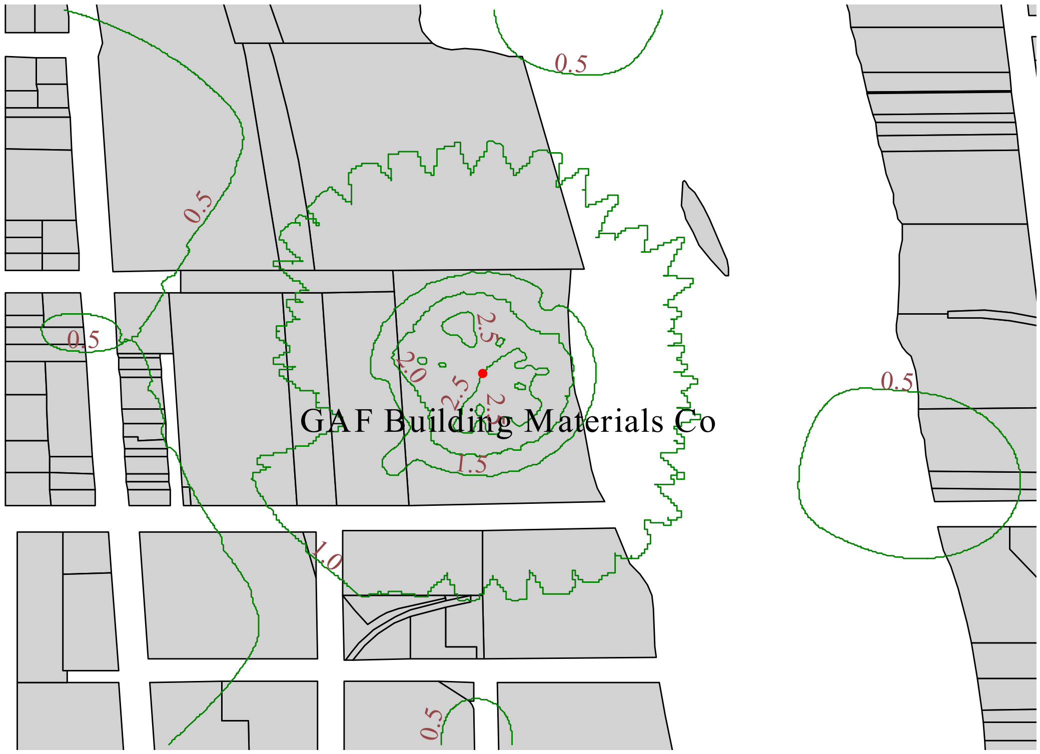

Figure 10: Concentration levels (in µg/m^3) of NO_2 around the GAF Building Material Plant. Contours are at an interval of 0.5m with base of 0m.

Conclusions

The project's objective was to pinpoint the facilities causing pollution in the Lind Bohanon neighborhood. This study was conducted using the data available to the citizens from state and federal government agencies. The most common criteria pollutants (CO, NO_2 and SO_2) were analyzed for this study. The results are well within the National Ambient Air Quality Standards (NAAQS). MPCA also validates these results. According to MPCA officials, the criteria pollutants considered for this study are within the limits and well below the national average. Contours were plotted with the data generated by ISC –3.0 dispersion model to get a sense of the emission dispersion pattern.

If we assume that the data made available by MPCA is accurate and there were no errors in the method of executing the ISC-3.0 dispersion model then the contours justify MPCA's finding. They do not, however explain the reason for illness amongst the residents, but do help in concluding that the problem is not with the criteria pollutant emissions.

Although the emissions are within limits, these facilities are time bombs ticking every second in the background. The accidental spill in the Owens-Corning plant in May of 2001 was a warning of what could happen in future at a more devastating scale. The proximity of the manufacturing facilities to school and residences is alarming.

It is suggested that other pollutants like Semi-Volatile Organic Compounds (Semi-VOC) and metals be measured and compared with the standards. Presence of rail and vehicles traffic on the periphery of the neighborhood may also account for the overall cause of complaints.

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