

Niki Hung

Geography Information Systems Certificate Program

2 June 2011

Toxic Release Facilities Analysis in the Southern Puget Sound Area

Through energy consumptions, recycling, and different kinds of operations, numerous facilities are disposing and releasing a significant amount of chemicals every day. Within all those chemicals, some do not have much impact on human health, while some are toxic, which could cause adverse impact for any individual's health and the environment (Hertwich et al., 2001). Focusing on three counties around the Puget Sound Region (Pierce, King, and Kitsap), the purpose of this project is to make use of the Geography Information Systems (GIS) to find out the areas with relatively serious toxic contaminated regions as well as the most affected group of people in those areas. The general public who are interested in environmental issues might get the idea of the toxicity around this area from what the maps express. Besides, taking into accounts that some groups of the population are suffering from the toxicity severely than some other groups, city planners might as well use the result of this project as a reference to consider whether new regulations about the amount of releasing toxic would be necessary.

Since many different types of chemicals were released by different facilities, after reviewing the chemical data that was listed in the TRI, facilities that released persistent bioaccumulative toxic (PBT) and dioxin were extracted from the data. PBT are toxic that have the properties of persistent, bioconcentration, and toxicity, which are important hazardous properties of organic chemicals (Maeder et al., 2004). However, PBT have always been overlooked since it comprised mixture of compounds (Booth et al., 2007). Some PBT were not massively released, such as Hexachlorobenzene and Tetrabromobisphenol, by the facilities in the

southern Puget Sound region. As a result, only some PBT were selected from the downloaded data and were analyzed for this project. The selected PBT chemicals are Benzo(G,H,I) perylene, lead and lead compounds, mercury and mercury compounds, and polycyclic aromatic compounds. In addition, dioxin and dioxin-like compounds were also selected for the analysis for this project. Since they are environmental pollutants that are commonly regarded as highly toxic compounds, and Miyashita et al. (2011) have claimed that “prenatal exposure to dioxin-like compounds might alter immune function and increase the risk of infections in infancy” in their research.

In order to conduct this project, a number of secondary data were collected. First, from the website of U.S. Environmental Protection Agency (EPA), a table of Toxic Release Inventory (TRI) was downloaded. The table includes all the addresses of facilities that released chemicals in the Washington state, as well as the amount of the different chemicals released in the year of 2009. From the U.S. Census Bureau website, 2010 road shapefiles of Pierce, King, and Kitsap County, tabular data of median income and race in 2005 to 2009 in the 3 counties by census tracts, as well as the polygon shapefiles of the census tracts were downloaded. After the data collection process, the analyses and visualization were all done by using ArcCatalog and ArcMap of the ArcGIS 9.3 package.

By using the road shapefiles, address locators was created through ArcCatalog, which allows the addresses of the three counties in the TRI to be geo-coded. After obtaining the points shapefiles of all the facilities, separated shapefiles were then exported according to the selected toxic chemicals. Then, in order to interpolate the raster surfaces from the points, the kriging tool was used for each toxic chemical. The kriging process created continuous surfaces that represent concentrations of the chemicals at every spot in the three counties. Next, the Reclassify tool was

used to create classifications based on the severity of the contamination of those toxic. Later, by using the Raster Calculator of the spatial analyst tool was then used to conduct an overlay analysis of all the reclassified raster layers. A map showing the toxic concentration in the southern Puget Sound area was then created.

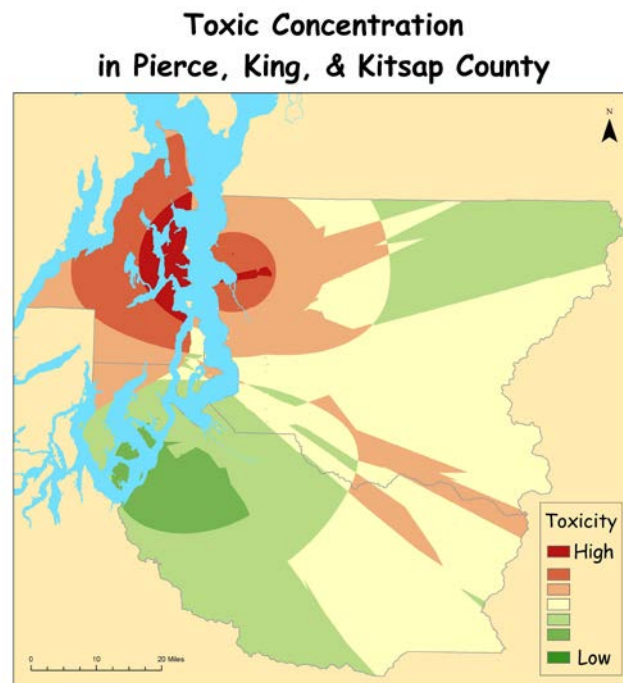


Figure 1.

The Toxic Concentration map (Figure 1) used a red to green color ramp to show the toxicity level of Pierce, King, and Kitsap County from high to low. According to the map, Pierce County has relatively low level of toxic concentration while Kitsap County obtained most of the highly contaminated land. Besides, most of the highly contaminated areas are in the coastal area. Although the inland area also has some high contaminated areas, those are not the areas with the highest toxic concentration.

Joining the tabular data of income and race into the census tracts layer, a new polygon shapefile with all the necessary data was exported. By using the raster calculation again, Figure 2 was produced by overlaying the Toxic Concentration raster layer with a raster layer of

population density, which was created by adding a new field in the attribute table with the use of the field calculator. A red to green color ramp was used to show the population density level from high to low. Besides, from the Toxic Concentration map (Figure 1), the highest two classes of toxicity were outlined with pink representing the high level of toxic concentrated areas while red was used to outline the area with highest toxic concentration. This map shows that the coastal areas in King County have relatively high effects on the population while the highest contaminated areas are mainly in Kitsap County. As Kitsap County has a relatively low population density than King County and Pierce County, although the toxicity levels in Kitsap County is higher than the other two counties, less people are actually affected in those areas. While the coastal areas in King County have fairly high level of toxicity and high level population density, more concerns might be needed on those areas instead of the areas with the highest level of toxic concentration, which is Kitsap County.

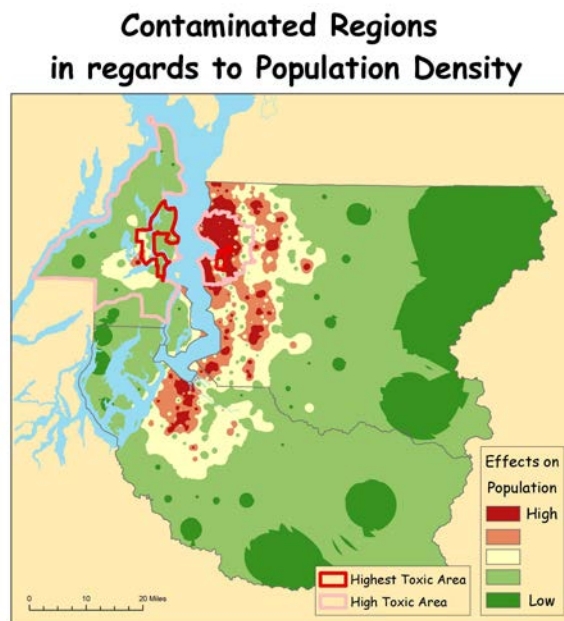


Figure 2

After that, by using the zonal statistics tool, a new raster dataset with the mean toxicity was calculated for the census tracts. In order to interact with the toxic data in the raster layers using

vector tools, the conversion tool was used to convert the raster to points. Afterwards, by using Spatial Join, a polygon layer with both the census data and the toxic data was obtained. The above steps allow us to select focused area and examine the census data within those areas. Two other maps, zooming into the highest contaminated areas, were then created.



Figure 3

In Figure 3, a color ramp of light green to dark green was used to symbolize the amount of median household income from low to high. Again, from the Toxic Concentration map (Figure 1), the highest two classes of toxicity were outlined with pink representing the high level of toxic concentrated areas while red was used to outline the area with highest toxic concentration. Within the high toxic area, all levels of median income could be found. However, in the areas with highest toxicity, only relatively low levels of median household income could be found. The two highest classes of median household income were not in the highest toxic concentrated areas at all. Therefore, we could tell that the areas with higher level of median household income are mainly not affected by the highest contaminated area that are caused by the toxic release

facilities, the areas with lower level of median household income are the ones that are mostly affected instead.



Figure 4

Figure 4 shows the density rate of the minority races in the highly contaminated areas with a color ramp of light green to dark green showing the percentages of the minority density rates from low to high. Minority here refers to people who are African American, Asian, Alaska Native, Native Hawaiian, or any other races that is not White. Again, areas with high level of toxic concentrated were outlined with pink representing while the highest toxicity areas were outlined with red in this map. Once more, within the area with high toxicity, all rates of minority density could be found. Only a very small area in King County obtains the highest rates of minority density. Furthermore, in the areas with highest toxicity, only areas with relatively low minority density rates could be found. As the highest contaminated areas do not contain any area with high rate of minority density, we could tell that the people who are affected by the toxic release facilities most are not necessary to be any one of the minority races.

To conclude, although Kitsap County looks more contaminated with the amount of the PBT and dioxin-like chemicals that its facilities released, it is not actually that hazardous with its lower density of population. Instead, coastal areas in King County might need more concerns about toxic releasing facilities since larger population are being affected in the area. In terms of the environmental justices' issues, household with lower median income level seems to have higher chances to be suffering in the highly contaminated area. However, even there are researches showing that "race [was] found to be more strongly related to the incidence of pollution" (Mohai and Bryant, 1992), this project shows that minority races are in fact not concentrated in the areas that are mostly contaminated.

The locations of the toxic releasing facilities are scattered around the southern Puget Sound area. Although Pierce County looks rather safe comparing to the other two counties, it does not mean that Pierce County is actually safe and pure, nor the other two counties have immediate problems with the toxic chemicals concentration. GIS is a powerful tool that capable to add various types of data into it (Robbins, 2003). However, since there are still limitations for data collection and the implementation, more research would be essential in order to make the best use of GIS. In addition, GIS is about complex interaction with many other aspects. Besides the social aspect, it also includes the economic, institutional, political, and cultural aspects too. There are always tight connections between people and technologies (Chrisman, 2005). There are many other factors could be taken into considerations in terms of the group of people that are mostly affected by the toxic concentration, such as age, socio-economic status, and education background. Therefore, as this project only show relatively high to low levels of toxic concentration within the southern Puget Sound Region, more detailed researches would be necessary for implementing remediation.

Work cited:

- Chrisman, N. (2005). "Full Circle: More than Just Social Implications of GIS." Cartographica 40: 23-35.
- Booth, A.M., et al. (2007). "Unresolved Complex Mixtures of Aromatic Hydrocarbons: Thousands of Overlooked Persistent, Bioaccumulative, and Toxic Contaminants in Mussels." Environ. Sci. Technol 41(2): 457-464.
- Hertwich, E.G., et al. (2001). "Human toxicity potentials for life-cycle assessment and toxics release inventory risk screening." Environmental Toxicology and Chemistry 20(4): 928-939.
- Maeder, V., et al. (2004). "Toxic Ratio as an Indicator of the Intrinsic Toxicity in the Assessment of Persistent, Bioaccumulative, and Toxic Chemicals." Environ. Sci. Technol 38(13): 3659–3666.
- Miyashita, C. et al. (2011). "Effects of prenatal exposure to dioxin-like compounds on allergies and infections during infancy" Environmental Research 111(4): 551–558.
- Mohai, P., and B. Bryant. (1992). "Environmental Racism: Reviewing the Evidence." Race and the Incidence of Environmental Hazards Boulder: Westview Press. 163-76.
- Robbins, P. (2003). "Beyond Ground Truth: GIS and the Environmental Knowledge of Herders, Professional Foresters, and Other Traditional Communities." Human Ecology 31(2): 233-253.