Toxicity of Pollutant emissions in Rhône stations
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Abstract— In this paper, we explore the different characteristics of pollution, focusing on the department of the Rhone. The primary objective is to determine the main pollution stations by taking into account the different types of pollutants. Thereafter, the visualization emphasizes the progression of emission of gas or particles polluting over time. After a reminder on notions of pollution, various factors and consequences on the environment and health, we discuss on the consequences of the limits to be taken into account on the results as well as the possible plan of evolution. Finally, we conclude with the remarks and observations we can make with regard to the results obtained

Index Terms—Pollution, Toxicity, France, Rhône, Visualization

1 INTRODUCTION

Pollution problems in the World and in France are in the spotlight, for drivers or stations: pollution picks in Paris, Lyon, Grenoble, alternate circulation, the income of classifications stickers for polluting cars, directives for reducing speed on big axes, …

A French public health study published on Tuesday 21 June 2016 estimates that air pollution was responsible for 9% of the mortality in France and causes 48 000 premature deaths a year. Today, pollution affects nearly 47 million inhabitants and affects particularly the big cities. This represents a cost of 100 billion euros for France. This problem coupled with global warming is one of the main concerns about the future of our planet. As students in a large city, Lyon, we decided to take a closer look at our department to measure the toxicity of the air we breathe every day. The objective is to visualize the main stations responsible for this deterioration of air while contrasting the emission values of the pollutants taking into account their degree of toxicity.

Here is the list of the different pollutants that we studied with their different characteristics:

Pollutants	Source	Impact on the environment	Impact on the health
Oxide of nitrogen (NOx) NOx = NO + NO^2	Any high-temperature combustion of fossil fuels (coal, gasoline, fuel). The nitrogen monoxide (NO) released from the exhaust is oxidized in air and converts to nitrogen dioxide (NO^2), which is 90% a secondary pollutant	**Role of precursor in the formation of ozone** in the lower atmosphere. Contribute to **acid rain** affecting plants and soils. Contribute to the concentration of nitrates in soils.	NO2: **gas irritating to the bronchi** (increases the frequency and severity of seizures in asthma patients and promotes infantile lung infections). NO: non-toxic to humans at environmental concentrations
Ozone (O3)	Secondary pollutant, produced in the atmosphere under the effect of radiation by complex reactions between certain primary pollutants (NOx, CO, VOC) and the main indicator of the intensity of photochemical pollution	Disrupts photosynthesis and leads to a **decrease in yield** (from 5 to 10% for wheat in Île-de-France, according to INRA) **Necrosis** on the leaves and needles of forest trees **Oxidation** of materials (rubber, textile, …) Contributes to the **greenhouse effect**	Gas **irritating to respiratory system and eyes** Associated with **an increase in mortality** at the time of episodes of pollution (Study ERPURS / ORS)
Particulate matter or airborne dust (PM)	Industrial combustion or domestic, road transport diesel, natural origin (volcanism, erosion, …) Filed according to their size: - **PM10:** Particulates with a diameter of less than 10 micrometers - **PM5**: Particulates with a diameter of less than 5 micrometers	Contributes to **fouling** of buildings and monuments: cost of repairs to public buildings 1 billion euros per year (Source PRQA Île-de-France) Cost of cleaning the Louvre 6 billion euros (Source PRQA Île-de-France)	**Irritation and alteration of respiratory function** in susceptible persons Can be combined with toxic substances or even carcinogens such as heavy metals and hydrocarbons. Associated with **increased mortality for respiratory or cardiovascular causes** (ERPURS / ORS)

2 RELATED WORK

When searching for information on the subject, we found a number of websites that deal with the topic, including the government's website that provided the data and offers limited view: data is displayed only for a given station and a given pollutant. There is no comparison between data and between stations and data is not superimposed. Spatial data is limited to a map with the station and its name.

Once the problem was defined, the first part of the work was to find an appropriate set of data. The website air-rhonealpes.fr gives us access to different data of the air, such as the pollution caused by the different stations of the region. We are also sure of the accuracy of data since this site is approved by the Ministry of Environment, Energy and Sea.

3 APPLICATION

3.1) Data gathering:

The data we have decided to use are group by station, we have 17 mesure points in the Rhône. These are available with different levels of granularity: the last 12 months, the last 6 years and also daily data (but these are only available for the last week, so we decided that they would not be significativ to visualize).

We choose to use both annual and monthly sincethey give the closest idea to the reality of the pollutant emmission and see if there is a global trend on a long period of time. The data is downloadable in .csv format and gives different information about a station: the pollutant, the measured value, the unit of measure and the value per month and per year

Once all the data of the stations that interest us (those of the Rhone) gathered, we have cleaned and parsed the data in the format that interests us and we have grouped all the stations, with one file per granularity.
The GPS positions of the stations were not indicated in the data but were present on the website, so we recorded them in a file.

The major problem of the project was to understand the effect of these pollutants and to be able to measure their level of toxicity. Indeed, a gas emitted in large quantities but harmless have to appear less toxic than a pollutant emitted in small quantities but highly toxic.
Thus, the objective was to find a way to standardize and normalize all the pollutants in order to have a coherence of the displayed values.

There are several tools for measuring the toxicity of a pollutant:

NOAEL: no-observed adverse effect level. In toxicology it is specifically the highest tested dose or concentration of a substance (i.e. a drug or chemical) or agent (e.g. radiation), at which no such adverse effect is found in exposed test organisms where higher doses or concentrations resulted in an adverse effect

LC50/LD50: median lethal dose, LD50 (abbreviation for "lethal dose, 50%"), LC50 (lethal concentration, 50%): The value of LD50 for a substance is the dose required to kill half the members of a tested population after a specified test duration

EVL/AEV: Unit of measure
EVL: Exposure limit value for a maximum of 15 minutes.
AEV: Average exposure value over 8 hours.
Ppm: Part per million 10,000 ppm = 1% FLIGHT

After a study of these different units of measure, our choice was the LC50 for the main reason that we had the values of conversion of the pollutants that interested us. It is also a frequently used unit in the measurement of toxicity (with the DL100 also). Therefore, the lower the LC50 value, the more toxic the pollutant is because a low dose is sufficient.
The values we used were obtained in laboratories, testing pollutants on male rats after 1 hour of exposure.

3.2) Visualisation:

Our visialisation is developped in JavaScript, using the library D3 for the drawing/event part, but also with the API Leaflet that is used to show a map. It is composed of two tabs:

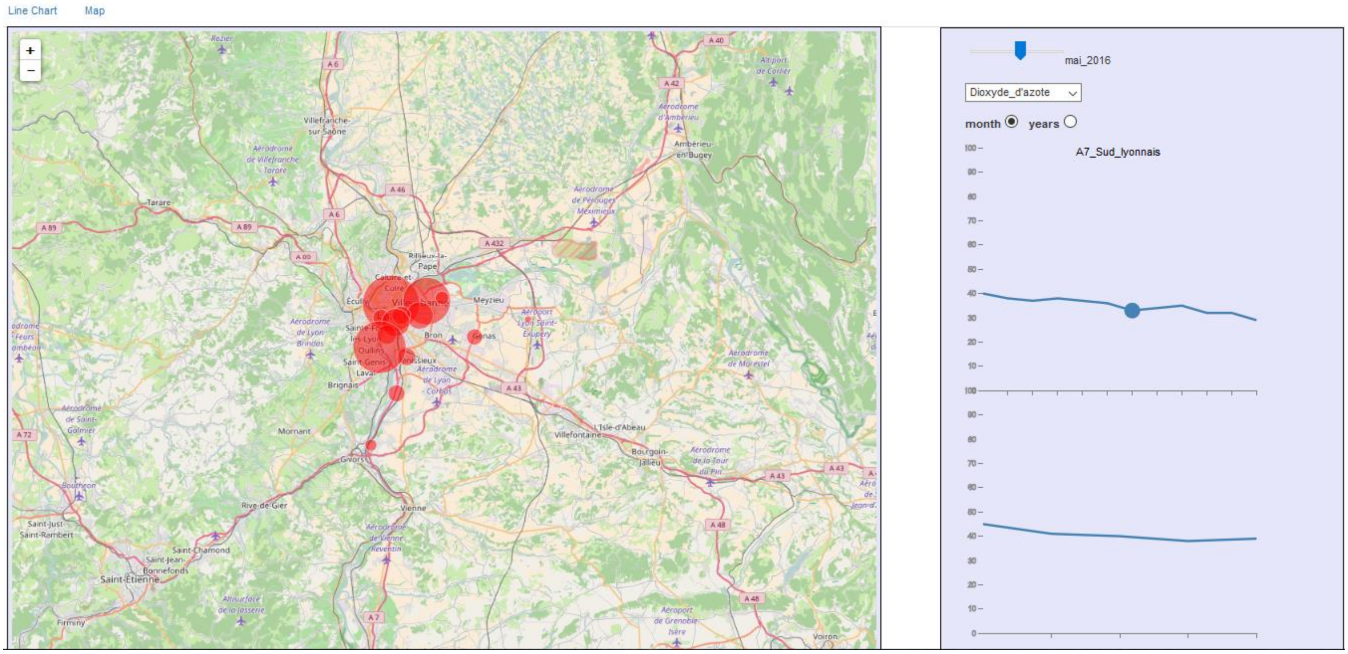

Fig. 1. Map

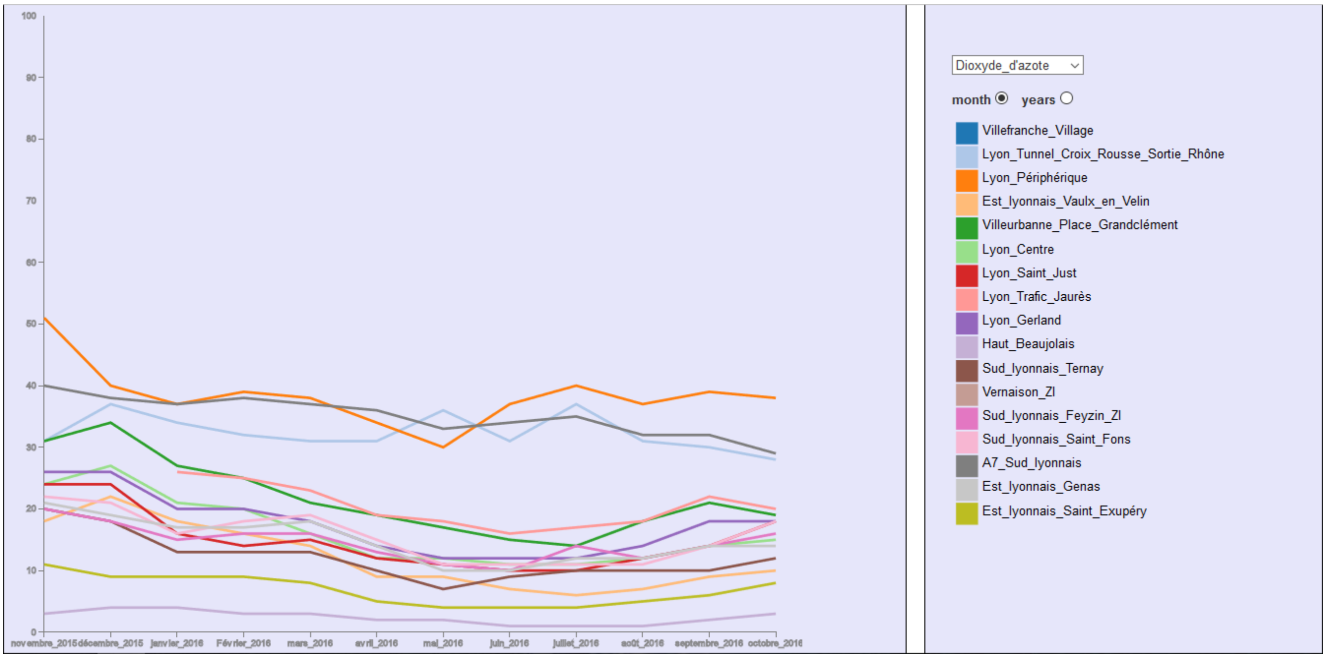

Fig. 2. Line Chart

The display of pollutants by station is done in a comparative way at first, by the use of a line chart. It is possible to choose the temporal granularity as well as the pollutant. By passing the mouse over a line, details of the station appear in pop-up. On the right is the legend, with the list of all stations (even when no data is available). It is possible to switch to one of the stations to highlight its data. This visualization offers a global view of stations over the time and permit to see immediately if one station is more toxic than another, but also to see its evolution over the time.

Choosing the "map" tab, the data is displayed at the station position and the size of the circle represents the amount of pollutant emitted. The commands are the same, with the possibility of temporal choice. When flying over a station, the details of the station and the value emitted are displayed. When we click on one of the circle, a line chart updates under the legend for more information about the evolution in time of this specific station by month and by year

For both visualization, we can choose which pollutant to show, but we also computed a normalized toxicity of a station that regroup three of the pollutant: Nitrogen dioxide, Nitric Oxyde and Ozone
Our normalization is based on the LC measure and consists into a ponderated mean of values.
We also have a last pollutant: Particles PM10 that doesn't count in the normalised (because we could not have a LC50 for this one) but we decided to show this anyway because the pollution alert threshold is set in function of this measure. This threshold appears in red on the line char view when you select this pollutant

4 Discussion

One of the problems we faced for the generalization of pollutants was the case of PM10 fine particles. This type of pollutant has no equivalent LD50 since it does not cause immediate death in a laboratory subject. It severely impairs health and causes cardiovascular or pulmonary disease. We can compare these effects with those of the cigarette: it is "mortal in the long term". We could not really compare it with the other pollutants but we chose to keep it in visualization since it is considered one of the most present pollutants today.

Some results are biased by the quality of the data. Some data were missing. With the limited information available, it was difficult to interpret this lack: closure of the station, malfunctioning sensor, etc. Consequently, instead of extrapolating this data (which could sometimes beimpossible since in some cases the data were absent for several consecutive months), we chose not to take into account the missing pollutant (for the global emission calculation). This is usually found in the line chart with a descending peak.

Observations:

The line chart visualisation allows to easily see what are the main sources of the pollution: if we see the last 5 years visualisation we see that the A7 station which is a highway) is very toxic. Also if we see the 2016 month visualisation, we see that the "périphérique" (another highway in Lyon) have huge amounts of NO and No2.
We can see that the evolution over years of all pollutants is extremly stable (no increase but no decrease either, except for the A7).
If we go back to the visualisation over month, we can see for the nitric oxyde and for ozone a bigger concentration on some period of the years. Indeed, we checked if there where a correlation and we found a perfect match : the ozone stay on the grount in presence of high temperature, thus we can see that the amount of ozone is higher in the summer period. On the other hand, the nitric oxide is favorised on cold temperature, and see on our visualisation that its higher in winter.

Our code is generic enough to extend our visualization to the whole of France (with the data files) and if we were to propose to a continuity on this project, we would go in this axis. Also, if we had access to other data per month, it would have been interesting to see if some cyles appeared. unfortunately, the webside didn't offer this data.

It would also have been interesting to have the opinion of an expert in the field to further understand and interpret the results obtained ...

One interesting thing that we had imagined is the prediction of peak pollution, landing on a model. The problem arises on the granularity of the data that is too high: a peak of pollution occurs over a few days, out, our data are per month thus difficult to apply predictive models

5 Conclusion

This project allowed us to better understand who is responsible for pollutions in the Rhône and to better understand their role and impact. Lyon is a heavily polluted city by a multitude of components. Our visualization allowed us to highlight what pollutants are impacting and what their evolution is.
Data from highway / peripheral stations compared to other more standardized stations give us a better understanding of the important impact they have on our environment and gives us a better understanding of some of the measures taken by the government: Speed, alternating traffic, vignettes.
Although the trend in emissions is rather decreasingslightly in the Rhone, peaks are still occurring (linked to other factors such as weather) and it is therefore important to remain vigilant on this subject by further increasing efforts to reduce pollution. Important issues are in place, such as public health and the environment

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