The Tell Tale Heart

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During the first week of December 1952, a dense toxic fog settled over London, resulting in a total excess of 4,000 deaths compared to the previous week. The magnitude of this event, in terms of the number of people affected, finally confirmed that air pollution caused by human activities can be deadly. For the first time in history, humans became aware of the urgent need of building a relationship with the environment that achieves, in addition to their own development, their survival. The Great London Fog of 1952 is a milestone in air pollution epidemiology and environmental toxicology. This is the story.

> *Fog everywhere. Fog up the river where it flows among green airs and meadows; fog down the river, where it rolls defiled among the tiers of shipping, and the waterside pollution of a great (and dirty) city.... Chance people on the bridges peeping over the parapets into a nether sky of fog, with fog all round them, as if they were up in a balloon and hanging in the misty clouds.*
>
> *Bleak House - Charles Dickens*

On December 5th, 1952, London woke up wet and grey, almost like any other morning. To fight the cold, Londoners did what they always do: apologize four or five times before getting out of bed, eat breakfast as if there was no tomorrow, and burn tons and tons of coal to heat the houses. Meanwhile, outside, the day was starting and the famous fog was beginning to form. Nobody paid much attention to it at that time. It was such a frequent situation that, in another expression of the particular British sense of humor, they kindly called it *pea soup fog*, or simply *pea souper*, because of the greenish-yellow color it took from time to time. Yes, quite tasty, but this time, it was far from being the almost romantic fog that Dickens had written about a hundred years earlier.

Upside down

On an ordinary day, the sun heats the surface of the Earth (and the air that is in contact with it), so that if we were to go up in a hot-air balloon, we would feel the temperature of the atmosphere decrease as we ascended and separated from the ground. When this surface air gets hot enough, its density decreases and rises until it meets the colder denser layer of air above it, that acts as a cap. When this new layer of cold air reaches the ground, it quickly warms up, rises again, and is replaced

by another one, which eventually will warm up again, to rise again and be replaced by a new one. Ascending atmospheric convection, so they say. All very nice so far, but it can fail.

During the night, the ground cools down and the air above it forms a layer of cold and heavy air. Normally, at dawn, the sun begins to heat the ground and sets the air in motion. But it turns out that the shy winter sun which rose in London that day took a little while to warm the ground, so that this cold surface air, instead of warming up, rising, and dispersing, stayed just there, on the ground floor**. London was left inside a bubble which prevented the normal circulation of air.** Moreover, the winter of that year was a particularly cold one, and people had to burn more coal than usual. **Emissions were dangerously trapped near the ground and the air became loaded with soot particles.** To top it all off, these were very windless days, so the air was not renewed at all. It was all set for a British version of The Perfect Storm, with less George Clooney and more top hat people coughing around.

The fact that a layer of cold air is located below a layer of warm air is a quite common natural process known as **'thermal inversion of the atmosphere'**, which occurs especially in winter and in valleys with low air circulation. This inversion is usually 'broken' when the air in contact with the ground gets hot enough to become less dense than the air above it, so it starts to rise and normal circulation is restored. According to the weather conditions, this can happen in a matter of hours or last several days.

If this phenomenon happens to us in Siberia, alone and in the middle of nowhere, it is not that serious (or at least it is not more serious than being in Siberia, alone, in the middle of nowhere). **But the London of that time was one of the most populated cities in the world**. Moreover, it was quite difficult to obtain good quality coal in the post-war period, and **the available one for internal consumption was**

loaded with toxic compounds that, when burned all night inside the homes, were slowly and quietly released.

The next morning, December 6th, everything was completely dark. The incandescent lanterns that tried to light up the streets ended up making it look even gloomier, Gotham City-like. The newspapers that covered the news wrote about the reduced visibility, which reached the point of forcing the interruption of the transport network and the closure of the airports. It was not a minor event in the life of the city. People were a bit displeased, but there was no panic (Spoiler Alert) yet.

During those days, the fog barely lets us see the Tower Bridge. Nothing can also be seen of the famous London Eye, a little because of the fog, a little because it is on the other side, but mostly because it was built in the year 2000.

Day three. Public transport was completely banned due to the high number of traffic accidents caused by the low visibility. London was paralyzed and chaos slowly began to develop. However, the newspapers were more concerned about the millions of pounds the government would have to pay for the whole thing, about how criminals had taken over the streets, and about some bizarre issues such as the

suspension of performances in cinemas because 'screen visibility was no higher than the fourth row' or the cancellation of concerts because 'the choirs could not see the conductor's baton'.

Fourth day. The choristers were still lost and there was a growing concern about the rising criminal activities and the number of people accumulating in the hospitals. **The air in London was already suffocating.** Something was not right, but life went on. Netflix exaggerated a little bit (*The Crown* S01E04), but they represented quite well in Winston Churchill's character what Londoners thought and felt at the time: "*It's fog. Fog is fog. It comes and it goes away. (...) It's weather. And for better or for worse, we get a great deal of it on this island*". And so it did. Well, maybe not so much. **The Great London Fog of 1952 took five days to disperse, and at no time was there any despair. However, it wasn't until the following week that people realized what had really happened.** Just before the incident began, on December 4th, almost 300 people were dying in the city every day. Four days after the fog began, that number had already tripled, **resulting in a total excess of more than 4,000 deaths over the previous week.** This is about five times more than during the worst week of the cholera outbreak that striked London a century earlier, which gave birth to modern epidemiology by the famous Dr. John Snow. Not the Game of Thrones bastard, another one.

The good thing is that now we have epidemiology, the bad thing is that we need it a lot.

Smoke bomb

Londoners were aware that their air quality was not generally the best. Similar events to this one, although much shorter, had been reported throughout the 19th century. By the 20th century, the weather conditions of the area had changed and these phenomena became much less frequent. It was not until the winter of 1946 that the fog reappeared, but it was short-lived and led to 'only' a few hundred deaths. At the time, it was believed that waste from the use of fossil fuels was harmlessly diluted in the air (why think otherwise, right?), and that the deaths that occurred during these weather conditions were a consequence of the low temperatures. Since people were dying mainly from respiratory diseases, perhaps this is why it was initially suggested that the cause behind this whole story was a flu. Or maybe it was because it was easier to blame the weather or a small virus than to look beyond the ego of humanity and take responsibility for our actions. Or, perhaps, because the country that was the birthplace of the Industrial Revolution did not want to accept that its growth was at the expense of putting at risk the environment and the health of the people who lived there. In any case, no solid evidence was ever found to link such a virus with the excess of deaths that were recorded during this incident, and the flu hypothesis was quickly dismissed. **The magnitude of the 1952 Great Fog of London, in terms of the number of people affected, finally confirmed that air pollution caused by human activities can be deadly.** It was the landmark in environmental toxicology. **For the first time in history, humans became aware that they must have a relationship with the environment that achieves, in addition to their own development, their survival.**

Luckily, the subject wasn't left there. The consequences of the deadly fog led the British Parliament to enact the Clean Air Act in 1956, and the United States to do the same a few years later. The search for safer fuel alternatives, the identification of areas prone to high levels of air pollution, and a great deal of research on the subject began. And that's when the real problem was understood: the situation was far worse than previously thought.

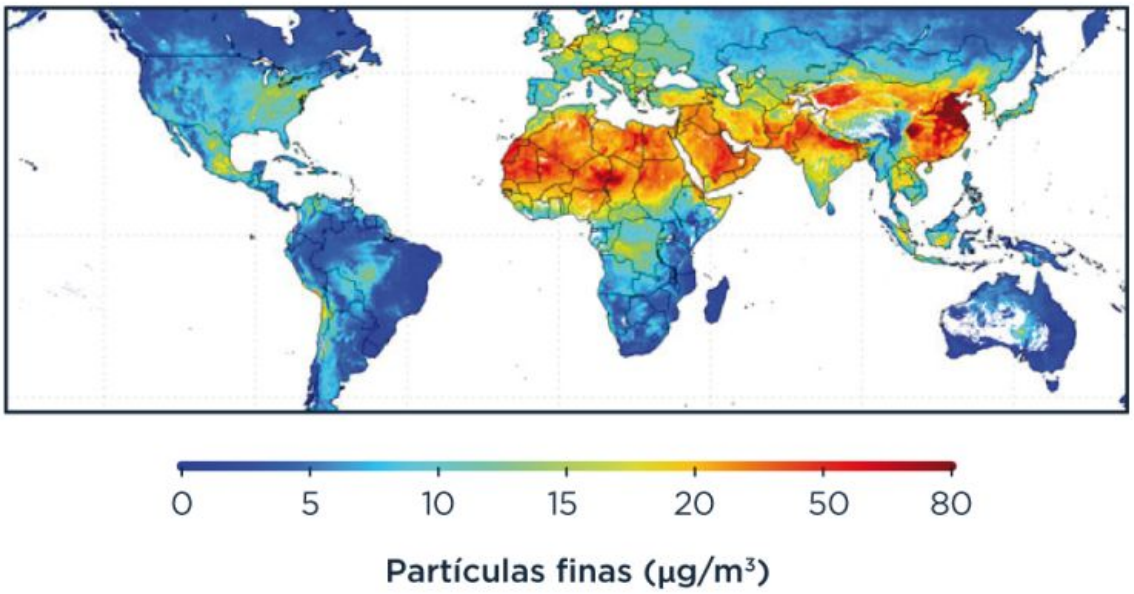
Including data from the two months following the London incident, it was found that the toxic effects of the fog resulted in the deaths of more than 12,000 people in total, and more than 100,000 became ill. Then, analyzing populations in different cities around the world, many large-scale retrospective epidemiological studies confirmed this observation. It turns out that a few days of breathing in high levels of air pollution are lethal in an acute fashion, but might be even more dangerous in the long term. Actually, the debate on this issue is far from over. It is still not entirely clear whether the harmful effects found in long term studies are not, in fact, a consequence of acute exposures to high levels of air pollution that has occurred during the period of study. Epidemiology still has to give us some explanations here. On the other hand, it seems that there is no need for an atmosphere laden with tons of coal, like that one of London in 1952, to suffer its negative consequences. Breathing air that is not that polluted, like in most urban areas nowadays under normal weather conditions, is bad enough for our health. Moreover, some believe that there is no such thing as an air quality threshold below which a person is completely safe, and they fight to have air pollution considered an additional risk factor (such as high cholesterol, hypertension or high school WhatsApp groups) for the development of cardiovascular and respiratory diseases.

Moreover, it would seem that the toxic effects of air pollutants vary in such a way that at relatively low levels of air pollution, such as those breathed in most urban environments, mortality increases rapidly with a slight increase in these pollutants, like in a logarithmic mathematical function. Then, when pollution levels are higher, as

during that fog in London or in highly polluted cities (such as Beijing, Delhi or Mexico City, among many others), a plateau is reached, the system is saturated, so that the same rise does no longer increase mortality rates too much. It is precisely on this plateau that workers who are especially exposed to air pollutants and smokers are also found. This would also explain why if you smoke like a chimney (or if you work inside one) there is no additional risk from breathing the city's polluted air. The problem is that, ultimately, smoking is a personal decision, an active and conscious act involving only a part of the population. In contrast, absolutely everyone living in a city are exposed to the toxic effect of its air, usually without realizing it and being able to do very little about it.

Part of the air

Let's go back to London. As usual, someone has to be blamed for everything. As the first candidate is usually the smallest and most helpless one, this time it was the turn of particulate matter (PM). Despite the large number of toxic compounds present in the air we breathe, many epidemiologists agree that particles smaller than 2.5 micrometers ($PM_{2.5}$) are mainly responsible for harmful health effects of air pollution. These particles are much smaller than the diameter of a hair, totally invisible to the human eye, and small enough to penetrate deep into the lung and make a tremendous mess. This is where alveolar macrophages come in, cells of the immune system that are responsible for phagocytizing (eating) any foreign element that we put in front of them, and that would seem to play an important role in controlling the toxicity of these particles.



While we see urbanized areas with very high levels of fine particles, there are other regions with high concentrations that are not related to the use of fossil fuels.

The epidemiologists contributed with one more finding, as important as it is counter-intuitive: despite the fact that the lung is the first organ in contact with air pollutants once inhaled, **only 1 in 5 people exposed to environmental pollution die from respiratory diseases,; the rest actually die from acute myocardial infarction or stroke.** It seems that when alveolar macrophages phagocytise the particles that reach the lung, there is such an imbalance in the immune system that other organs are affected as a domino effect. The result, according to the World Health Organization, is that 7 million premature deaths occur every year (more than 10% of total global mortality) from breathing polluted air. From those, almost 5 million are from cardiovascular disease. Although we are not fully aware of this, that we do not see it, that we do not feel it, air pollution is there all the time, it exists, and in the end, as in the tango, the one who suffers most is the heart.

To the world

To fight this situation, various policies are being carried out around the world with the aim of warning the population and reducing emissions of air pollutants. One example is the comprehensive global awareness campaign BreatheLife, which hopes to reach air quality standards in all cities worldwide by the year 2030. Another example is the United Kingdom itself, when at the end of April 2017 it covered its energy demand for 24 hours without the use of coal. This was the first time since the Industrial Revolution, and 65 years after the deadly fog of 1952.

Despite these well-intentioned efforts, much is also being done to make the situation worse. **In recent years, it has been observed that global levels of air pollution continue to rise, and it is estimated that at least 90% of the people living in urban areas breathe excessive levels of these pollutants.** Large multinational car companies manipulate their cars to pass emissions tests in laboratories, when in fact they produce far more polluting gases than international agreements allow. World leaders are threatening to step out of the Paris Agreement because they 'don't believe' in climate change. As citizens, in addition to claim politicians to take these problems seriously (and, much better, not vote on them if they don't) we can also directly contribute, for example by using the car less and the bicycle more, not setting the air conditioning at 17 degrees, decreasing meat intake, moderating electricity consumption or separating our waste, among other actions. Returning to public policies, if we continue like this, without adequately regulating the emissions of pollutants, without complying and enforcing existing laws, without punishing those who do not follow them, and with government leaders lacking environmental awareness, things can only get worse and worse.

On the one hand, there is hope. London seems to have learned from its mistakes. The fog incident changed the mindset of a world that underestimated the tremendous effects that pollution can have on health and the environment, and the scientific research that was promoted at that time provided the evidence needed for the development of public policies that would prevent similar catastrophes.

On the other hand, the current scenario is different: **now, the main emissions of environmental pollutants no longer come from burning coal to heat homes, but from the use of petrol byproducts to move around as quickly as possible**. And the scientific evidence is consistent: environmental pollution kills. If we want to continue enjoying our cities (and the planet in general) it is time to develop more and better public policies, well oriented, on a large scale, that will allow us to confront this invisible but effective killer.

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