Political airs: From monitoring to attuned sensing air pollution

Nerea Calvillo

Centre for Interdisciplinary Methodologies, University of Warwick, UK

Abstract

In Madrid, as in many European cities, air pollution is known about and made accountable through techno-scientific monitoring processes based on data, and the toxicity of the air is defined through epidemiological studies and made political through policy. In 2009, Madrid's City Council changed the location of its air quality monitoring stations without notice, reducing the average pollution of the city and therefore provoking a public scandal. This scandal challenged the monitoring process, as the data that used to be the evidence of pollution could not be relied on anymore. To identify the characteristics of some of the diverse forms of public's participation that emerged, I route theories of environmental sensing from STS and feminist theory through the notion of *attuned sensing*. Reading environmental sensing through the processual and orientational processes of attunement expands the ways in which toxicity can be sensed outside of quantitative data. This mode of sensing recognizes how the different spontaneous attunements to and with air pollution and the scandal acknowledged Madrid's chemical infrastructure, rendering visible qualitative conditions of toxicity. This mode of sensing politicized the toxicity of the air not through management or policy making, nor only through established forms environmental activism, but through contagion and accumulation of the different forms of public participation. All together, they made air pollution a matter of public concern. They also redistributed the actors, practices and

objects that make the toxicity not only knowable, but also accountable, and most importantly, they opened up spaces for citizen intervention.

Correspondence:

Nerea Calvillo, Centre for Interdisciplinary Methodologies, University of Warwick

Social Sciences, Coventry CV4 7AL, UK

Email: N.Calvillo@warwick.ac.uk

'If all air quality monitoring stations were removed, Madrid would officially be a non-polluted city.' With these words, Madrid's Public Prosecutor for the Environment, Antonio Vercher, summarized an event that had taken place in the autumn of 2009, when the City Council changed the location of some of its air quality monitoring stations without disclosing this to relevant organizations, stakeholders or the public (Mendez, 2011). After some months, the change was identified by members of the opposition parties and NGOs through a lack of coherence in the datasets published by the City Council, as the names of some monitoring stations had disappeared from the data feeds and new names had replaced them. In this way, the City Council had reduced Madrid's air pollution average – a figure that makes local governments legally accountable to the

European Union (EU) – claiming that the concentrations of nitrogen dioxide (NO_2) were 20% lower than the previous year (González and Sevillano, 2010). As the Council acknowledged that the stations that had disappeared were ones that had been registering the worst concentrations, legal procedures were initiated by various parties and the press hosted a public debate. The Public Prosecutor for the Environment sued the mayor, arguing that 'the elimination of the stations at the locations of worst pollution does not mean that the pollutants do not exist, only that they have not been measured' (Mendez, 2011). The climax to this chain of events arrived in January 2011, when the EU fined Madrid City Council for not complying with the pollution limits agreed upon in 2006 (Sevillano, 2011). The lack of compliance, together with the City Council's trickery in designing the city's air pollution average, initiated a creeping but intense scandal, in which citizens participated by suing, blogging and organizing flashmobs. As I discuss, through these multiple registers of engagement, air monitoring – and air pollution – was made a matter of concern and a public problem for the first time in Madrid, which had political, legal and social consequences.

This protracted controversy also raises larger questions about knowing the environment through the use of monitoring devices. Just what do the averages that City Councils present to the EU tell us about polluted air? The averages are aggregate measurements taken by automated networks of sensors at street level, which take hourly measurements of concentrations of selected atmospheric gases and particles. These networks are managed by local governments, which are requested to monitor and comply with the maximum limits stipulated in European law, in line with global standards for substantiating the atmosphere (Choy, 2012). These limits are defined on the basis of

epidemiological and toxicological studies, which have established the impact of different concentrations of particles in the air on human health; therefore 'toxicity' has become a quantitative connection between the composition of the air and its harm to human bodies at population level. The average is the only number that is assessed against legally binding standards, and is considered to be the key assessment of air quality and toxicity for policy making (Ecologistas en Accion, 2010).

This article does not dismiss the political potential of this type of number; rather it aims to find other arenas in which to deal with the toxic air. The contribution of the EU regulations to making air quality an issue of public interest is clear, as is the way in which they enable the production of evidence and help to ensure its presence on the political agenda (Rydin, 1998).

As the scandal reveals, air monitoring is not only disputed in data, but also through a whole assemblage of practices, instruments and institutions that constitute a 'regime of perceptibility', or 'the way a discipline or epistemological tradition perceives and does not perceive the world' (Murphy, 2006: 10). What could be called the air monitoring regime made perceptible a very specific aspect of air pollution: concentrations of particles and gases, measured in micrograms per cubic metre, attributed to specific locations in the city. And yet, the scandal also reveals how this data may not be trustworthy. If this is the only accepted evidence of toxicity, what do we know then about the toxicity of the air?

Some citizen science and science for justice projects have engaged with the production of alternative data with low cost sensors. This is relevant when there is a need to prove environmental injustice, as often the most polluted sites are not monitored. But,

in cities like Madrid, which exceeds the legal limits every year, is there really need for more evidence of the air's pollution? Is there not enough evidence to prompt action? In addition, Shapiro et al. (2017) have demonstrated that enumerative practices on their own have rarely improved the object they enumerate. I ask, then, if there are other forms of knowing and acting on the toxicity of the air in which citizens can engage apart from alternative data production or enumeration practices. This is not just a response to bad science, but a space for new engagements with toxic air, to proliferate the practices, as Haraway (2016) suggests, of staying with the trouble. The ways in which politicians, associations and citizens responded to the scandal may shed some light in this direction. Through their actions, I argue, they constituted a new regime of perceptibility, whose distinction from the monitoring one will form the empirical core of the article. To account for this regime, it may be productive to shift the focus from asking 'what is toxic?' to asking 'what do we need to know about the toxic to act?' How do we account for the distribution of toxicity across bodies, spaces and time? As citizens, how many spaces of intervention can we imagine?

Expanding notions of toxicity and sensing

To expand narrow understandings of toxicity as an ontological property of matter (of some specific gases, for instance), I engage with feminist scholars' approaches to toxicity, which suggest that toxicity is an interaction between bodies that takes place in multiple contexts and formats (Chen, 2012; Mol, 2002; Schrader, 2010). These interactions are temporal and depend –and act- on the context, from a cough from an elderly person to a legal complaint in the EU. But, borrowing Hecht's definition of 'nuclearity' (2012:14), toxicity is not only an interaction between bodies, but it is also

distributed among things, as a contested technopolitical category. This approach has three main advantages for expanding the toxicity of the air from gas and particle concentrations. First, we do not have to study an isolated material (NO2, for instance) but can examine its relationships with others. This can take place beyond the microscopic scale, and other bodies or elements may be affected. Second, as this relationship depends on the specificity of bodies, toxicity is necessarily situated –challenging the standardisation of toxicity through generic bodies. And finally, its quantitative aspect is only one of its conditions; it may also be relevant to know other qualitative aspects of it, like how, for whom, when, under which circumstances, and where, do toxic interactions occur? This means that instead of focusing on 'how much' a generic body may suffer an excess of certain gases in the atmosphere, a question that is too generic, we may want to know specifically 'for whom or what' those gases are toxic? And what are their effects and causes, and their temporalities and space? We may need to consider, in sum, the toxicity of the air's "chemical infrastructure" (Murphy, 2013), including the places and practices distributed in space and time that relate to and are affected by air pollution.

These qualitative aspects include but also exceed the data produced by the monitoring stations. Therefore, toxicity is not only about quantifiable concentrations embodied in bioscientific ways of knowing, but is also about cultural understandings of it (Gugliotta, 2003; Liboiron, 2015) as well as its chemical infrastructure, which involves different forms of contestation and intervention, ventilation shafts, neighborhood playgrounds, festivities or birds, among many others. An epistemic question then becomes crucial.[1] How do we get to know the toxicity of the chemical infrastructure of the polluted air? Sensing as just monitoring is not enough. But due to the fact that sensing

is considered the legitimate way of knowing the toxicity of the air, I suggest that we keep using this notion and expand on it.

Bringing together notions of sensing from ANT and feminist approaches to environmental sensing, and drawing on the work of philosopher Alfred N. Whitehead, Gabrys describes sensing the environment as a process that exceeds the technical apparatus and involves '"tuning" the subjects and conditions to new registers of becoming', where 'taking account of environments is a way of capturing what is relevant, and through being affected also transforming environments as relations' (Gabrys, 2012). From this definition, sensing is a process that includes tuning, selecting and transforming. Capturing what is relevant distinguishes how, within all the qualities of a chemical or a process, sensing is about deciding which one matters in a certain context. The transformative capacity of sensing adds to a limited understanding of it as just knowledge production, and makes visible how it also intervenes in those environments. Tuning attends not necessarily to the quantitative aspects of measuring (producing a number), but to the interaction occurring (or not) between the entities. Therefore, sensing is a process in which attunements between humans and more-than-humans, machines and the environment take place, with a generative capacity for worldmaking.

In acknowledging forms of sensing the air other than monitoring, some researchers have inquired into how human bodies attune to the air, composing completely different regimes of perceptibility: from collective associations around bodily symptoms in relation to multi chemical sensitivity (Murphy, 2006), to intimate interactions with the toxic (Choy, 2011; Shapiro, 2015). However, the mode in which toxicity unfolded in Madrid was not through a direct physical interaction between toxic air and bodies, but

through a wide range of practices of contestation that emerged spontaneously, triggered by the scandal and mediated by the press.

It is not easy to imagine how writing a blog post or producing an app can be a mode of sensing or tuning to the environment. Anthropologist Kathleen Stewart's notion of 'atmospheric attunements' (2011) provides the key to capturing these as sensing processes. It permits the description of attunements, where 'the intensities of living through things accumulate and pool up in worldings and forms of attending to what is happening – trauma cultures, redemption cultures, recreational worlds, public feelings fuelled by humour, sarcasm or rage, forms of critique or cocooning, worlds of volunteering, or self-help or activism or art or exercise' (452). This concept becomes an analytical instrument with which to recognize how, through the scandal, people connected to specific conditions of the toxicity of the air, and provoked transformations and worldmaking. Attuning to different aspects of the scandal produced spontaneous public feelings and forms of critique of the toxic air and its monitoring infrastructure away from the positivist idea of the environment standing on its own. However, they did not only attune to the issue of air pollution or to the (mis)management of its monitoring practices. They contributing to sensing other conditions of toxicity, making them sensible and accountable.

Attuned sensing

I propose 'attuned sensing' as a concept with which to think about the practices that emerged in Madrid as forms of sensing toxicity, and therefore as the mode of sensing chemical infrastructures. I use both concepts, attuned and sensing, to recognize the

multiple conditions of a sensing process, and to recognize atmospheric attunements as sensing processes. There is a tension in putting together sensing and attunement. On the one hand they can feel redundant, as in common language sensing is always a form of attunement. On the other, both concepts might seem incompatible, as Gabrys and Stewart's attunements are different: the first one is an attunement to material environments and the latter to situations. And yet to articulate an expanded form of sensing keeping the tension between the two is productive, to remind that sensing is always an attunement -and therefore it includes a diverse range of kinds of sensing and things sensed- and to reinforce that atmospheric attunements are also forms of sensing and making accountable.

Attuned sensing then includes monitoring and bodily interactions with the air, but also exceeds them, and focuses on the partial engagements with, and spontaneous responses to, the toxicity of the air, in this case through the scandal. The practices that emerged did not focus on quantities of pollutants, but specified, spatialized and differentiated what the toxic air was and to which other materials, infrastructures and institutions it was connected in Madrid between 2009 and 2011. So toxicity was not a quantitative, but a qualitative condition distributed in space and time. And yet, they also made the object sensed accountable, but in other ways. Instead of becoming evidence of gas concentrations, attuned sensing made visible the objects, humans or environments that were interrelated with high levels of pollution in the city, identifying them as possible contexts for action and suggesting or enacting forms of intervention.

Attuned sensing works as a heuristic of a mode of sensing toxicity that is sensitive to the processual, material and affective encounters between humans and more-than-humans, which take place within institutional spaces but also in everyday life, and attentive to all of the sensing practices and objects that are present, and mediate or activate those encounters. Attuned sensing, as a sensing project, looks at and takes into consideration material, spatial and temporal configurations, and, as will be unfolded, creates its own regime of perceptibility, which opens up and expands the monitoring form of understanding the toxic and its politics.

Unfolding Madrid's scandal

The empirical analysis is based on the analysis of digital online material, to understand how air pollution was conceived and discussed in the public realm. In particular, I have researched two main sets of online documents and websites. I reviewed the website of the City Council and specifically its section on air quality (www.munimadrid.es) from 2008-2017. News articles and blog posts where the event of the change of location of the monitoring stations was mentioned have been exhaustively collected and reviewed. They include online daily news and associations and personal blogs from 2009-2012, with a peak in the winter of 2011, when the EU announced possible sanctions. I tried to answer two main questions: how was toxicity described or referred to, and what were the material actions deployed.

Monitoring regime of perceptibility

To understand the process by which institutional modes of air-monitoring constructed data and datasets and to unfold the material practices and agents that constituted this monitoring regime, I will inquire into the monitoring stations at the core of the scandal. I aim to demonstrate how sensing the air to produce quantitative evidence of gases and particles is already a very complex process of composition and recomposition of numbers, a process distributed in time and space. This challenges ideas of instant and objective sensing processes as well as the confinement of sensing as an exclusive physical interaction between bodies. These challenges are relevant to embrace attuned sensing as a sensing practice.

The stations are part of the Air Quality Surveillance System, which belongs to the Integral Air Quality System of Madrid City Council.[2] They contain sensors that measure the concentrations of sulphur dioxide (SO_2), nitrogen dioxide (NO_2), nitrogen oxides (NO), carbon monoxide (CO), particulate matter (PM10), and ozone (O_3), which are the basic components requested by the EU and regulated in Spain through the Real Decreto 717/1987 (Area de Gobierno de Medio Ambiente Madrid, 2006). The stations also measure meteorological data (such as wind speed and direction, atmospheric pressure and rain) and radiation, and some of them measure toluene and benzene.

Measuring these particles is not an instant operation that translated an air out there, but a complex process of interrelated sensing practices that moves beyond the sensors. Measuring the concentrations is achieved by producing physical and chemical transformations in the air, not by comparing their concentrations to a standardized unit of measurement (as in using a meter to measure a distance). It is literally an excitation of environments where, through different types of sensors, the air is stimulated (SO_2),

burned (hydrocarbons) or percolated (PM) (Area de Gobierno de Medio Ambiente Madrid, no date). Numbers are assigned to those physical and chemical operations and then they are calibrated. The data calibration is a calculation process that operates as model-based active sampling, where the system learns from previous measurements, and uses this to optimize the sensing (Rundel et al., 2009). To do so it stabilizes the measurement when it behaves as previous datasets, following EU calibration protocols (European Commission, 2009; Kamionka et al., 2006). Thus the sensing is not only a physical and chemical reaction, but also a process of stabilization of a figure that involves mathematics and statistics, incorporating EU standards, the history of the air at that location or meteorological conditions, among other things. This stabilization process is co-produced by the sensing device, routine technical calibrations by technicians from the City Council, and its Centre of Operations, where the datasets are finally assembled.

In the period at issue, this monitoring made perceptible hourly the concentrations of pollutants in each of the 28 stations distributed across Madrid. These thresholds were collated and publicized through an Air Quality Index, a range from good to bad, to make the measurements understandable for the general public (Citeair I, 2007; Shooter and Brimblecombe, 2009). By publishing them on the City Council's webpage, the data was made – in principle – perceptible and knowable (Harvey et al., 2012). But as Murphy observes, any regime of perceptibility also renders invisible other aspects of the assemblage, making them imperceptible.

As an evidence-based environment, the focus was on the precision of the data (Callon et al., 2009; Murphy, 2006; Shapin and Schaffer, 2011), and its production conditions; the materiality of the sensing infrastructure and the agents involved in the

process were invisibilized. This invisibility was intensified by a politically-led process that not only made some of the monitoring conditions imperceptible, but could be considered a deliberate attempt at producing zones of ignorance (Proctor and Schiebinger, 2008) concerning urban air pollution. The monitoring stations were hidden by transferring some of them to parks (Fraile, 2010) and the structure of the webpage where the data was made public made data comparison difficult, as only one measurement was given per component and station at a time. So the fact that the data was published did not mean that toxicity was necessarily perceived by citizens; to the point that it took some months for Ecologistas en Acción and the parties in the opposition to find out about the changes to the stations. In addition, the communication campaign of the City Council neglected for years the existence or relevance of high levels of gases or particles. This was manifested, for example, by Ana Botella, Chief of Environment Affairs, who became popular for her repeated quotes: 'what bothers people are important issues like unemployment, not air pollution' or 'people should be happy and not worry about air quality' (Sérvulo, 2009; Sevillano, 2011). The City Council also made traffic, the biggest source of air pollution in Madrid, literally invisible, by sinking parts of the city's ring-belt in what became, above ground, the Madrid-Rio park (Europa Press, 2009).

In the monitoring regime of perceptibility, the sensing was carried out by a network of machines, deployed by scientific and governmental institutions, where a whole set of material practices were put into place to obtain the most precise number and to remove the effects of the materiality of the sensors through complex and distributed calibration practices. The monitoring was framed as a techno-scientific process, as a spokesperson of

the City Council Area of the Environment claimed in a communication with the press: 'if the technicians of the city council made that decision [the change of the monitoring stations], it must be because it is the best way of doing it' (Fraile, 2010).

As for climate change or ecological research, air quality monitoring became accountable by connecting environmental sensing with policy making (Miller and Edwards, 2001; Rundel et al., 2009). What monitoring offered was 'evidence of policy action; a solution which has techno scientific credentials; a solution which supports the interests of the environmental health procession; and a solution which offers the prospects of a key resource to local authorities and to the provision of information' (Rydin, 1998: 1440). Therefore, monitoring brought together accounting and policy-making as a form of governing (Asdal, 2011; Barry, 2002; Lidskog and Sundqvist, 2011).

However, the monitoring made it difficult for citizens to contest the data (and therefore the toxicity), as scientific realms can only be contested through another centre of calculation, by their own means and with their own instruments (Latour, 1987). In other contexts, citizens have helped to produce evidence by collaborating in science or policy-making led projects (Callon, 1999; Ellis and Waterton, 2005; Lidskog and Sundqvist, 2011). Citizens have also produced counter-evidence, as in the developing field of citizen science, where citizens have built and deployed inexpensive sensors themselves (Aoki et al., 2008; Braschler, 2009; Gabrys et al., 2016) – and even though citizen science may expand environmental sensing to environments that acknowledge other sensitivities, such as electromagnetic radiation waves for instance (Tironi and Criado, 2015), it still relies on quantitative evidence. Others have used art or activist projects to make the quantitative data visible (Kuchinskaya, 2017).

Drawing on the analysis of the Chernobyl radiation disaster, Olga Kuchinskaya has suggested that data is political when it is produced by experts and made visible – which makes sense in the case of Chernobyl, where there was a refusal to produce quantitative evidence to avoid political responsibility (2014). However, in cases like Madrid, where there is already enough data about the pollution of the air, the backdrop of relying only on the visibility of quantitative data to gain political power is twofold. First, the quality and quantity of data are limitless, as actors can always argue that data is not good or insufficient, and hence delay action. Second, it translates to citizens the responsibility to act, either by managing their own health by paying attention to the Air Quality Index, or by reducing emissions, as the spokesperson of the City Council Area of the Environment suggested: 'it is citizens, who have to be aware of the problem and make a more reasonable use of cars' (Gonzalez and Sevillano, 2010).

Taking Ranciére's definition of politics as a distribution of the sensible – as the condition of possibility of perceiving and therefore acting (2004) – it could be argued that pivoting the debate and battles of toxicity solely around gas concentrations de-politicizes air pollution, as it diminishes the possibilities for action for actors who may not have the technological knowledge or scientific means to refute or produce counter evidence. Instead of (or as well as) making data visible, it is productive to specify, situate and differentiate the toxic, and make visible other qualities of it.

Emerging attuning practices with the toxicity of the air.

No matter how strongly the City Council worked on making pollution invisible, for the media, if Madrid was not complying with EU limits then Madrid's air was toxic

(Gonzalez and Sevillano, 2010). This triggered a whole set of actions that could be understood as sensing practices, because they made other conditions of Madrid's air visible and accountable. These actions constituted a different regime of perceptibility, which embraced other activities, materials, instruments or devices, and criticized or opened up the monitoring regime. Looking at some of these instances enables us to unfold how different people and collectives connected to the toxic air through atmospheric attunements, engaging with material practices and sensing and politicizing – distributing what can be perceived – other aspects of the air.

Political parties in the opposition, like PSOE or Equo, among all the issues that the scandal brought to the fore, attuned to the change of location of the monitoring stations. Discussions about which and where air components should be sensed confronted the need to monitor new gases or to continue monitoring the same ones, in order to maintain consistency in the datasets. The City Council claimed that the change – removing some stations and moving the existing ones to 'less urbanized areas and with trees' (Sérvulo, 2009) – had been made to comply with EU suggestions to, for example, increase the variety of types of monitoring stations (traffic, industrial or background) and the components measured (adding ozone and smaller sized particles PM2,5). Their opponents argued that, if in Madrid more than 77% of air pollution comes from traffic, most stations should monitor this type of pollution (Fraile, 2010). Geo-social aspects of what it is important to measure confronted the centre and periphery, the urban fabric and population density. By attuning to the monitoring process, the political parties sensed socio-economic and demographic implications of Madrid's polluted air and how it is distributed in relation to urban density. Through political opposition, they made visible

how decisions about where or which air needed to be monitored could not be resolved through regulatory criteria alone, nor through more transparent processes, as the usual responses in the monitoring regime were.

The Regional Federation of Neighborhood Associations (FRAVM), together with Ecologistas en Acción, also attuned to the physical infrastructure of air quality monitoring, and in particular cared about their specific location of the monitoring stations in public spaces. Referring to a recently eliminated monitoring station that used to be next to a playground, they argued that the City Council should 'preserve the health of Madrilenians, but most importantly, of the youngest' (Fraile, 2010), while headlines in the leading paper quickly dramatized this potential violence against the youth: 'Luca de Tena: the station disappears, pollution and kids stay' (Fraile, 2010). Toxicity was, for this association, not so much about pollutants as about environmental injustice, sensing the unequal effects of air pollution at that specific square. They temporarily transformed the public space, displaying a sign that informed people about the bad air quality at that location: 'Breathing is bad for our health', 'Danger, area with polluted air', and 'Demand solutions of the City Council' (Ecologistas en Acción, 2010).

The environmentalist NGO Ecologistas en Acción, involved for many years in monitoring the City Council's policies and producing the only independent annual reports on air pollution in the city, attuned to the lack of action of the City Council in activating abatement policies. Ecologistas en Acción sued the Mayor and the Representative of the Area of the Environment was charged in the Penal Court with crimes against the environment, typified in article 325 of the Penal Code, which punishes whoever pollutes the environment directly or indirectly with jail and professional censure (V.T.B., 2011).

Ecologistas extended toxicity from the health of humans to the health of the whole environment, making accountable the impact to more-than-humans and offering a less anthropocentric form of living.

Existing collectives were already attuned to air pollution, such as the neighbourhood association Afectados Nudo Sur. It attuned to a ventilation opening of the Madrid Rio underground highway located in its neighbourhood EFE (2010). The city average did not matter much to Afectados; it sensed the impact of large infrastructures on the local neighborhood's air. The risk and uncertainty of the emissions emerging from that hole in the ground prompted the association to complain to the City Council, and after some unfruitful attempts through the institutionalized protocols of citizen participation, it offered to develop an air quality information app in exchange for solving this very specific infrastructural problem. For Afectados, toxicity was about the uneven distribution of pollution, making visible that sinking a highway does not eliminate, but only displaces, air pollution.

A woman who had a personal blog about the city's festivities and picturesque hidden places, suddenly wrote a blog post about air pollution in 2012. Her opening to a long and detailed post, where she described the sequence of events of the scandal, read: 'While the Mayor keeps neglecting the high levels of pollution of Madrid's air, there are others who do care for the cloud of air pollution' (Madrileña, 2012). After going through the keystones of the event, quoting the Spanish expert on air pollution Xavier Querol, she argued for a need to define low emission zones, and described in detail the state of the art in Madrid in this regard: 'Even though Madrid has defined low emission zones in the centre of the capital, the only thing it does is to charge 10% more for parking and extend

the parking time by one hour, as well as renovating the public buses that drive in the area. A previous plan, from 2006, did prohibit access to polluting cars, but was never put into action'. She sensed the differences between different deployments of low emission zones, discussing what makes them effective – how it is not only about increasing parking prices and renovating buses, but also impeding the access of 'dirty cars'. Toxicity became about mobility and urban planning. And yet Madrileña not only focused on an issue that involved the air, but also contributed to thinking about ways of living in the city and our daily lives: as the price of public transport is related to the toxicity of the air through emissions, it is also a fundamental factor in regard to the distribution of social justice and equality in the city, job flexibility and other issues that affect how people dwell and relate to each other.

These disparate actions – from parliamentary debates, NGO protests and court actions, individual protests and blog posts – used different knowledge production devices and had different political aims. I consider them to constitute a regime of perceptibility because they did not produce independent data as counter-evidence to the City Council's figures as a form of contestation, nor did they strictly denounce the changes in the locations of the stations. They were attuned to practices of monitoring, to the trickery of the council and to urban infrastructures. They shifted the attention from the quantitative to other aspects of the toxic, such as for whom is air pollution toxic, which airs public institutions need to monitor, or what kind of air is needed at public infrastructures such as playgrounds. My objective here is not to systematize these practices, nor to identify a unifying pattern, nor to discuss the larger claims or aims of these groups or individuals. Distinctive here is how toxicity was qualified, to what it was related, the types of actions

engaged in, and the synergies created with less visible forms of action (Bellacasa, 2017).

Materially aware accounts of issue formation have demonstrated how citizens have intervened in the air by acting with or through objects (e.g. Barry, 2013; Estalella and Corsín, 2016; Marres, 2011, 2012). Other inquiries have shown how significant issues like climate change, for instance, have been relocated and entangled in everyday activities, as the only means to produce awareness and behavioural change (Latour and Weibel, 2005; Macnaghten, 2003; Miller and Edwards, 2001, 2011). In other contexts, citizens have acted through intimate caring practices for others or the environment (Lyons, 2018; Tironi, 2018). In health-related contexts, different actors, through a wide range of practices, have produced different types of knowledge as forms of evidence-based activism (Rabeharisoa et al., 2014). And yet, compared to installing an ecometer in a teapot or embodied practices such as gardening, what emerged through the scandal was a range of shorter-term and isolated forms of paying attention to toxicity, including through ephemeral and uncoordinated actions in the public sphere. These activities, whether independent or collective, provided specificity and differentiation to the toxicity of the air. That specificity pointed to spaces, bodies and objects that mattered in Madrid's air as spaces for immediate action, but also manifested how toxic air is not only about air concentrations, but is also about urban planning, public infrastructures and institutional politics. This is a form of knowledge production, but in a less-conscious or less-organized manner than in, for example, counter-evidence activism.

The attuned sensing regime of perceptibility

All of these practices configured a different regime of perceptibility than the monitoring one, what I am calling an 'attuned sensing' regime, which produced other forms of citizen relations with toxicity. Toxicity was sensed by politicians, associations and individuals through different atmospheric attunements, where citizens did not sense the toxic air directly (either with sensors or in embodied ways). They attuned to the monitoring infrastructure, to the trickery of the City Council, to their abatement policies, or to larger urban planning strategies. These attunements were modes of relating to toxicity that exceeded critique of the city's monitoring practices, as they also sensed qualitative aspects of toxicity, such as where, for whom or how toxicity is toxic. The result allowed the emergence of – and therefore the making sensible of – the air's chemical infrastructure. Madrid's toxic air became not only about concentrations of NO_2 or other gases or particles, nor about the issue of air pollution as a whole, but about specific and situated conditions of it, such as the location of the stations, the price of public transport, or the right to access public infrastructure. The actors not only made visible, but also intervened: They sued, programmed, wrote blog posts, etc., things that are normally not considered forms of engagement in environmental issues.

Politics of accumulation and stimulation

The practices of the new regime of perceptibility look small and unrelated, but their political potential emerged when considered all together. They gained power through the 'politics of swarming' (Connolly, 2017), where actions acquire political capacities by inspiring, stimulating or being coordinated with other actions.[3] In Connolly's terms: 'the politics of swarming, then, is composed of multiple constituencies, regions, levels,

processes of communication, and modes of action, each carrying some potential to augment and intensify the others with which it becomes associated' (Connolly, 2017: 125). In Madrid, various actions created an atmosphere of awareness, critique and contestation in the public sphere, which included proposals on what should be collectively discussed, how monitoring stations should communicate their data or what the best low emissions zone is. Actors operated through contagion, without coordination. And although they did not change the composition of the air, they made the air in Madrid a public object of interest, and people started speaking about it on the streets. It could be argued that, among many other micro-practices, they laid the ground for a public discussion about air pollution to take place, initiating a process of collective awareness that has enabled the current city council to address air pollution as one of its priorities.

The swarming accumulation had other effects. It politicized the air's chemical infrastructure, as well as qualitative conditions of the air. From the average that makes the city legally accountable, attuned sensing redistributed who could speak about pollution: from scientists to professional politicians, activists or independent citizens – without levelling them either as experts or as lay people. This event also challenged participation in environmental politics as something permanent and coordinated, as in revolts or planned activism. Here, participation was spontaneous, sometimes individual, sometimes collective, and only sometimes organized, taking place only once, as compared to daily routines of material participation (Macnaghten, 2003; Marres, 2012; Marres and Lezaun, 2011). It temporarily redistributed what was accountable with respect to the toxicity of the air, from the concentrations of gases to environmental justice or urban planning. There was a politics of redistribution among different agents, to which

Ecologistas en Acción called attention, which enabled other entities such as more-than-humans to participate in forms of living together that are not about consensus, but cohabitation. The swarming also redistributed the instruments that are objects of politics: from sensors and data to everyday objects that acquire temporary political capacities, such as a sign on a fence, a blog or a suit.

Thinking about toxic air relations through 'attuned sensing' seeks to 'question before the question' (Shapiro et al., 2017). It seeks to move away from 'how much' to 'what' or 'why', to find other modes of dealing with polluted air. The perspective is productive because it does not confront different forms of environmental response, but makes visible the value of disconnected and heterogeneous practices, acknowledging the value of all of them, from legal processes for environmental injustice to evidence-based knowledge production practices, app design and blog writing, which acquire relevance precisely in their accumulation. More or less spontaneous and non-coordinated, it is relevant to understand them as forms of sensing because each of them perceived the scandal and made other aspects of the toxicity of the air (its causes and effects and its chemical infrastructure) visible and accountable.

Another way of looking at these sensing practices is that they open up spaces for intervention for citizens and different actors to work politically on air pollution. This is because the issues raised are as much aspects of toxicity as their politicization, which shows how intervening in the environment can be carried out in ways other than producing quantitative counter-evidence. Some actors made visible other questions, such as how to deal with the tension of having more vulnerable bodies (who in this case are not distributed in relation to economic or racial factors, as in many social justice

environmentalisms) where there is more pollution. Should these areas be monitored more? How do we collectively want to manage this tension? By preventing certain bodies from accessing polluted areas, as Air Quality Indexes suggest, or by having some areas that are cleaner than others? Which impacts on which bodies should be considered important and therefore accountable?

Conclusions

Air pollution is in general made knowable and legally accountable through techno-scientific monitoring processes based on quantitative data. Looking at how the monitoring stations in Madrid produced this data, we have seen how data are not a direct translation of air into numbers, but an assemblage of practices, objects, spaces and actors. They constitute a specific regime of perceptibility that makes visible concentrations of gases and particles, while hiding their whole sociotechnical assemblage. In this monitoring regime, toxicity is defined as a quantitative relation to human health, and is made political through policy making.

   The scandal in Madrid provoked a set of citizen actions that not only sensed the political (mis)management of air pollution, but also sensed other aspects of toxicity. I have named these practices 'attuned sensing', with the aim of expanding the ways in which toxicity is sensed outside of monitoring practices. This 'attuned sensing' configured its own regime of perceptibility, which did not produce evidence of whether or not the air was toxic in quantitative ways, but enabled toxicity to be spatialized, differentiated and specified.

Even if these 'attuned sensing' practices were very different in their social configuration, epistemic tools and political aims, they acquired power by the possibilities of contagion from one another, to produce a larger change. In Madrid, they politicized the polluted air as a social and political problem. They also politicized the qualitative conditions of the toxic air, and redistributed toxicity from science and policy making environments to less institutionalized realms: Who can speak about the toxicity of the air, or the practices that count as knowledge-making and engagement with the environment? But most importantly, all of these redistributions, even if only temporary, showed how there are more spaces for citizen intervention than monitoring, such as the collective decision about the location of the monitoring stations, or the discussion on how to deal with environmental injustice. They also offered insights about possible ways of living together with the toxic that may not be restricted to gases or particles, but include environmental justice, urban planning and public infrastructures. Therefore, regardless of the efforts of some agents to make toxicity invisible, through apparently small and disconnected interventions that pay attention to other conditions of air pollution we can act politically in the toxic air.

Acknowledgments

References

Aoki, P., Honicky, R. J., Mainwaring, A., Myers, C., Paulos, E., Subramanian, S. and Woodruff, A. (2008) Common Sense: Mobile Environmental Sensing Platforms to Support Community Action and Citizen Science, *Human-Computer Interaction Institute*. Available from: http://repository.cmu.edu/hcii/201 (Accessed 26 June 2013).

Area de Gobierno de Medio Ambiente Madrid (2006) *Estrategia Local de Calidad del Aire de la Ciudad de Madrid 2006-2010*.

Area de Gobierno de Medio Ambiente Madrid (no date) Analizadores y Técnicas de Análisis. Available from:http://www.mambiente.munimadrid.es/opencms/export/sites/default/calaire/Anexos/aparatos_de_medida.pdf (Accessed 26 June 2013).

Asdal, K., (2008). Enacting things through numbers: Taking nature into account/ing. *Geoforum* 39, 123–132.

Barry, A. (2002) The anti-political economy, *Economy and Society*, 31 (2), pp. 268–284.

Barry, A. (2013) *Material Politics: Disputes Along the Pipeline*. 1 edition. (Chichester, West Sussex: Wiley-Blackwell).

Braschler, B. (2009) Successfully Implementing a Citizen-Scientist Approach to Insect Monitoring in a Resource-poor Country, *BioScience*, 59 (2), pp. 103–104.

Callon, M. (1999) The Role of Lay People in the Production and Dissemination of Scientific Knowledge, *Science ,Technology & Society*, 4 (1), pp. 81–94.

Callon, M., Lascoumes, P. and Barthe, Y. (2009) *Acting in an uncertain world. An essay on technical democracy*. (Cambridge, London: The MIT Press).

Chen, M. Y. (2012) *Animacies. Biopolitics, Racial Mattering and Queer Affect*. (Durham and London: Duke University Press).

Choy, T. K. (2011) *Ecologies of comparison: an ethnography of endangerment in Hong Kong*. (Durham, N.C.: Duke University Press).

Citeair I (2007) Comparing Urban Air Quality Across Borders. European Union.

Conolly, W. E. (2017) *Facing the Planetary: Entangled Humanism and the Politics of Swarming*. North Carolina: Duke University Press.

De la Bellacasa, M. P. (2017) *Matters of Care: Speculative Ethics in More Than Human Worlds*. Mineapolis, London: University of Minessota Press.

Ecologistas en Acción (2010, March 18) Luca de Tena: la estación desaparece, la contaminación y los niños permanecen, *Afectados Nudo Sur*. Available from: http://www.afectadosnudosur.com/nudosur/index.php?option=com_content&view=article&id=406:luca-de-tena-la-estacion-desaparece-la-contaminacion-y-los-ninos-permanecen&catid=37:medioambiente-noticias&Itemid=264 (Accessed 6 February 2016).

EFE (2010) Nudo Sur se 'ofrece' a Gallardón para informar sobre polución, *Afectados Nudo Sur*. Available

from:http://www.afectadosnudosur.com/nudosur/index.php?option=com_content&view=article&id=504:nu
do-sur-se-qofreceq-a-gallardon-para-informar-sobre-polucion&catid=37:medioambiente-
noticias&Itemid=264 (Accessed 12 June 2016).

Ellis, R. and Waterton, C. (2005) Caught between the Cartographic and the Ethnographic Imagination: The
Whereabouts of Amateurs, Professionals, and Nature in Knowing Biodiversity, *Environment and Planning
D: Society and Space*, 23 (5), pp. 673–693.

Estalella, A. and Corsín, A. (2016) Matters of Sense: Preoccupation in Madrid's popular assemblies
movement, in: Blok, A. and Farias, I. (eds.) *Urban Cosmopolitics: Agencements, Assemblies, Atmospheres*.
London, New York: Routledge, pp. 147–163.

Europa Press (2009, December 9) La nueva red de medición de la contaminación atmosférica obtendrá
niveles un 25% inferiores a los actuales, según PSOE, *EcoDiario.es*. Available from:
http://ecodiario.eleconomista.es/espana/noticias/1759396/12/09/La-nueva-red-de-medicion-de-la-
contaminacion-atmosferica-obtendra-niveles-un-25-inferiores-a-los-actuales-segun-PSOE.html (Accessed 6
August 2016).

European Commission (2009) National Air Quality Reference Laboratories and the European Network
(AQUILA). Available from: http://ec.europa.eu/environment/air/quality/legislation/pdf/aquila.pdf
(Accessed 26 June 2013).

Fraile, O. (2010, January 21) El Consistorio de Madrid aleja del tráfico las estaciones medidoras de
polución, *20minutos.es*. Available from:
http://www.20minutos.es/noticia/611254/0/alejan/medidores/polucion/ (Accessed 6 February 2016).

Gabrys, J., Pritchard, H., Calvillo, N., Shapiro, N. and Keene, T. (2016) Becoming Civic: Fracking, Air
Pollution, and Environmental Sensing Technologies, in: Gordon, E. and Mihailidis, P. (eds.) *Civic Media:
Technology, Design, Practice*. (Cambridge, Mass: The MIT Press).

Gabrys, J., (2012). Sensing an Experimental Forest: Processing Environments and Distributing Relations.
Computational Culture. Available from: http://computationalculture.net/article/sensing-an-experimental
foresthttp://computationalculture.net/article/sensing-an-experimental-forest processing-
environments-and-distributing-relations (Accessed May 31, 2013).

Garnett, E. (2016) Developing a feeling for error: Practices of monitoring and modelling air pollution data ,
Big Data & Society.

González, J. S. and Sevillano, E. (2010) Madrid 'reduce' la contaminación cambiando la forma de medirla,
EL PAÍS. Available from: http://elpais.com/elpais/2010/11/11/actualidad/1289467026_850215.html
(Accessed 12 June 2016).

Gugliotta, A. (2003) How, When, and for Whom Was Smoke a Problem in Pittsburgh?, in: Tarr, J. A. (ed.)
Devastation and Renewal: An Environmental History of Pittsburgh and Its Region. Pittsburg: University of
Pittsburgh Press, pp. 110–125.

Haraway, D. (2016) *Staying with the Trouble: Making Kin in the Chthulucene*. Durham, NC: Duke
University Press.

Harvey, P., Reeves, M. and Ruppert, E. (2012) Anticipating Failure: Transparency devices and their
effects, *Journal of Cultural Economy*, 6 (3), pp. 294–312.

Hecht, G. (2012) *Being nuclear: Africans and the global uranium trade*. Cambridge, MA: The MIT Press.

Kamionka, M., Breuil, P. and Pijolat, C. (2006) Calibration of a multivariate gas sensing device for

atmospheric pollution measurement, *Sensors and Actuators B: Chemical*, 118 (1–2), pp. 323–327.

Kuchinskaya, O. (2014) *The Politics of Invisibility: Public Knowledge about Radiation Health Effects after Chernobyl*. Cambridge, MA: MIT Press.

Kuchinskaya, O. (2017) Connecting the Dots: Public Engagement with Environmental Data, *Environmental Communication*, 0 (0), pp. 1–12. DOI:10.1080/17524032.2017.1289106.

Latour, B. (1987) *Science in Action*. (Cambridge: Harvard University Press).

Latour, B. and Weibel, P. (eds.) (2005) *Making Things Public: Atmospheres of Democracy*. (Cambridge, Mass.: Karlsruhe, Germany: MIT Press).

Liboiron, M. (2015) Redefining pollution and action: The matter of plastics, *Journal of Material Culture*, pp. 1–24.

Lidskog, Rolf and Sundqvist, Göran (ed.) (2011) *Governing The Air. The Dynamics of Science, Policy, and Citizen Interaction*. (Boston: The MIT Press).

Lyons K (2018)

Madrileña, R. (2012, July 23) Bruselas vigila la 'boina' de Madrid, De Madrid al Cielo. Available from: http://demadridacielo.blogspot.co.uk/2012/07/bruselas-vigila-la-boina-de-madrid.html Macnaghten, P. (2003) Embodying the environment in everyday life practices, *The Sociological Review*, pp. 63–84.

Marres, N. (2011) The cost of public involvement Everyday devices of carbon accounting and the materialization of participation, *Economy and Society*, 40 (4), pp. 510–533.

Marres, N. (2012) *Material Participation: Technology, the Environment and Everyday Publics*. (London: Palgrave Macmillan).

Marres, N. and Lezaun, J. (2011) Materials and devices of the public: an introduction, *Economy and Society*, 40 (4), pp. 489–509.

Mendez, R. (2011, January 29) El fiscal tumba el ardid de Gallardón para enmascarar la contaminación, *EL PAÍS*. Available from: http://elpais.com/diario/2011/01/29/sociedad/1296255604_850215.html (Accessed 6 February 2016).

Miller, C. A. and Edwards, P. N. (eds.) (2001) *Changing the Atmosphere: Expert Knowledge and Environmental Governance*. (Cambridge, Mass: The MIT Press).

Mol, A. (2002) *The Body Multiple: Ontology in Medical Practice*. (Durham and London: Duke University Press).

Murphy, M. (2006) *Sick Building Syndrome and the Politics of Uncertainty: Environmental Politics, Technosience and Women Workers*. (Durham: Duke University Press).

Murphy, M. (2013) Chemical Infrastructures of the St Clair River, in: Boudia, S. (ed.) *Toxicants, Health and Regulation since 1945*. Pickering & Chatto, pp. 103–116.

Nixon, R. (2011) *Slow Violence and the Environmentalism of the Poor*. (Cambridge, Mass: Harvard University Press).

Proctor, R. N. and Schiebinger, L. (eds.) (2008) *Agnotology:The Making and Unmaking of Ignorance*. Stanford: Stanford University Press.

Rabeharisoa, V., Moreira, T. and Akrich, M. (2014) Evidence-based activism : patients' organisations, users' and activist's groups in knowledge., *BioSocieties.*, 9 (2), pp. 111–128.

Rundel, P. W., Graham, E. A., Allen, M. F., Fisher, J. C. and Harmon, T. C. (2009) Environmental sensor networks in ecological research, *New Phytologist*, (182), pp. 589–607.

Rydin, Y. (1998) 'Managing Urban Air Quality': Language and Rational Choice in Metropolitan Governance, *Environment and Planning A*, 30 (8), pp. 1429–1443.

Schrader, A. (2010) Responding to Pfiesteria Piscicida (the fish killer): Phantomatic Ontologies, Indeterminacy, and Responsibility in Toxic Microbiology, *Social Studies of Science*, 40 (2), pp. 275–306.

Sérvulo, J. (2009, May 18) Botella justifica en una directiva la supresión de medidores de polución | Edición impresa | EL PAÍS, *EL PAÍS*. Available from: http://elpais.com/diario/2009/05/18/madrid/1242645857_850215.html (Accessed 6 August 2016).

Sevillano, E. (2011, October 9) Madrid, a su aire, *EL PAÍS*. Available from: http://elpais.com/diario/2011/10/09/madrid/1318159454_850215.html (Accessed 6 February 2016)

Shapin, S. and Schaffer, S. (2011) *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*. With a New introduction by the authors edition. (Princeton, N.J: Princeton University Press).

Shapiro, N. (2015) Attuning to the Chemosphere: Domestic Formaldehyde, Bodily Reasoning, and the Chemical Sublime, *Cultural Anthropology*, 30 (3), pp. 368–393.

Shapiro, N., Zakariya, N. and Roberts, J. (2017) A Wary Alliance: From Enumerating the Environment to Inviting Apprehension, *Engaging Science, Technology, and Society*, 3 (0), pp. 575–602.

Shooter, D. and Brimblecombe, P. (2009) Air quality indexing, *International Journal of Environment and Pollution*, 36 (1/2/3), pp. 305.

Stewart, K. (2011) Atmospheric Attunements, *Environment and Urban Planning D: Society and Space*, 29, pp. 445–453.

The Council of the European Union Council Directive 96/62/EC of 27 September 1996 on ambient air quality assesent and management, , Pub. L. No. Council directive 96/62/EC (1996). Available from: http://ec.europa.eu/environment/air/quality/legislation/directive.htm (Accessed 6 February 2016).

Tironi M (2018)

Tironi, M. and Sánchez Criado, T. (2015) Of Sensors and Sensitivities, *Italian Journal of Science & Technology Studies*, 6 (1), pp. 89–108.

V.T.B. (2011, November 2) Ecologistas demanda a Gallardón por un delito contra el medio ambiente, *EL PAÍS*. Available from: http://elpais.com/elpais/2011/02/11/actualidad/1297415823_850215.html (Accessed 6 August 2016).

Author biography

Nerea Calvillo is Assistant Professor at the Centre for Interdisciplinary Methodologies at the University of Warwick. Her interests are at the intersection between architecture,

science and technology and feminist studies, new materialisms and urban political ecologies. She investigates the material, technological, political and social dimensions of environmental pollution. This has led her to analyze notions of toxicity, digital infrastructures of environmental monitoring, smart cities, and feminist approaches to sensing the environment. Lately her interests have translated into studies of pollen and how they contribute to queer urban political ecologies.

Notes

[1] I am suggesting an ontological turn that requires other epistemic practices. If the questions I am asking are what, for whom, and how – instead of how much – toxicity, they require other forms of knowing, because institutional monitoring sensors only tell us how much.

[2] Dirección General de Calidad, Control y Evaluación Ambiental, Historia de la Red de Vigilancia. Available from: www.mambiente.madrid.es/historia_svcaam.pdf (Accessed February 22, 2012). The current network seems to be quite similar to the one in 2009. However, as in the City Council's current webpage at the time of writing there is less technical information about the network, the paper will focus on the time of the episode. It is also worth noting that the description made is specifically of the Madrid's Air Quality Surveillance System. Even though all the networks in the EU share the same protocols, there are differences, which is why the description made cannot be generalized. And last, since 2015 with a change in the City Council's government, air pollution has become a major political issue, and stronger measures are being set in place.

[3] I take the word 'swarming' from Connolly. Even though I find problematic the use of references from biology to describe social issues (and even more in such a generic way as Connolly does), his 'politics of swarming' is very helpful to renegotiate how the environment and politics come together. What may look as a deficiency from other understandings of politics (intermittent, unstable and uncoordinated actions), acquires capacities in this form of organization.