China's Air Pollution Meets Public Participation and Citizen Science

Abstract

This article discusses how China's new era of air pollution control has provoked the engagement of groups of urban residents and nongovernmental organisations (NGOs) to adopt citizen science and disseminate technoscientific knowledge. Their actions include sharing photographic records, posting scientific evidence online, testing air purifiers and air pollution masks and reporting data results from low-cost sensors. The interviews with the leaders of these initiatives show the changing patterns of pollution activism in the country and the civic and resistance approaches that have displayed technoscientific knowledge. Following recent work of citizen science as resistance and Chinese studies on pollution activism, the civic adoption of scientific knowledge and technological devices is presented as instrumental to activists but also problematic to navigate through the complex participative context of the country. The dynamism of the actions, first marked by the mistrust of official data and then expanding to other agendas, brings a novel approach about resistance in the context of environmental health crisis in China.

Keywords: air pollution in China, resistance, pollution activism, citizen science, public participation

Introduction

The year 2008 brought to China the Summer Olympics (hereinafter 'the Olympics') in Beijing and inaugurated a new kind of citizen awareness about air pollution. The commitment of the central and local governments with the International Olympic Committee to clear the skies during the sport event popularised the political statements explaining the issue, increased media attention, and contributed to the implementation of new regulations. Chinese citizens, who in the past had some concerns about air quality and some notion about the official management, started to receive, diffuse, and produce more information about the problem.

In the years after the Olympics, the seed of public engagement grew higher for nongovernmental organisations (NGOs), netizens, start-ups, and academics who diversified the understanding of air pollution to areas that were not a priority in the past, such as health, air quality standards, type of pollutants, the use of air purifiers, protection masks, testing, and monitoring devices. The diversity of actions, mistrust to the official information, and use of scientific information and technology were mark of their actions to bypass the governmental prosecution. Their pressure produced changes in the political role of citizens towards pollution and pressure to enforce a new air quality monitoring system and regulatory standards (Ho & Nielsen, 2013; Lin & Elder, 2014; Zhao et al., 2015).

Most of the citizens and organisations that introduced alternative information sources about air pollution now agree that the official information is reliable and that 'things have changed'. They consider that air quality activism was key to achieve positive changes, but now is time for other actions. In general, they propose to engage in air pollution awareness in areas like indoor pollution or wearable devices.

In this article, we expose the case of citizens engaging China's air pollution awareness, through citizen science and the popularization of knowledge. The analysis results from two sources: 1. The documentation of the media coverage about air pollution events in the country between 2008 and 2013, and 2. Interviews of citizens and NGO representatives, made between January 2015 and September of 2015. Our aim is to continue the discussion of the role of citizen science as a resistance (Kullenberg, 2015; Ottinger, 2010a), applied in the context of China's environmental citizen activism (Lora-Wainwright, 2013; Van Rooji, 2010). We discuss diverse ways of public engagement with air pollution through the 'civic' use of technoscientific knowledge (Corburn, 2005; Fortun & Fortun, 2005; Jalbert, 2016; Wylie et al., 2014). We also focus on the popularisation of knowledge about air pollution and the adoption of testing and monitoring instruments. All these elements were key to providing a 'safe space' of participation for citizens and NGOs in China. In that regard, we question the official 'domestication'

of activism generally associated with the Chinese environmental agency (Ho & Edmonds, 2008; Li & O'Brien, 2008).

New Forms of Environmental Governance in China

Official air quality and environmental management

During the last four decades, China's sustained economic growth has produced an unprecedented material wealth, lifting millions of people from poverty levels. This development has caused, however, a very complex environmental health crisis (Holdaway, 2010). China is the world's largest emitter of carbon dioxide (CO2) (WRI, 2015), mostly as a result of its heavy reliance on fossil fuel consumption, where coal represents about 70% (IEA, 2009).

Air pollution is one of the most visible effects of China's development, affecting large areas of the country and impacting health (Zhu et al., 2013), environment, and the economy (Ho & Nielsen, 2013). In 2013, China's premier, Li Keqiang, declared a 'war against air pollution' (Wong & Buckley, 2015) to tackle comprehensively the problem. Accordingly, the 'war' will continue until 2030, when China should attain the World Health Organization's standards on air pollution. The road to accomplish it remains slow and difficult. In 2014, only eight in 74 cities attained national air quality standards (MEP, 2015).

China's air pollution is not a recent phenomenon. It dates back to the foundation of the country in 1949, with the effects of the reconstruction of the country through a Soviet model known as the 'Big Push Industrialization' (Naughton, 2007). This model produced the first ecological excesses of the triad of socialist planning, heavy industry, and land exploitation (Shapiro, 2001). During the 'Great Leap Forward' (1958-1960), the country witnessed the first peak of particulate pollution (PM) and sulphur dioxide (SO2), when 'millions of so-called "backyard furnaces" flourished all over China in an ill-fated attempt to produce the much-needed steel for the nation' (Fang et al., 2009: 80).

It wasn't until the 1970s that China made the first steps to manage air pollution. As a newcomer to the United Nations (UN) stage, China ratified the declaration of the Stockholm Conference of 1972. Environmental problems, air pollution included, were circumscribed as economic, knowledge-based, and management issues (He et al., 2012). This modern environmental management came in a key moment of the history of the country, that is, the verge of transitioning from socialist central planning to a socialist market economy, known as the 'Chinese Economic Reform of 1978' (hereinafter 'Opening-Up').

Arguably, the Stockholm Conference and the Opening-Up have shaped the basis of China's environmental arena on institutional, legal, and management fronts (He et al., 2012: 30).

Carter & Mol (2007) argue that during the last four decades China has witnessed a process of ecological modernisation, characterised by: (1) the transition from socialist economy to market economy, and (2) the institutional and legal reforms to manage the environment. In this transition, the government has presented civil society as a crucial actor for environmental governance, but, in reality, the studies show the enormous limits of the exercise of critical citizenship in the forms of decision-making or open-access of environmental information (Mol, 2006; van Rooji, 2010; Wu, 2009). Although important steps have been made towards transparency, the disclosure of information, and public participation (Jun, 2008; Zhang & Cao, 2015), there is evidence of problems of misreporting, faking data, secrecy, and opposition at local levels (Andrews, 2009; Ghanem & Zhang, 2014; IPE & NRDC, 2015).

The main approaches of the country's laws, plans, and policies towards the prevention and control of air pollution (PCAP) framework are top-bottom and command-and-control (Feng & Liao, 2016). Because of that, restricted political space has been left to the citizens and non-traditional actors (e.g. academics, NGO, and enterprises) to know about air quality data or influence the policy and decision-making of PCAP. It was only after the inclusion of China in the World Trade Organization (WTO) in 2001 and a series of domestic laws (i.e. the Cleaner Production and Promotion Law of 2003) introducing sustainable development and wider legal rights (He et al., 2012) that the political context favoured the role of citizens and NGOs.

Environmental pollution activism

The literature about citizen participation and environmental crisis in China has focused on the ways in which people have engaged in actions and demands to the government for effective governance. Two complementary concepts have been embraced in recent studies. The first is 'rightful resistance' (Li & O'Brien, 2008), which explains how Chinese citizens framed their actions and language upon the governmental boundaries and discourses to legitimise their demands. The second is 'embedded activism' (Ho & Edmonds, 2008), which presents a 'respectful' civil society that does not confront directly the government.

The two concepts face some problems. First, the growing numbers of demonstrations and protests in the last decade (Gardner, 2014) have been diversified in geographical areas, actors, and methods (van Rooji, 2010). Second, the two concepts have mainly been used in conflicts of middle class-urban settlers within

a strong presence of governmental institutions. The situation might be different in the case of rural areas affected by pollution. Ethnographic works (Lora-Wainwright, 2013; Deng & Yang, 2013) have shown that Chinese rural areas affected by pollution are confronting it through resistance and citizen agency, and also, paradoxically, through trade-offs between pollution victims and polluting industries. Environmental activism does not follow the stereotype of environmental awareness coming after subsistence needs have been accomplished (Lora-Wainwright, 2013: 48). Moreover, villagers allow polluters to co-exist, strategically blaming other issues due to economic interests, in a phenomenon called 'piggybacking on other grievances' (Lora-Wainwright, 2013: 248).

The evolution of wide public engagement of air pollution in China has characteristics of embedded activism, rightful resistance and piggybacking on other grievances. During the last couple of years, the diversification of expressions towards the topic cannot be interpreted flatly as a middle class-urban struggle. As we will see in the examples of citizen science and popularisation of air quality science in China, the role of the internet (especially social media), the timing of actions (very short or short rather than long-term) and the actors (a synthesis of experts and engaged activists) makes the public engagement of air pollution a very difficult topic to frame.

In that regard, this article adopts the lenses proposed by Van Rooji (2010) of looking in detail at the 'isolated activism' in China. After analysing political and legal actions of pollution victims in China, Van Rooji argues that this type of activism occurs so often that it has become a 'developing form of social action', which should be a reason to make it a topic of research. Johnson's (2010, 2013) research of 'not in my back yard' (NIMBY) trend in the environmental activism in China could be seen as a potential example of Van Rooji's call. NYMBYism has the property of explaining the grey areas in which Chinese citizens understand and complain about specific environmental topics in present-day China. It is supported by NGOs, good relations with local officials, scientific knowledge, and proactive actions. NYMBYism faces problems of reaching broader audiences, sustained influence in decision-making, and transcending local matters.

Air pollution as a public matter

Beijing Olympics and the popularization of air quality politics

In 2008, Beijing held the Olympics and its administration was committed by the International Olympic Committee to work on the air quality prior to and during the event (Ramzy, 2008). With the management of air pollution as a background, the Olympics triggered the legitimation of knowing and talking about

air quality within different levels of society and at a national scale. The media played an important role in setting the tone of the agenda. Coverage about the topic increased (Kay et al., 2014) and condensed two types of messages: (1) an explanatory approach about what was air pollution ('popularising the topic'), and (2) a supportive approach toward the official strategies of preventing and controlling air pollution ('legitimation of the topic'). On 4 May 2008, almost two months before the Olympics, the official state media, Xinhua, released a report about air pollution. Among the people interviewed, Wang Qiang, professor and member of the China Meteorological Administration explained, 'The reason why Beijing's five or six surrounding provinces are having a prevention plan (on air pollution) is because Beijing's air pollution is not an exclusive problem, but a regional one. Air pollutants can travel from surrounding regions to Beijing!' (Xinhua, 2008). When talking about how China has reported fog (雾) as a weather condition, he reminded that it could have been misleading because most of the times the weather condition was actually haze (霾): 'Fog (雾) and haze (霾) have ambiguous and complex relation, and we have been busy to not explain the public about it. The current weather report is shallow. It describes foggy days when in fact are hazy days the most common' (Xinhua, 2008).

Just before the Olympics, the pressure on China increased, especially from the international community (Hooker, 2008). The media closed ranks, spreading the official discourse about measures, standards, and regulations. On 26 June 2008, the Beijing Environmental Protection Bureau (BEPB) sub-director stated, 'According to the 14 stages of Beijing's Air Pollution Plan, the 200 measures have been accomplished, together with the temporary emission reductions for the Games. I believe Beijing will attain the air quality standards during the Olympics' (Xinhua, 2008b).

Indeed, the air quality during most of the days of the Olympics attained Chinese standards (Rich et al., 2015). Radical measures, such as shutting down industrial facilities of the city and surrounding region and limiting the circulation of private cars (based on the 'odd-even number' on their plates), were key contributors to the temporal good air quality (Rich et al., 2015). Nonetheless, as soon as the Olympics ended, the air levels of pollution returned to their historical levels (Spencer, 2008).

The US Embassy incident

Mistrust of official air quality monitoring and the resulting data were two topics that rapidly escalated in the netizens forums. Before the Olympics, the government used to report in two ways, through indices and criteria pollutant records used by experts and policymakers, and through public information in the form of blue-grey skies (blue for good air quality, grey for polluted) (Andrews, 2009). The official reports

were published on some governmental websites, but with little accessible and relevant information for the public (Andrews, 2009).

The official air quality data entered into a crisis in 2008, when the U.S. Embassy in Beijing started to post a real time Air Quality Index (AQI) on Twitter. AQI is a communicative tool to inform in a simple way the air pollution levels of common criteria pollutants, such as ozone (O3), particulate matter (PM), carbon monoxide (CO), and sulfur dioxide (SO2). AQI is expressed in a single number that indicates the concentration of pollutants, ranging from 0 (good air quality) to 500 (hazardous). 'The higher the index, the higher the level of pollutants and the greater the likelihood of health effects' (Griffin, 2007: 312). According to the U.S. Embassy, its AQI had the intention of informing US citizens living in Beijing to take the necessary actions to protect their health. Nonetheless, the index was widely view and shared by Chinese netizens, as well (Kay et al. 2014).

The adoption of the U.S. Embassy's AQI did not pass unnoticed by Chinese officials. According to a leaked cable from WikiLeaks (U.S. State Department, 2009), China's Ministry of Foreign Affairs presented complaints to the U.S. Embassy, based on reports from the BEPB and the Ministry of Environmental Protection (MEP). They argued that the U.S. data, resulted from a particulate monitor placed on the compound of the Embassy, was producing '"confusion" and undesirable "social consequences" among the Chinese public' (U.S. State Department, 2009).

Beijing and the U.S. Embassy had different methods of obtaining, analysing, and publishing air quality data. Readings of AQI resulted from a single machine, a MetOne BAM 1020, placed in the busy traffic district of Chaoyang. The AQI produced 'real time' data, an hourly updated aggregate index. It included a criteria pollutant known as fine particulate matter (PM 2.5), a particle with an aerodynamic diameter smaller than 2.5 μm (approximately 1/30th the average width of a human hair), which can lodge deeply into the lungs. Beijing's counterpart used an aggregate Air Pollution Index (API) from multiple monitoring stations located around the city. The API delivered a report every 24 hours and did not include PM2.5, but only coarse particulate matter (PM10)—that the AQI had as well—which does not pose as much health risk as fine particulate matter.

The incident put on the table the continuities between the technoscientific and the political, in which the former projects social values that supports specific form of power (Jasanoff, 2004). AQI and API represented two different forms of governing the air pollution, the former prioritising the information in regard of the citizen's health, and the latter addressing policy issues. Academics and experts accept both uses (Ruggieri & Plaia, 2012). Indeed, there is an intensive debate (Hsu et al., 2012) about the

effectiveness of these types of indices to actually achieve the purposes for which they were created. However, as seen in context, the disparities between the readings of AQI and API portray two different ways of approaching open access to pollution information and health awareness. China had started to measure PM2.5 earlier, but its API showed criteria pollutants that were either as harmful or had shown a historical decrease (such as PM10 and SO2) (Ho & Nielsen, 2013).

Air Pollution Activism

Photography record and social commentary

The popularisation of the air quality topic triggered the first citizen actions expressing better information and doubts about official data. In 2009, Weibo, a website similar to Twitter, was launched and became one of the preferred channels of social commentary. Netizens made air pollution a common topic of criticism (Kay et al., 2014) by posting snapshots of hazy skies and questioning the air quality management.

The initiative that received most media attention (China Daily, 2015) was the photographic record made by Beijing resident Zou Yi during 2013 and 2014. After two years, he organized an exposition that he called ‘As plain as daylight’ (from the Chinese idiom 一目了然), displaying daily photos of the Beijing sky taken from the same place (fig. 1). The exposition reached national exposure when it was mentioned in the documentary ‘Under the Dome’ (2015) by Chinese journalist Chai Jing that was seen 200 million times over a week (Ren, 2015).

Fig. 1 'As plain as daylight' shows daily photos of the sky taking by Beijing resident Zou Yi.

In general, photography and social commentary have been continuous forms of public engagement regarding air pollution until the present. They were key, for instance, in making one of the worst episodes of air pollution in Beijing—the 'Airpocalypse' of January 2013 (Kaiman, 2013)—a political and public issue.

Photographs and online social commentary, in the context of Chinese air pollution events, should be understood as a civic record without the purpose of becoming a research tool (Dickinson et al., 2010; Silvertown, 2009). The double approach of registering and filling the gap of information, however, cannot be considered outside the diffusion of technoscientific knowledge. Photos served at times as legitimate counter-facts to air pollution data for audiences that did not have access or did not understand the index data. The subtle critic of a photograph, however, was hard to be controlled by the government. Applying censorship would have lead to exaggeration, casting more doubt about official data.

With the freedom to discuss air pollution, Weibo activity shows that the most popular terms used included air quality data, pollutants, real time index, respiratory, heart, among others (Kay et al., 2014). The civic record of air pollution became a public platform for popular understanding of air quality. The photographs made it accessible to a larger audience.

Nevertheless, it is clear this phenomenon has some limits. The government has stepped on Weibo, asking officials in the environmental sector to actively post. Businesses have done the same, posting about air

quality products, beauty, and health protection, etc. Together, official and corporate social media activity is the main source of the China's current Weibo activity about air pollution (Kay et al., 2014).

Testing the air quality

In the context of the U.S. embassy incident and the Airpocalypse, some citizens and NGOs engaged in air pollution awareness through diverse actions, such as using air quality testing machines, informing the public about the scientific evidence, and discussing the effectiveness of masks and air purifiers.

In November 2011, Beijing-based NGO, Green Beagle (GB), organised and coordinated a national action to independently monitor air pollution. The action was named 'My country measures the air' (in Chinese 我为祖国测空气) and attracted national media attention (Feng & Lu, 2011; Xinhua, 2011). Although the action was addressed directly to its network of volunteers and partners, GB sent a general message about the scarce information on PM2.5 and the need for more open information for the public.

GB only had prior experience of testing radiation with low-cost devices. Their focus on air pollution occurred in May 2011. Some months before the national action, GB started using portable, low-cost particle counters to become familiar with measuring particulates. Some of its members, with post-graduate degrees in environmental sciences, asked their academic and professional networks about the type of data resulting from these devices. They learned that, although a rapid solution, portable particle counters were not a very reliable source of air quality data. GB invested in a 20,000 Yuan (about 3,000 U.S. dollars) to meet accepted standards by expert communities. When the national action started, GB asked the five cities that answered positively (Beijing, Shanghai, Guangzhou, Wenzhou and Wuhan), to commit to acquiring a similar air quality device.

According to Xiaoxia He (2015), director of GB, it has been a process of learning-in-the-making. Purchasing the instruments, organising the national initiative, and publishing the data were all challenging because of the technical (i.e. calibrating the test equipment) and scientific demands (including control measures of temperature, humidity, pressure, etc.). The political side of the action was clearly the most difficult aspect to manage. In that regard, after the national call was launched, GB carefully changed the description of what they were doing. The government would have banned statements they were producing alternative air quality data. Instead, 'testing' the air quality was acceptable because the resulting data would be used for internal purposes and record only. They publicly acknowledged there was no 'comparability' between the official API and their data, which only has the purpose of 'judgement' and reference" (she uses the Chinese words '判断和参考'). About the change of

strategy, Xiaoxia justifies it in the context of low public trust on air quality data and scarce public awareness of health effects. GB understood that 'civic testing' (in Chinese '民间检测') was an exercise that could help people to understand why China needed to update the country's standards as well as bring clarity to the relationship of pollution and health.

GB's network of volunteers shows another side of the citizen engagement with air quality in China. One of the most active is Liu Jun, a young man who lives in the city of Wuhan, located in the centre of the country. Liu has divided his time between working in the financial area of a company and testing air pollution from his apartment since 2012. He convinced a few volunteers (among them, local school teachers and an owner of a cafe) to use a device and deliver city online reports on Weibo. Once they agreed to participate they called themselves 'Wuhan Air Watch Organisation' (from here Air Watch) and begun reporting online 'Wuhan's Air Diaries' (in Chinese 武汉空气日记), with information about their daily tests.

Fig. 2 This caricature, published by Southern Weekend, shows citizens with air quality testing instruments that will be used to push the government to act. Source: http://www.infzm.com/content/64281

Air Watch has interacted with local environmental officials and experts to receive more advice and legitimise their method of collecting data. Liu explains (2015) that in one instance he contacted the dean of the School of Environment at Wuhan University of Geosciences to ask his opinion. The professor was surprised by Liu's initiative and confirmed Air Watch was using standardised methods. But he also recommended exercising more caution about sending a wrong message to citizens. For example, Liu learned that the values of AQIs and APIs were different from their particle counter values. Moreover, a more systematic approach to Air Watch's own information could help people understand their reports.

Therefore, in 2013, Air Watch launched software containing historical readings of the updated official AQI (before API) and their own test readings. The official AQI was not available to the public and Air Watch provided another type of information. Led by Liu, there are 10 cities with volunteers recording the air pollution and sending the data through mobile devices. The software transforms this data into reports that are released online via Weibo, together with atmospheric and weather data (e.g. pressure, humidity, and temperature), photos of the skies, and the AQIs from the U.S. Embassy and the local Environmental Protection Bureaus. According to Liu, this range of information and the records of both the official and non-governmental data constitutes a more scientific attitude toward the subject.

The Beijing-based NGO Friends of Nature (FON) was another key actor who joined the process initiated by GB and Liu. FON is the oldest environmental NGO in China. In 2014, FON begun 'The Blue Skies Lab' (in Chinese 蓝天实验室, hereinafter 'Blue Skies'), a series of workshops and field trips addressed to citizens interested in understanding air pollution. According to Blue Skies coordinator, Hui Guo (2015), FON did not want to measure air quality using an expensive device, but instead using portable particulate counters in places like public transportation (e.g. subway system and buses), residential spaces, and commercial spaces (e.g. malls, indoor playgrounds, etc.). Guo argues that although there are technical reasons and limitations, like controlling the test site condition (e.g. humidity, pressure, and levels of radiation), FON wants to make people aware about the presence of air pollution in their daily spaces. People who join Blue Skies often interact with academic and experts who attend the activities to understand the science behind it. Blue Skies has organised field trips to BEPB to talk with officials about the city's plans and air quality indices.

In general, the process and related actions of GB and 'My country measures the air' depicts another side of the citizen engagement with air quality, through the use of more traditional means of citizen science. The semi-opened door left by the government for public participation related to air pollution (Huang, 2014) made possible a strategic use of instruments to provoke local awareness. Individuals in second-

tier cities (i.e. Wuhan) have echoed the transboundary effect of air pollution and the popularisation of the topic. The adoption of technological devices in different geographical spaces ('more quotidian') than the official monitoring sites were pretended to challenge the official air pollution data. Different from the social commentary and photographic record, the national call was purposely intended to produce an alternative approach to the existent data. This needed a more complex understanding of air pollution and technical instruments. The networks of academic experts and local environmental officials were key to legitimising their instruments and methods, bridging communication with wider audiences, and sometimes keeping a good relation with officials.

In 2012, earlier than planned, China updated its API to an AQI, adding PM2.5 and health advice very similar to the index of the U.S. Embassy. It is interesting to see the strategies adopted by the members of the action. GB and FON, strategically entrenched in their role of 'civic testers', did not controvert official data, but instead focused on education and awareness. This change can be framed on the embedded activism and rightful resistance approach: GB and FON formalised their role in the public understanding of air pollution by adopting the rhetoric of the limits imposed by the government and softened the scope of their data. On the other hand, Air Watch has advanced in refining data and expanding their approach to other cities—perhaps because they are less visible to local powers. The actors involved in 'My country measures the air' are what we call 'naive experts', who introduce the use of technological instruments to raise air pollution awareness. As their action evolves, they adopt their discourse to the existent limits of the political and knowledge contexts.

The expat community

Air pollution in China and citizen participation has presented a topic unexplored in the literature but one that might contribute to thinking different about the dynamism of activism in the country. Foreign citizens also have to explore ways to influence citizen participation and awareness in regard to air quality. This phenomenona is not so new in the wider context of environmental activism. Since the 1990s, the country has witnessed a growing number of transnational networks of NGOs and civil society communities interacting with Chinese citizens (Chen, 2010).

The health blog of Dr. Richard Saint Cyr, My Health Beijing, is one example of how air pollution in China opened the door of the expat community. Dr. Saint Cyr is a family medicine doctor from the US who settled in Beijing in 2006. He works for the elite Beijing United Family Hospital, which provides bilingual (Chinese-English) services to patients. After coming to China and realising that patients lacked

reliable information pollution and health risks, he launched the blog mainly to addressed the expat community and Chinese citizens who read English.

One topic he blogged about was his worries about the air pollution in Beijing. He believed the pollution was really bad, although he could not fine any specific data or historical records. Before the Beijing Olympics, he posted information about how to protect oneself from air pollution and why the problem was a health threat. He acknowledged his limitation to reach wider audiences: 'It did frustrated me at the beginning realizing that less than 1% of Beijing that can even read my blog was getting health advice but most Chinese people me had no clue' (2015).

After the Olympics and with the release of AQI by the U.S. embassy, Dr. Saint Cyr noticed that the Chinese patients were asking more questions about the topic, such as which masks were more effective, which air purifier worked better, what to eat, and how to protect their children. In 2009, he posted:

> In real life terms, there is *definitely* a risk from air pollution to your health. The underlying damage seems to be the tiny particles getting sucked deep into your lungs and initiating an inflammatory response — and long term exposure has a dose-response increase in chronic bronchitis, lung cancers, and atherosclerotic heart disease. It has been studied extensively, and I have links below to a couple of the best articles (Saint Cyr, 2009).

After studying Mandarin, Dr. Saint Cyr he decided to deliver bilingual information in Weibo. His posts about air pollution interested his followers, most of whom were Chinese. He decided to publish two types of information about air pollution: an explanation of relevant peer-review studies and the results of tests of particulate respirators (a mask to protect from air pollution) and air purifiers (Fig. 3).

The reception to this information has been positive. Today, Dr. Saint Cyr has 36,000 followers. He explains, 'Chinese people are starved for trustworthy health information about everything. So if I could provide evidence based tips I really feel like I contributed a little bit to some people in China' (2015).

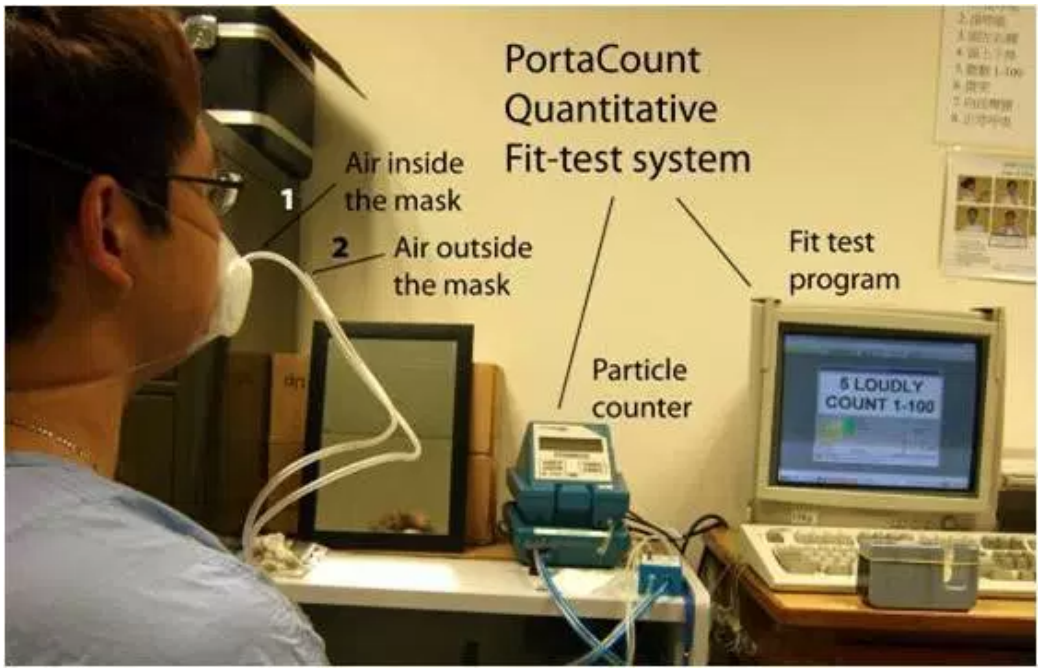

Fig. 3 In this photo, Dr. Richard Saint Cyr shows how he tested the effectiveness of the most popular air pollution masks in the market. Source: www.myhealthbeijing.com

Project FLOAT, led by Xiaowei Wang, was another example of the civic engagement of air pollution by foreigners. In 2012, Wang, an American and Harvard master's degree student, came to China to develop a project of on pollution awareness through citizen science and design. Along with two friends, Wang approached kite masters in Beijing and proposed installing on their kites do-it-yourself (DIY) sensors to measure air pollution.

FLOAT tried to take off through community participation. As Xiaowei explains, 'If you go into the Hutongs (historical residential areas), to the community centers, there are lots of information and knowledge sharing and people take care of the environment together, in a non-official way' (2015). The project made an online call for volunteers and participants. During three weeks, participants joined workshops and learned how to make a kite and install air quality sensors. Arduinos, open-source hardware and software very common nowadays in these types of projects, was used used to measure air quality.

In the air, the sensors displayed colours with LED lights: green indicating good air quality and pink indicating really bad air quality. Xiaowei maintains the resulting information was not intended to produce insight similar to the official or U.S. Embassy indices. Combining DIY electronics with community participation in public areas was an invitation to engage citizens in the understanding of air pollution in

a more quotidian way. ‘An important part of citizen science is not just collecting data right? Because you could have this network of machines collecting data for you. But a large part of it is social, and cultural, and having citizens informed each other and engaged each other. That way, any kind of dry science becomes really meaningful’ (2015).

Another area where expats interacted with Chinese citizens was the creation of start-ups with a social message behind the business. Two examples portray this context: air purifiers and wearable devices.

Thomas Talhelm, a US psychologist who had lived in China since 2006, created the start-up Smart Air. It started operating in 2013 by selling air filters and DIY air purifiers. Earlier that year, Talhelm was not thinking about opening a business but rather how to protect oneself from air pollution after witnessing the ‘Airpocalypse’ in Beijing. He checked the prices of most of the air purifiers in the market—they ranged from 1,000 yuan to 8,000 yuan (about $180 US to $1,300 US). By conducting a simple search on the internet, Talhelm learned it was relatively easy to build an air purifier—just assemble together a fan and a filter (2015).

From Chinese websites, Talhelm purchased several filters claiming to follow the standard of the U.S. Department of Energy (known as ‘high-efficiency particulate arrestance’ (HEPA)). Then he bought a $200 US indoor particle counter to confirm the efficiency of the filters. Eventually, some friends who had in their homes branded air purifiers let him conduct the same tests. He organised the data and published it online. The demand for trustworthy information about air filters was increasing in China, as were the prices of the air purifiers. So he asked some friends (i.e. expats and Chinese) to open the start-up, and sell the filters and fans on the popular e-commerce website, Taobao. Ever since, they also run workshops in different cities in China for the price of the kit (i.e. filter and fan). In those workshops, they introduce the data, how Thomas measured it in his room, and how it should be used. Although new companies have tried to replied the approach of Smart Air, Thomas thinks that customers recognise that behind their filters there is a level of independence and engagement hard to find in China’s competitors.

An area that has received considerable attention in the lasts years by DIYers and citizen science projects is the portable and wearable. In the US, projects like Habitat Map (aircasting.com) show the potential of this next generation of personal devices and crowd source map. In China they are relatively new. Han Wang[1] (2015), a young entrepreneur and bachelor’s degree student at a renowned US university, saw the possibility of introducing wearables that could measure PM2.5 in China. At this time, the device did not

1 The name was changed due interviewee request.

exist; therefore, a group of classmates created a prototype. The university encouraged them to commercialise it, so they began a journey that has taken Wang back to China.

Although the device has not been released commercially, it has made a career in the media and received supported from the popular hardware developer, Hax. Wang has mixed feeling about the potential use in China. He regards the political culture as not ready to let millions of potential users of wearables to sensing the air pollution. He explains that if millions of users the monitoring approach that China has in the present will collapse. He believes that Chinese citizens have the right to really know what is happening at the street level because of the magnitude of the problem. Sensors will be a main challenge for the government in the near future, he concludes.

Discussion

In the changing landscape of environmental governance in China, three aspects have cleared the way for citizens to become more aware and effective in demanding environmental protection: (1) the role of internet in diversifying the circulating messages and sources, not always respecting the official or sound technoscientific knowledge but also generating alternative 'disorganised knowledge' (Bertilsson, 2002); (2) the government's relatively open attitude towards public engagement that is leaving new 'safe spaces' of non-formal citizen participation; (3) the political pressure and media attention brought by international events (the Olympics) and pollution events (i.e. U.S. Embassy incident and Airpocalypse).

This new scenario is helping to overcome what Mol (2009) understands as an 'information-poor' environment: information asymmetries and the suppression of alternative informational sources. It seems a more robust and diverse information context is taking place, in part because of citizen participation and the adoption of sound technoscientific knowledge. However, there is a long way to overcome the pushback that government displays against this type of participation. The cases presented in this article portray unsettled issues: citizens demanding more transparent and reliable information, and a government that prioritises political control, centralising knowledge management.

The novelty of citizen science and the popularisation of scientific knowledge about air pollution in China contribute to understanding the complexity of Chinese citizen participation in the last decade. In general, the examples above show how citizens adopted a 'civic' (Corburn, 2005; Fortun & Fortun, 2005; Wylie et al., 2014) approach to technologies (i.e. testing instruments and monitoring devices) and science (especially epidemiological studies). By choosing the 'correct' technologies and sound science, activists were willing to question what they interpreted as a main problem in China—trustworthy information.

This situation was far from static. From 2008 to 2011, citizens expressed distrust of official data. The motivations behind the related actions were to confront the existing knowledge and give more reasons (such as health effects) to the citizens to demand prompt measures. Reframing a problem that was traditionally in the hands of the government and experts gave citizens a platform to interact with them, and make own ignored issues (i.e. PM2.5 and health effects). Ottinger (2010b) has referred to this type of situation a change in the epistemic reference of experts and public. After 2012, mistrust has vanished in different degrees, and confronting data was no longer so important. The redirection included: testing instead of monitoring, data for reference instead of comparability, assessment of commercial products (e.g. masks, air purifiers) instead of effectiveness of official decisions.

In that sense, China's activists could differ from their Western counterparts in the way they express their political struggle. Their success always remains an open question. Producing facts outside the institution of science (and the government) was an important achievement (Kullenberg, 2015), but not the most relevant. The examples show that in the context of limited rights participation, it was more important to legitimise their action in the eyes of possible censorship. Survival of the practice became key to understand their role, and more importantly, to be conscious of the possibilities that technoscientific knowledge had for participation.

Whether this is a 'tactical' (Wylie et al. 2014) or a 'normal' evolution of their actions is something that the activists do not express straightforward. In some cases, they express that the weight of technoscientific knowledge softened the scope of their actions. Asked about using any strategy to avoid official censorship, they all recognised they were conscious that their activity could become a sensitive issue for authorities, so they tried to be as less antagonistic as possible. They also expressed they were either lucky or their audiences were not so significant to consider them a problem. Only Wang affirmed this has been an important issue for the start-up, so much that they preferred to present themselves as a business idea.

Another noteworthy point is the obstacles of making reliable data. After consulting with their networks, which included experts and environmental protection officials, NGOs have found that their data is limited. Expats tried to legitimise their knowledge with sources they believed out of the circuit of Chinese people and accepted by international scholars. The cases of photographic record and the commercialisation of purifiers and wearables, are problematic in the sense that they do not bridge resistance and citizen science flatly. It is important to ask whether these could constitute channels of citizen science or whether they could be considered citizen science. We regard them as so, but only in the context of 'poor-information',

where ‘naive experts’ use them for a higher, but not public, purpose (e.g. criticize official data, support citizens’ agency, etc.).

In general, more research is needed to understand the following questions. Are these type of resistance made for specific events and to address specific problems? Deng & Yang (2013) support the idea that in China ‘pollution and protest is context dependent’ (2013: 323). But seen from the citizen science as a form of resistance, is that the case? A quick glance on how the activists approached their actions situates them in specific social (i.e. urban, middle educated classes) and political contexts (i.e. Beijing Olympics, US Embassy incident, and Airpocalypse). As the actions evolved, they showed they were not only contextual, and they become part of wider circuits in the internet, second-tier cities, and the business world.

Conclusions

The official control of air pollution and citizen engagement to the problem portrays an extended form of governance of the atmosphere and society (Whitehead, 2009). This article intended to echo recent debates from the area of Chinese Studies, about citizen agency and environmental health in China, by discussing examples of citizen science and popularisation of technoscientific knowledge about air pollution in the country. In exploring this less known facet of citizen participation, we expect that more research will continue filling the gap on the use of technoscience for civic and environmental purposes in the country.

Finally, two complex questions remain open: (1) has the government taken back control of citizen participation, at least from the side of citizen science approach?, and (2) what is the role of the next generation of citizen engagement with air pollution? We have two speculations. The popularisation of wearables might bring again a crisis in the current regime of air quality data. This knowledge could constitute a ‘peer review’ (Yearley, 2006) for policy purposes and an area of citizen action, too. The second is that until now we have witnessed only the beginning of citizen engagement with air quality in China. As access to the internet grows larger and cheap monitoring and testing devices get more accessible, more places like second-tier cities and villages might adopt similar patterns of activism. With the rhetoric of air quality and health effects becoming greater, it seems that localised resistance through citizen science could contribute to more effective control and regulation.

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