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Analysis

Activism mobilising science

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ABSTRACT

The article sheds light on a process where unequal power relations are contested through the co-production of scientific and local knowledge. I argue that lay citizens, communities and local grassroots organisations immersed in socio-environmental conflicts are engaging with professional scientists to understand the impacts a polluting project is causing to their environment and themselves. Together with scientists they co-produce new and alternative knowledge that gives the local organisations visibility and legitimacy, information on how to protect themselves from the impacts, and allows them to engage in practical activism, challenging the manufactured uncertainty and other information produced by the state or companies running the projects. This process is what I term Activism Mobilising Science (AMS). It is locally driven by activists who have built related capacities and is generally based on voluntary work. AMS is compared to other participatory processes and gives clues into how grassroots organisations can avoid co-optation. The analysis is based on two uranium mining conflicts in Niger and Namibia where two local organisations are trying to confront the manufactured uncertainty of the nuclear industry through an AMS process.

1. Introduction

> "We had no knowledge that radon could travel, we thought that you had to be in contact with uranium, otherwise radioactivity would not impact you" (A. Alhacen, Pers. Comm., 1 February 2013).

In Niger, Almoustapha Alhacen is the head of Aghir in'man, a local NGO in Arlit, located next to the uranium mines of Areva, the French state nuclear giant. After working for more than 20 years in the uranium mines he saw several of his colleagues getting sick from diseases they did not understand. He wanted to know more; understand why that happened, and take measures to protect himself and others.

In a similar way, Bertchen Kohrs and Hilma Shindondola-Mote, heads of two NGOs in Namibia (Earthlife Namibia and the Labour Resource and Research Institute, LaRRI) had been trying to gain more knowledge about the impacts of radioactivity. In 2008 they carried out an investigation and campaign revealing that an unknown number of mineworkers of Rio Tinto's Rössing uranium mine had been getting sick and some of them dying. The workers believed their diseases were connected to their work in the mine. They had heard about radioactivity but didn't know how it could impact them. By highlighting and exploiting the uncertainty over radiation related occupational health diseases (Hecht, 2012), mining companies have impeded workers from claiming compensation. Moreover, the nuclear industry has also manufactured this uncertainty (Michaels and Monforton, 2005) by for example producing studies denying the impacts of radiation (Hecht, 2012). The manufacture of uncertainty has been used with great success by polluters and manufacturers of dangerous products (best known examples are the tobacco and asbestos industries) by questioning the validity of scientific evidence on which regulation prohibiting those products is based (Michaels and Monforton, 2005). I differentiate between knowledge *produced* by the mining companies that is based on their own measurements or monitoring of impacts and *manufactured* knowledge that aims at covering or increasing uncertainty about an impact. The two Namibian NGOs wanted to challenge this uncertainty by learning more about radiation and its impacts.

As a result, both Aghir in'man from Niger and Earthlife from Namibia contacted CRIIRAD, a French independent laboratory specialising in radiation. CRIIRAD visited the two countries marking the start of an on-going collaboration, allowing these organisations to learn more about radiation and challenge the knowledge created by the mining companies.

These alliances emerge as a result of the increasing pressure for extraction driven by the increasing social metabolism, a decline in the quality of minerals and reserves and an increasing competition among land uses. This is driving the commodity frontier into more ecologically and socially vulnerable areas, with higher environmental impacts

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(Moore, 2000). These areas are often inhabited by indigenous people or historically disadvantaged social groups, whose livelihoods are highly dependent on their land (Guha and Martinez-Alier, 1997). These phenomena set the conditions for the emergence of resource extraction conflicts (Martinez-Alier et al., 2010). The expansion of the commodity frontier or the increasing impacts in these areas after many years of extraction is causing local communities to react and confront these operations. This is coupled with an increasing capacity by local organisations to make extra-local contacts (Keck and Sikkink, 1998), in this case with scientists.

In political ecology literature several authors have examined how mining companies have access to and control over resources, land, water, energy, minerals (Bebbington et al., 2010; Bryant and Bailey, 1997; Martinez-Alier, 2003). However, to date the literature does not sufficiently explore how knowledge is co-produced, manufactured and controlled by these companies in order to create discourses and truths. Knowledge production and control does appear in the literature when looking at how historically, knowledge has been appropriated by colonial officials (Bryant, 1996; Neumann, 1996; Peluso, 1993; Robbins, 2004), conservationist NGOs (Bryant, 2002) or institutional narratives (Fairhead and Leach, 1995; Sletto, 2008), imposing their discourses and 'truths' on grassroots organisations. Although examples where grassroots organisations contest these different narratives through relevant science-based knowledge are explored (Bebbington, 1996; Forsyth, 1998; Peet and Watts, 1996), little attention has been placed on the dynamics and processes of how this happens (see for example Peluso, 1995). In this article I explore one such mechanism of resistance, looking at how the interactions and processes of power can be reversed. Knowledge, be it local or scientific or newly co-produced (Jasanoff, 2004), becomes a political tool that can express and exercise power.

I argue that with a process which I hereby call 'Activism Mobilising Science' (AMS), lay citizens, communities, and local grassroots organisations are engaging with professional scientists to learn from them the tools and the scientific language they need to produce a new and alternative knowledge with which they can challenge dominant discourses and engage in practical activism.

Through AMS, activists become visible actors in the governance of extractive industries and environmental health, engaging politically and influencing environmental actions and outcomes together with the state and the companies (Lemos and Agrawal, 2006). For instance, urban neighbourhood organisations might call for expertise from environmental chemists who can teach them how to measure dioxins when confronting a new incinerator (GAIA, 2003), or peasant groups might ask a sympathetic hydro-geologist to instruct them on how to take water quality measurements when trying to challenge an open cast gold mine (FPIF, 2012).

The aim of this article is to build the definition of AMS by understanding *how* and *why* is activism mobilising, using and co-producing, science. The next section introduces the case studies' context; the manufactured uncertainty and opacity the nuclear industry often uses, which the AMS processes presented are challenging. The theoretical background and methods are explained in Sections 3 and 4. Section 5 explains how and why two grassroots organisations engage in an AMS process to confront uranium mining whilst Section 6 gives clues into how these organisations have avoided co-optation. Section 7 situates and compares AMS in the literature on participatory processes and Section 8 draws some conclusions.

2. Uranium Mining and the Manufacture of Uncertainty

The cases presented in this article deal with Low Level Radiation, radiation under 100 mSv, caused by uranium mining and affecting workers' health and communities living nearby. Despite half a century of intensive research in the field of radiation and human health, uncertainty is still prevalent as science has yet to find a way to clearly connect an individual's exposure to low doses of radiation to subsequent health problems or fatal diseases. Only with large groups such as the Wismut and Navajo cases[1] have large epidemiological studies with lifetime follow-up been able to detect a significant increase in cancer mortality (Brenner et al., 2003; Land, 1980). Science cannot yet prove causation in particular cases (Brenner et al., 2003; Connor, 1997; EEA, 2001; Hecht, 2012). Given the difficulty to carry out these studies, the radiation protection community has been using since the 1970s the linear no-threshold model that assumes that the biological damage caused by ionising radiation is directly proportional to the dose (Kathren, 1996). In other words, there is no safe radiation dose. However, responding to pressures by the industry, the International Commission for Radiological Protection (ICRP), which sets the radiological limits adopted by the International Atomic Energy Agency, proposed the ALARA principle in 1977 (ICRP, 1977) by which all exposures should be kept As Low As Reasonably Achievable. According to Hecht (2012), this move tried to remove the exceptionalism of nuclear risk by comparing it to other industrial risks. It set a permissible threshold below which a reduction in exposure is not worth the investment. This caused a major debate in the nuclear industry, with the ICRP modifying the threshold downwards twice since then. With people impacted by Low Level Radiation claiming causal links that are still not scientifically proved and safe limits being modified as new research appears, it is safe to say that the impacts of Low Level Radiation are shrouded with uncertainty (Hecht, 2012; Kuletz, 1998).

The industry didn't only exploit this uncertainty but in many occasions manufactured it. Hecht (2012) points in her book to numerous accounts where mining officials contested the findings of the ICRP in order to defer regulation. She dubs the scientists behind this manufacturing as the "merchants of doubt" (Hecht, 2012:209). As with tobacco or asbestos cases, it has been argued that "the cause-and-effect relationships have not been established in any way; that statistical data do not provide answers; and that much more research is needed" (extracted from Michaels and Monforton, 2005). The established radiation limits (under 20 mSv per year for workers) and the ALARA principle, allows the uranium mining companies to comply with the regulations, thus liberating them from any responsibility over sick workers. As with the lead industry case, the blame was shifted "from the lead itself and the manufacturing process, and claimed that the workers had sloppy habits and were careless" (extracted from Michaels and Monforton, 2005). In Niger's and Namibia's uranium mines the responses are similar, "the diseases are caused by the eating and social habits of the workers, who don't exercise (…) and in many cases smoke" (Rössing Manager, Pers. Comm., 21 June 2009).

As a result, the burden of proof of the impacts of Low Level Radiation is left to the communities. They however lack the technical expertise required by orthodox science to claim that they are being impacted. The State and the companies value the formal and quantitative information that the communities lack. They privilege evidence produced by experts trained in scientific disciplines. On top of this, communities face also the opacity of the uranium industry that made "invisible" black African miners (Hecht, 2012), Indian Nations in the US (Kuletz, 1998) and communities in Jharkhand, India (Ramana, 2012), bypassing for decades radiological safety regulations and not informing miners of the deadly hazards they were exposed to. To bridge this gap, it has been argued that these problems can no longer be viewed as purely technical and left exclusively to professionals. Due to high uncertainty, the urgency to solve this issue by those workers who are still alive and sick and the high stakes involved, the study and evaluation of Low Level Radiation in the nuclear industry could be considered a case of Post Normal

[1] After WWII uranium mining expanded in the Wismut province in East Germany and in several states of the South West of the US, drawing (in the second) Navajo People to work in their mines. Numerous epidemiological studies have proven occupational related cancers (see among others, Kreuzer et al., 2010 for Germany and Gilliland et al., 2000 for the US). In the US this led to the passage of the Radiation Exposure Compensation Act.

Science. According to Funtowicz and Ravetz (2003) these problems must be managed by extended peer groups that should include lay knowledgeable people with stakes in the issue. Relevant knowledge "may include community knowledge of places, anecdotal evidence… [where actors] can create their own knowledge" (Funtowicz and Ravetz, 2003). These processes give legitimacy and visibility to actors through a combination of local and scientific knowledge as I describe below. Presently though, local knowledge such as the workers' own accounts of health problems generated by grassroots organisations tend to be ridiculed or neglected, motivating some activists to engage in AMS processes. I argue that by instituting processes of AMS, workers and communities produce Post-Normal Science on the ground.

3. Theory

Below I present two bodies of theory to help understand the process of AMS. The first one introduces how AMS challenges power relations through knowledge co-production. Then I frame AMS within other participatory or collaborative processes.

3.1. Knowledge co-Production and Power

Power is "a disciplining force dispersed through society" (Jasanoff, 2004). Power is located in the interactions and processes that build social relations and is shaped by the asymmetrical distributions of resources and risks (Hornborg, 2001; Paulson et al., 2003). The burden of environmental impacts in a socio-environmental conflict is a consequence of these power relations (Bryant, 1998; Peluso, 1992). Weaker actors are not only marginalised by the unequal distribution of the environmental burdens but by the predominant discourses that exercise and consolidate – in themselves – power (Bryant, 1998; Foucault, 1980; Peet and Watts, 1996). Such dominant discourses are embodied in environmental and social impact studies as well as Corporate Social Responsibility programmes that propose development projects for local communities. These development discourses consolidate the mining companies' domination over land and water (Escobar, 1995). They are accompanied by scientific methods and language that are used to produce knowledge about the impacts of projects, increasing in some cases the uncertainty about these impacts.

Power is not static; it circulates, is continually "reinscribing itself in our communities, institutions, practices, discourses and scientific products" (Jasanoff, 2004). As such, strong actors such as mining companies rarely have overwhelming power, and weaker actors can challenge their legitimacy (Bryant and Bailey, 1997; Foucault, 1980). The literature on resistance emphasises the use of local environmental knowledge to subvert the activities of powerful actors (Guha, 1989; Peluso, 1992). It has long been argued that local knowledge should be included to reframe environmental policy towards more locally relevant needs (Chambers, 1997; Hecht and Cockburn, 1989), in environmental decision making processes (Corburn, 2005; Fiorino, 1990; Peluso, 1992) and in the management of natural resources (Agrawal et al., 2008; Gadgil et al., 1993; Toledo et al., 2003). This could signify a democratisation of science (Brown, 1998; McCormick, 2009) through the emergence of alternative networks that may exist in parallel, or outside the formal boundaries of scientific institutions (Forsyth, 2002).

Scientific knowledge has traditionally been seen as supporting hegemonic political forces and actors. However, like all knowledge, scientific knowledge is partly socially constructed (Foucault, 1971). Science depends on observation, measurements and testing of the natural world, but is also subject to its social history as well as the interests and stakes in place (Barnes, 1977); the social practices, material resources and institutions that contribute and disseminate this scientific knowledge (Corburn, 2005; Jasanoff, 2004). Scientific knowledge doesn't inherently favour strong actors such as mining companies or the State. Murdoch and Clark (1994) proposed a 'hybridity' of scientific and indigenous knowledge in projects to achieve sustainable development. It can also be used (and constructed) to expose and measure the impacts of polluting industries on local populations or communities. To this end, there have increasingly been more cases that combine the best of local and scientific knowledge through a co-production framework.

Taken from Science and Technology Studies (STS), the concept of co-production entails the "dynamic co-evolution of knowledge and social change" (Forsyth, 2002). It refers to processes where knowledge, scientific as well as local knowledge, is "framed, collected and disseminated through social interaction" (Jasanoff, 2004). Under this framework, science and values are negotiated, their objectivity and subjectivity is challenged and rethought. The knowledge produced by the mining companies, immersed in their own values and subjectivities, is contested by activists. These in turn co-produce their own knowledge, with their own biographies, explanations and applications. STS stresses that the making of science cannot be seen as an autonomous independent process and it's in fact political (Jasanoff, 2004). AMS has the political aim of altering power structures by challenging 'taken for granted' or manufactured knowledge.

Jasanoff (2004) describes co-production as more of a "bricolage" than an idealized scientific method, "opening conversations with other approaches of social and political enquiry". My take on STS is on the process of co-production itself, on how different kinds knowledges are blended in the context of a socio-environmental conflict. Corburn (2005) in his book on Street Science took on this challenge, albeit situated in a more urban and more policy oriented context.

In a socio-environmental conflict, a co-production framework should include all those "with a desire of participating in the issue" through an extended peer community (Funtowicz and Ravetz, 1993). The empowering aspect is not whether local or indigenous or scientific knowledge is used and co-produced, but it is about 'knowledge' itself. The same knowledge can be classified in one way or another "depending on the interests it serves, the purposes for which it is harnessed, or the manner in which it is generated" (Agrawal, 1995).

3.2. Participatory Processes

The use of local knowledge and the promotion of participation of communities are not new. Indeed starting with Participatory Rural Appraisals (Chambers, 1983), the field of participatory development emerged in the 1980s with the objective of making development projects legitimate, making sure that they encompass all the issues relevant for local actors (Hickey and Mohan, 2004; Reed, 2008).

Participation has also become relevant in other disciplines such as policymaking and research, evolving into other forms of participatory processes. At its roots is the rejection of the 'deficit model' that assumes lay people lack sufficient understanding and knowledge, and need education in order to participate in policymaking and scientific undertakings (Sturgis and Allum, 2004).

The degree of participation of grassroots organisations and the power asymmetries between these and the institutions are controversial factors that differentiate various collaborative and participatory methods. Action and Participatory Action Research (PAR) highlights the importance of local and bottom-up approaches to research and decision-making (Minkler, 1997; Reason and Bradbury, 2001). With a higher degree of participation and acknowledgement of local knowledge, in Community Based Participatory Research (CBPR), community partners are involved in all phases of the research from its inception, research questions and study design, to the collection of the data and interpretation of results (Minkler and Wallerstein, 2003; Shepard, 2002). However CBPR is generally started by the researcher, who brings into the community the history of the research institution and of the researchers themselves. Scientists can be reluctant to have their credibility challenged whilst activists face the possibility of being co-opted by participatory mechanisms that allow their superficial involvement but

do not give them decision-making power (McCormick, 2009; McGrath et al., 2009; Montoya and Kent, 2011). These participatory processes are a step forward from the deficit model, but embrace instead a 'complementary model'. In it, the communities are given a voice and invited to give political considerations but they still don't engage in technical issues (Corburn, 2005; Wynne, 1991). Following Corburn (2005) I argue that when local knowledge is acknowledged, incorporated and used to develop scientific knowledge, a co-production framework is adopted.

The participatory paradigm also comprises different forms of participation in the production of science. Civil, citizen, civic, stakeholder and democratic science all embrace the idea that science and science policy have political and social implications and that citizens must "have a stake at the science–politics interface" (Bäckstrand, 2003). Civic science aims at enhancing public understanding of science, increases and diversifies participation and promotes the democratisation of science (Bäckstrand, 2003). The democratisation of science (McCormick, 2009; Nowotny, 2003) criticises and contests expert knowledge for being biased and politically driven and aims to give legitimacy to lay knowledge in science. It aspires to transform the institutions of science including more democratic principles and reframing research and scientific objectivity. It goes beyond representation and participation to the heart of scientific enquiry (Bäckstrand, 2003; McCormick, 2009).

Closer to what I call AMS is citizen science where lay citizens who are not trained as conventional scientists participate and enact science; they collect and process data as part of a scientific enquiry. It differs however from AMS in that nowadays most citizen scientists participate in research projects that are designed and adapted to them. We see this especially on the fields of ecology and environmental sciences where citizen scientists record for example sightings of bird species (Silvertown, 2009).

Another way of linking experts and lay citizens are science shops. Largely in urban settings, science shops act as "brokers" between community groups or NGOs and university researchers on themes defined by the NGOs (Barr and Birke, 1998; Dickson, 1984). Also in urban contexts but challenging the conventional use of science, Corburn (2005) proposes the framework of Street Science. Using four case studies in Brooklyn, New York, he describes how grassroots organisations use local knowledge to engage in environmental health issues affecting their communities. He argues that these organisations challenge the "dominant system" by "deconstructing professional ideas as inadequate representations of reality", contesting conventional ways of framing problems and employing methods. Street Science also embraces a co-production framework, placing great emphasis on the role of local knowledge. Also based in industrialised economies, the counter-expertise model describes a specific type of activist–scientist relation whereby laypersons liaise with scientists to produce alternative knowledge in a context of high uncertainty and risk such as nuclear energy. As I will analyse in the discussion, AMS is close to Street Science and the counter-expertise model but differs from them in some elements.

Although grassroots organisations are not always aware of it, all these collaborations between traditionally historically marginalised communities and professionals can be classified as part of the environmental justice movement, as they demand an end to social and economic policies that subject excluded and poor communities to environmental hazards affecting their health (Bullard, 1990; Cole and Foster, 2001). Although centres of environmental justice as well as science shops can be defined as Community Based Participatory Research (O'Fallon and Dearry, 2002; Shepard, 2002), the way the research is defined and used will depend on the power structures of each case.

4. Methods

The case studies in this paper were chosen as paradigmatic case studies (Flyvbjerg, 2006) to understand the emergence of a coalition between scientists and activists that has been emerging with the rising number of environmental conflicts, especially in the global South (Martinez-Alier, 2003). Although these coalitions are indeed happening with other environmental conflicts, such as gold mining (FPIF, 2012) or GMOs (Saunders and Ho, 2012), uranium mining is an excellent example of what AMS is trying to confront with knowledge creation: the opacity of the nuclear industry and the uncertainty of Low Level Radiation. The cases of Niger and Namibia are very illustrative because mining has been taking place there for more than 30 years in colonial and post-colonial contexts with deeply embedded power relations that only recently are starting to be challenged. One such mechanism of contestation is AMS.

The empirical research is based on the thematic analysis of 11 interviews carried out in person or via skype or telephone during 2012–2013 with key activists and scientists in the two AMS processes. A newspaper search was carried out as well as a survey of relevant documentation of the grassroots organisations, CRIIRAD, of Areva's subsidiaries Cominak and Somaïr and Rio Tinto's mine Rössing. The paper also benefited from two field trips to Namibia carried out in 2009 and 2012 and the participation in the EU funded project EJOLT (Environmental Justice Organisations, Liabilities and Trade), which provided the funds for CRIIRAD's visits to Namibia.

5. Uranium Mining in Niger and Namibia

The towns of Arlit and Akokan, in Niger, were built by Areva (then Cogema) in 1968 to house the workers of its two uranium mines: Somaïr and Cominak. Of the 100,000 residents that currently inhabit the area (Areva, 2011), only those working for the mines and the town officials have running water, electricity and health services. The rest, around 60,000 residents, live in houses built out of mud, corrugated iron and scrap metal (Greenpeace, 2010; The Guardian, 2009). Water is polluted and access to it is inadequate (Chareyron, 2003, 2008). Areva has already used 20% of the local aquifer's capacity (Areva, 2009). Marginalisation and dependence is acute, with nearly all inhabitants connected in some way to Areva's mines (Areva, 2009). Areva remains the biggest private employer and exporter in Niger (Reuters, 5 February, 2014) giving leeway to their activities. This context has placed Areva in an extremely powerful position vis a vis the workers and inhabitants of Arlit and Akokan. With colonial ties that have consolidated since the mine's opening and limited independent oversight that only in the last decade is starting to break, local communities and workers are in a clearly marginalised position.

One of the biggest concerns for the workers and residents near the mines is the impact of Low Level Radiation on their health. This can be external radiation (beta and gamma) emitted by uranium and its decay chain, as well as internal radiation fixed inside the body when breathing radon gas, inhaling dust or drinking and eating polluted water and food. One of the biggest hazards emitting Low Level Radiation are the tailings dams and the waste rock piles, where all the mining waste is deposited, radionuclides can be transported by air and seep into underground waters. Tailings contain 85% of the original radioactivity and will remain radioactive for hundreds of thousands of years (Chareyron, 2008). Both mines have created since their opening in 1968 more than 30 million tonnes of tailings (AREVA, 2011). In underground mines such as Cominak, radon gas is a major hazard both for its workers and for the residents living near the ventilation shafts (Chareyron, 2008).

Areva has manufactured uncertainty about the hazards that the local population faces. A case in hand occurred when the IRSN (the French Institute of radioprotection and nuclear security) visited the mines at Areva's request in 2004 placing numerous recommendations. Although they were mostly followed (Areva, 2005) an exception was the high exposure in front of the police station in Akokan, which Areva denied and no remediation was undertaken (Areva, 2011).

Almoustapha Alhacen has been denouncing the impacts of the mines on the environment and the health of the communities because "Areva doesn't have a structure to inform people. Areva says nothing,

not an ounce, to inform them about the dangers of radioactivity" (A. Alhacen Pers. Comm., 1 February 2013). Since he founded the NGO Aghir in'man in 2002, he has been informing local residents and workers about the impacts and risks of radiation, engaging with the press, the chiefs and other political actors and co-producing new knowledge that contradicts Areva's manufactured uncertainty through an AMS process, as I will analyse in Section 5.3.

In Namibia, the town of Arandis was built to house the workers of Rössing uranium mine, a Rio Tinto mine that has been operating since 1976. Rio Tinto is the fourth largest publicly listed mining company in the world with mines in over 40 countries (Rio Tinto, 2014). During the 1990s, coinciding with low uranium prices, Rössing retrenched 70% of its workforce, resulting to many people fleeing the town. In 1992, Rössing handed the administration of the town to the government, forcing residents to pay for the first time for electricity, water, schooling and housing, further marginalising the town (Conde and Kallis, 2012). Like in Niger, residents and workers depend fully on the mine. Of main concern is the impact that Rössing has caused (and continues to be causing) on the environment and the health of workers. Like Areva's subsidiaries in Niger, Rössing has not declared a single occupational health disease related to radiation (Dr. Swiegers, Pers. Comm., July 2009). Moreover, the mine has never been open to release or collaborate with investigations connected to radiation related diseases. During the 90s the Mine Workers Union in alliance with anti-nuclear movements took action to uncover health impacts on workers through a study that was carried out by Dr. Zaire, a young Namibian doctor. Through government connections the company managed to revoke Dr. Zaire's research permission. The study was carried out in secret but its findings were rejected by Rössing (see Conde and Kallis, 2012; Hecht, 2010).

As a recent report carried out by Earthlife and LaRRI shows (Kohrs and Kapuka, 2014), this opacity is prevalent with Rössing's workers not given access to their medical records with some of them dying of diseases they don't comprehend. This opacity pushed Earthlife to start an AMS process.

5.1. How is AMS Carried out?

AMS is a locally-driven process that gives visibility to local activists. By local is meant community or grassroots organisations from the areas where the impact or activism is taking place. AMS is generally driven by one or two individuals that have built related capacities and is largely voluntary. AMS follows a co-production model where local as well as scientific knowledge is combined to produce new knowledge. The relationship between the scientific expert and the activist is of continuous collaboration and inter-dependence.

5.1.1. Locally Driven

Since 1999, Alhacen and other co-workers at Somaïr partnered with Areva to carry out some workshops on how to efficiently use water and electricity. Although their knowledge on radiation issues was close to nil, they had long suspected of a link between uranium mining and occupational illnesses, warning against excessive road dust or taking working clothes home. But it was not until three colleagues that worked in uranium concentration sections died, that Alhacen decided to cut the association with Areva and form Aghir in'man; "we wanted to understand what radiation was and how to measure it" (A. Alhacen Pers. Comm, 1 February 2013). They contacted Greenpeace and CRIIRAD; only the latter answered. Soon after, radiation measuring devices were sent to Aghir in'man so that they could take some initial samples and measurements. This sampling convinced CRIIRAD to make a field trip to Arlit in 2003. After the visit, CRIIRAD published the results through a press release and several reports confirming that there was radioactive contamination in the water, air and in the scrap metal sold at markets. They also pointed out the problem of radioactive tailings stored in the open air (Chareyron, 2003; CRIIRAD, 2005). To share these results, Aghir in'man organised and carried out workshops with women, local journalists and chiefs of different tribes. They organised sampling trips with local counsellors and journalists to take measurements in the polluted areas.

In Gabon, where Areva has also been mining for 30 years and the impacts are very great (see CRIIRAD, 2009; Hecht, 2012), Bruno Chareyron, CRIIRAD's laboratory director explains that no strong local organisation was driving the process locally: "in the case of Mounana (Gabon), if those people were to ask CRIIRAD [to come to Gabon], we would have made it a priority. We tried to do something [sending them a Geiger counter] … but both sides have to do something". In contrast, in Niger, Aghir in'man is leading the process; they take out samples, organise workshops, participate in public meetings, give interviews to journalists and locate funds to acquire new equipment.

Earthlife Namibia followed a different path. Since its creation in 1990, Earthlife has been denouncing the impacts on the environment of industrialisation and mass tourism, sometimes being the only source of dissent in the country. Major campaigns were the fight to stop the construction of a hydroelectric power plant at the Epupa falls (1996–1999) and the construction and operation of RAMATEX textile factory, that quit the country in 2008 leaving behind huge quantities of salty and toxic waste water on the outskirts of the capital (The Namibian, 7 October 2004). Although Earthlife tried to confront Rössing – Rio Tinto's uranium mine – right after independence in 1990, the opacity of the industry made it impossible for them to obtain any information about its possible impacts (B. Kohrs, Pers. Comm., 9 February 2013). It was not until 2005, when Paladin, an Australian company presented an EIA to open a uranium mine (Langer Heinrich) in a National Park, that Earthlife started to get involved actively in nuclear issues. The EIA was sent by Earthlife to a German research institute to revise it, who found it had many deficiencies (Öko-Institut e.V., 2005). In 2008, Earthlife together with LaRRI carried out a campaign denouncing the expansion of uranium mining in the country (Kohrs, 2008) and the impact on the health of workers (Shindondola-Mote, 2008). Interviews with workers and ex-workers of Rössing were carried out revealing that many of them were sick and didn't trust the opinion of the medical personnel at Rössing. In a country with almost 40% unemployment, a worker told LaRRI: "We keep the job as a security measure; your heart is telling you to work but your mind is telling you to go" (Shindondola-Mote, 2008). Rössing denied the accusations of Earthlife and LaRRI as un-scientific and emotional (Namib Times, 19 June, 2012). This set the foundation for an AMS process.

Earthlife entered in contact with CRIIRAD through the EJOLT FP7 EU funded project (Environmental Justice Organisations, Liabilities and Trade, coordinated by ICTA UAB) that aims at bridging EJOs and research centres or think tanks pursuing environmental justice. I invited Earthlife to participate as a partner in EJOLT. I was working in the project and knew Earthlife from when I had carried out fieldwork in Namibia in 2009. Since the start of the project in 2011, Earthlife has been driving the AMS process, with EJOLT's coordinators and myself acting as facilitators. Earthlife planned and organised the trip that CRIIRAD did to take samples in September 2011. And once the results were obtained, Earthlife asked CRIIRAD to pay a second visit to Namibia in order to share and explain the results.

Earthlife is also carrying out other activities that indicate that they are leading the AMS process; after CRIIRAD's second visit, Earthlife has a more fluent contact with Rössing and is demanding more information from them. They have enquired the Mining Commissioner about a uranium mining licence given to a Chinese company. They approached the Atomic Regulator enquiring about the Atomic Energy Act draft and submitted a proposal as part of the regulations of the Act. As part of EJOLT, Earthlife is presently evaluating Namibia's nuclear legislation and developing proper regulations on rehabilitation after mine decommissioning and together with LaRRI, a study on the health impacts on workers and ex-workers has been carried out (Kohrs and Kapuka, 2014). With funds

from a German foundation they are also training 10 Namibians on nuclear, energy and environmental issues. All these activities were not part of EJOLT's initial workplan but have largely benefited from the legitimacy acquired through the knowledge co-produced between CRIIRAD and Earthlife.

5.1.2. Knowledge co-Production

In Niger as well as in Namibia, the scientific knowledge of CRIIRAD on radiation and uranium mining is of utmost importance for the local activists in order to understand and analyse the impacts on the environment. However, experts don't understand the local complexity of the area; they know what to look for and know different measuring techniques and measuring devices, but in order to apply or use them, they need the local knowledge provided by grassroots organisations. Local knowledge is not limited to oral stories of the community. Certainly, the local geography (rivers, polluted areas) and how to access them (evading sometimes the company and state security guards), whom to interview, the social knowledge of health impacts (how many people are sick, who are they), and socioeconomic aspects (marginalisation, water supply), are also local knowledge. This knowledge is vital to the application of scientific tools.

As Chareyron of CRIIRAD explains:

> "We don't know the area and we spent only 2.5 days (in Arlit); where do we sample the water? What kind of water? Where is the scrap sold on the market? We had no maps, we need the people to understand where things are" (B. Chareyron, Pers. Comm., 15 June 2013).

Importantly, the interpretation of the results also depends on this local knowledge; high radioactivity measurements are dangerous in relation to the local population activities and movements, the accessibility to polluted sites. Do people live near the ventilation shafts? Which boreholes are being used? How is scrap metal being used? Do tourists have access to the waste rock dump? Are pastoralists more at risk than other community members? Who is at risk if the tailings dam broke? Do workers and residents have enough knowledge of the impacts of radiation? This knowledge has been crucial to interpret and communicate the newly co-produced knowledge.

The AMS process is not limited to the visit of the expert organisation. In fact, the new tools and scientific language acquired are crucial for the local community and groups in order to keep producing more knowledge. Both Earthlife and Aghir in'man have been doing, often in coordination with CRIIRAD, more sampling, placing demands and contrasting information provided by the mining companies or other institutions. In Niger, back in 2003, contaminated scrap metal was detected in a local market by CRIIRAD. Through the years Aghir in'man has been denouncing this fact and carrying out more tests warning the community against the use of this scrap metal. Only recently Areva has admitted: "1000 tonnes of this radioactive scrap metal had been found at a scrap metal dealer's" whilst another 600 were unaccounted for. They have now "immediately stopped the removal of all scrap from the sites" (AFP, 17 January, 2013).

5.1.3. Ability of Grassroots Actors to Participate in Politics

In order to be able to co-produce new knowledge and use it in their activism, one or few members of the grassroots organisations need to have the ability to participate in politics, in the mechanisms of power. In our case studies, both Kohrs and Alhacen have been able to develop capacities despite the high level of inequality and marginalisation in their countries.[2] When analysing their personal stories, we observe that both had developed abilities to talk in public, deal with the press or government officials, language skills and the capacity to develop extra-local contacts. They also had acquired a special sensibility regarding social and environmental issues.

Alhacen didn't receive a formal education. When he was 16 years old he worked for a French NGO who taught him not only how to read and speak French but also to deal with the press and engage with other organisations. He was sent to Germany and France, where he recalls: "was like having your head under the water and then coming to the surface" (A. Alhacen, Pers. Comm., 1 February 2013). He started working in Somaïr in 1978 when he was 21 years old and became an active union member in 1992. This position again trained him to deal with human rights and labour issues paving the way for many of his present activities. Kohrs grew up in a poor family in Germany in the aftermath of WWII; "we had to live off the land … we had to use everything that was there, that shaped my respect towards nature… my parents put that seed in me" (B. Kohrs, Pers. Comm., 9 August 2013). After acquiring college education and working, she moved to Namibia in 1973. She recalls: "when I stepped in [I told myself] this is your country, and from that time I was addicted". She was one of the founders of Earthlife right after independence and became the head of the organisation in 1992. Being of German origin she made most of the links with research groups and experts in Germany.

5.1.4. Grassroots Actors are Few and Volunteers

Following social movement theory, it is argued that AMS processes are durable and sustainable into the future because they are largely voluntary (McCarthy and Zald, 1977). Aghir in'man has managed to maintain the AMS process since 2002 and Earthlife's activities seem to follow a similar path. Although the organisations might at some point have used external funds, the activists are volunteers. Alhacen (from Aghir in'man) still keeps a job in the mine and Kohrs (from Earthlife) is currently working part-time for a German organisation in a biodiversity conservation project. The funds the organisations have managed to secure are used to buy new equipment, organise talks or sampling trips. AMS activists will be found in grassroots organisations or small NGOs, whilst big NGOs will probably use other processes to liaise with scientific experts.

Kohrs and Alhacen have been the main drivers of the AMS processes described here. Being driven by one or few members can be a potential source of weakness of AMS processes. They take the lead on most of the initiatives and the rest of the members rely heavily on them. This makes these processes potentially vulnerable if one of these key members was to disappear, leave or get co-opted. However, key to their durability, both leaders are delegating to newer or existing members and both organisations have created alliances with other local organisations; Aghir in'man is part of CSC (Coordination des organisations de la Société Civile d'Arlit) and GOSCRAZ (Groupement des Organisations de la Société Civile de la Région d'Agadez), groups of civil society organisations in Arlit and the region of Agadez. Earthlife is working with LaRRI, the Goethe Institute and several conservation and educational groups in Namibia.

5.2. Why AMS?

Did Aghir in'man and Earthlife need to learn about the impacts of radioactivity? Did they need to understand what a Sievert is or how to use radiation-measuring devices? In learning this, it could be argued that local organisations enter in the framing of the mining companies who can lure these organisations into complex EIA processes or information exchanges, neutralising their activist focus (Suryanata and Umemoto, 2005; Thompson, 2005).

Three reasons are outlined below as to why scientific knowledge needs to be acquired and reproduced by these grassroots organisations: i) to acquire visibility and legitimacy, ii) to learn about and protect themselves from the impacts, iii) to refute the produced information and manufactured uncertainty of the companies.

[2] Niger has the lowest (measured) HDI in the world (position 186) (UNDP, 2013) whilst Namibia has one of the highest Gini coefficients in the world (0,73) (HDR, 2007).

5.2.1. To Acquire Visibility and Legitimacy

> "Before we were afraid of the police, afraid of everything, of Areva, of the military… now I can speak to the military, I go freely wherever I want." (A. Alhacen, Pers. Comm., 15 March 2013).

> "Thanks to CRIIRAD we now have the equipment and the knowledge to go to a place and detect radioactive material. We feel free to write and address whoever we want" (A. Alhacen, Pers. Comm., 15 March 2013).

Through the creation of new co-produced knowledge, grassroots organisations engage in politics, in the mechanisms through which power circulates and is negotiated (Paulson et al., 2003). As this occurs, local actors acquire visibility by becoming new political actors. The fact that this new knowledge is a co-production between scientific and local knowledge gives local actors a legitimacy that would have otherwise been denied.

> "Many newspapers, politicians ask our opinion … people talk to us, we have an extremely important audience. We have been very sought out. We are the bridge with civil society because we speak about everything… Nowadays we have a lot more visibility and that is very important" (A. Alhacen, Pers. Comm., 15 March 2013).

Alhacen has gradually become a public figure. He is presently the president of the 'Commission environnementale du développement rural' of the 'commune' of Arlit making decisions ranging from water schemes to road construction and is in close contact with other local councillors, tribe leaders and the president of the 'commune'.

They have been asked to participate in public meetings of future mines, like the massive project in Imouraren (A. Alhacen, Pers. Comm., 15 March 2013) as well as being behind the organisation of three marches. The first one took place in May 2006 to denounce dust pollution. Areva paved 12 km of road leading to the mine after the march (A. Alhacen, Pers. Comm., 15 March 2013). Their appearances in national and international newspapers have been increasing, as well as their public appearances. In 2008 Areva was given the 'Public Eye Award' as the worst company in the world and Alhacen went to Davos to present the situation in Arlit. In 2010 Alhacen was also invited to present the impacts of uranium mining in Niger at the 8th Session of the UN Commission for Sustainable Development in New York. The visibility Alhacen acquired prevented Areva from firing him. Instead they 'punished' him by moving him to a lower responsibility job.

Although Areva (2011) has continuously denied all the accusations, they have gradually been improving security in the mine, providing better information to workers on radiation issues, more dosimeters (personal devices to measure gamma radiation) were given to workers, facilities were installed so that clothes weren't taken home (A. Alhacen, Pers. Comm., 15 March 2013). Around the mines, Areva invested to improve the water facilities (Aïr Info, 29 June, 2011) and is organising the "plan compteur" in Arlit monitoring the town for radiation (A. Alhacen, Pers. Comm., 15 March 2013).

Although Earthlife was already in the public sphere before their contact with CRIIRAD, a major boost to Earthlife's credibility was achieved with CRIIRAD's second trip to Namibia in 2012 when they presented the new co-produced knowledge (Press release, 11 April, 2012). A press conference was attended by all the major newspapers in the country (Namibian Sun, 24 April, 2012; New Era, 12 April, 2012; Republikien, 26 April, 2012; The Namibian, 13 April, 2012). Several meetings were organised with government bodies, regional councils and mining companies to present the results. After these meetings Kohrs stated:

> "Although the findings of CRIIRAD were downplayed by the management of the mining companies and the experts involved in the mining industry, they seem to be alerted. Several meetings were called and the press releases [of the mining companies] featured in local papers stating how harmless uranium mining is.… in general we created huge interest. We created awareness". (B. Kohrs, Pers. Comm., 9 February 2013).

Like Alhacen, Kohrs has become a public figure:

> "Shopping, or walking on the streets, I get approached". Moreover "now without being asked, Earthlife appears in the papers. If one paper writes about uranium mines, and they can't get hold of me, they quote something I have said before. I get quoted without realising or knowing"(B. Kohrs, Pers. Comm., 9 February 2013).

One could question if this newly acquired legitimacy and visibility is due to the liaison with CRIIRAD or if it is due to other activities carried out by Aghir in'man or Earthlife. However, before the liaison with CRIIRAD took place, neither organisation had the basic scientific knowledge required to co-produce new knowledge, which has been a crucial aspect to gain legitimacy:

> "Before the arrival of CRIIRAD we had zero knowledge. We didn't have materials or knowledge about radioactivity… Bruno [Chareyron] allowed us to realise that the scrap metal was contaminated so we could make the local population aware" (A. Alhacen, Pers. Comm., 15 March 2013).

> "…and for Earthlife it was a good change in a way that 'aha' it's not only emotional what I bring, I come with scientific facts, and we are taken more seriously. Especially by the experts in the companies, there is a different approach. It is evident that scientific data provided by CRIIRAD have a much greater impact than many years of Earthlife's activities providing general information on the impacts of uranium mining" (B. Kohrs, Pers. Comm., 9 February 2013).

5.2.2. To Protect from Impacts

In situations where knowledge and 'facts' have been produced and sometimes 'manufactured' by companies with no external scrutiny, local communities have no clue as to what they are confronting. They want to learn and understand what is impacting them and how to protect themselves. As Alhacen explains, before engaging in this AMS process:

> "People had no notion about uranium or radioactivity, the municipality, the tribes' leaders, there is a lot of ignorance and poverty" (A. Alhacen, Pers. Comm., 2 February 2013).

Alhacen is now able to tell the community, in the numerous workshops that Aghir in'man has organised, not to buy scrap metal in the market or not to consume water from certain boreholes. He can demand better protection for mineworkers or advise them to take seriously their radiological protection in the mine (A. Alhacen, Pers. Comm., 5 March 2013).

Rössing has admitted that their workers' knowledge of radiation issues needs to improve (Rössing Bulletin, 22 May, 2009). As an example, yellow cake has been stolen on several occasions by workers and taken to their homes in the hope of selling it (The Namibian, 8 September, 2009 and 6 September 2011). Earthlife and LaRRI want the workers to be fully aware of the impacts they are facing. As Shindondola-Mote argues:

> "I am against the ignorance of people being exploited for profit … if people were given the chance to make an informed decision of whether they want to work in a dangerous environment or not, then I would really have no problem. Because even if they (Rössing) come out and openly declare that these are dangerous zones, people will

still work, because they need their jobs, as long as people know they are not going to die today, [and] because they don't have any other option, they will still work for the mines, but at least they have made an informed decision" (H. Shindondola-Mote in Conde (2014) — 'Namibia's Uranium Rush' Documentary)

5.2.3. To Refute Manufactured Uncertainty and Other Information Produced by the Mining Companies

Areva in Niger and Rössing in Namibia have been producing information and magnifying uncertainty, always denying radiation related occupational health problems (see Section 5). The sampling and measurements carried out during and after CRIIRAD's visit allowed for the creation of new data, new knowledge, that directly challenged the knowledge that had been created by the mining companies. As an example, according to Areva's report (2010) "the results of these [water] analyses are compared to the World Health Organization (WHO) recommended limits and show that Nigerien and international drinkability norms are being met". However the measurements taken by CRIIRAD and Aghir in'man show that water is polluted above WHO limits (Chareyron, 2008; Press release, 18 December, 2003). Areva denied these accusations but closed two of the water boreholes that are mostly affected.

When accused of high death rates due to respiratory infection – the town of Arlit (16.19%) has twice the national average (8.54%) (Chareyron, 2008; Greenpeace, 2010) – Areva's response is to say that these "allergic disorders" are "caused by the aggressive impacts of sand on the eyes and lungs, and not by mining activity" (Areva, 2011). In the same report Areva (2011) states that "the environmental radiological monitoring network does not indicate massive dispersal of radioactive dust and confirms the absence of contamination within the towns". However, a field trip carried out by Aghir in'man and CRIIRAD collaborators denounced that the radiation in front of the Cominak hospital reached values 100 times higher than normal (CRIIRAD, 2007; Press release, 15 May, 2007). On the impacts of radon gas, the annual average for all sites is provided by Areva making it impossible to identify radiation hotspots (Areva, 2011). However, as pointed by Aghir in'man collaborators the level of gamma radiation 1 m above ground near the barbed wire of one of the ventilation mouths was 16 times higher than normal (CRIIRAD, 2008).

In Namibia, the abnormally high radiation measurements found in the Khan River downstream from Rössing were claimed to be natural by Rössing management (Rössing manager and G. Ellis, Pers. Comm., July, 2009). After the measurements carried out in their 2012 trip, CRIIRAD and Earthlife have been able to contradict this manufactured uncertainty: "The highest impact [on the Khan River] concerns the uranium concentration that increased by a factor of 2155, from 0.2 μg/l upstream to 431 μg/l downstream. The WHO recommendation for uranium concentration limit in drinkable water is now 30 μg/l" (Chareyron, 2014).

As Bertchen Kohrs states:

"Before we always said 'it could be that…, there is a danger…, it has happened in other countries'. But now [after CRIIRAD's results] we had facts and that was really worrying for the mines, and for the journalist was good food… If it means we are taken seriously, the more we can prove that we can understand what is going on, it's better" (B. Kohrs, Pers. Comm.,9 February 2013).

6. Avoiding co-Optation

Alliances of different actors can imply compromise and power struggles between partners leading to the co-optation of weaker actors and resulting in some powerful groups "speaking on behalf of others" (Forsyth, 2002). Co-optation is a process whereby a stronger group subsumes or assimilates a smaller or weaker group generally changing its original discourse or demands. This is a major risk in scientists–activists coalitions. Co-optation can take many forms and it can be an unintended consequence of these alliances. Local knowledge and discourses can get co-opted or disregarded by scientists with different research agendas (Cooke and Kothari, 2001; McCormick, 2009; McGrath et al., 2009; Michaels and Monforton, 2005), by bigger NGOs (Bob, 2005) or by corporate and the state 'sustainability' discourses (Bridge and McManus, 2000; Utting, 2005).

The AMS case studies described in this article have avoided (so far) co-optation. An analysis of the case studies from this perspective has surfaced three clues into how grassroots organisations can avoid co-optation in scientist–activist alliances: i) the scientific experts as well as the activists are independent both financially and institutionally, ii) the new co-produced technical knowledge does not become their only activist tool, claim or discourse and iii) grassroots actors avoid using technical language. I do not argue that AMS always avoids co-optation, but I point to factors that can help to prevent it.

i) Scientists can be hired by companies to carry out studies to challenge attacks on the industry, resulting in a conflict of interests (Michaels and Monforton, 2005). In an AMS process the scientific experts that assist the local organisations (CRIIRAD in our case studies) have no links to any industry, research center or institution. This allows them to engage in the co-production of knowledge only with the agenda and objectives of their own organisation. Moreover, as pointed by Cooke (in Hickey and Mohan, 2004), it is important that the consultants work at local rates or for free. In the case of CRIIRAD funding is coming from French citizens, allowing them to oppose strong corporations such as Areva. In the case of AMS activists, as observed before, they generally work on a voluntary basis allowing them to have certain independence.

ii) Co-optation can occur in different forms, there can be a co-optation of the discourse (their argumentation), the activities carried out, the language used, the objectives set, etc. As Bob (2005) points in his analysis of Nigeria's Ogoni movement, their original demands for political autonomy were transformed to environmental and human rights issues because of their interest in creating global alliances with large NGOs. Also Bridge and McManus (2000) point to how activists fighting gold mining in the US had their sustainability and 'appropriate technology' discourse co-opted by the industry. In the case studies analysed the new co-produced knowledge has not become their only discourse co-opting their argumentations, neither has it become the focus of their activities or only objective.
On top of radiological issues, Earthlife also raises concerns about the potential loss of tourism or the fact that mining investment is driven to their countries because of weak environmental legislation and lower taxes (Kohrs public presentation, 3 October 2009). Moreover, the study recently published on the health impacts on workers is exclusively based on local knowledge of workers and ex-workers of Rössing (Kohrs and Kapuka, 2014).
Aghir in'man in coordination with other organisations places many other demands that are not related to radiological contamination; company pay increases, government decentralization (Aïr Info, 6 December, 2011), payment and distribution of mining taxes and plundering of mineral resources (Aïr Info, 25 January, 2013; CSC, 10 October, 2011), demands for the electrification of the town of Arlit (Press release, 24 March, 2013), growing insecurity in the region, the improvement of the route between Arlit and Agadez, the capital of the region (Aïr Info, 3 February, 2011; Aïr Info, 6 December, 2011; GOSCRAZ, 2013) or the lack of respect to labour regulations or social security in the new Chinese mines of Azelic (Aïr Info, 25 January, 2013; GOSCRAZ, 2013).

iii) The use of scientific language can be an important aspect of

the co-optation process. Local activists can get carried away by the dominant-techno-scientific language; not being able to refute the industry's knowledge using technical language (Cooke and Kothari, 2001; Yearley, 1992). This can happen for example when grassroots organisations try to challenge the EIA produced by a company. However, it has also been argued that technical language can become a useful tool for activists, as with the AIDS case (Epstein, 1996; Forsyth, 2002), or when combating Monsanto's GMO seeds (Lepage, 2012; Saunders and Ho, 2012). AMS activists don't contest the tools or language of science, neither do they change or adapt scientific language to their needs. They do challenge the use and control of science, and in doing so, they need to learn the language for two main reasons; on one hand they want to carry out their own measurements and on the other, they need to be able to defend this new co-produced knowledge.

The local organisations in the case studies have however avoided their whole discourse becoming too scientific; they adapt their presentations to their audiences. Thanks to the continuous collaboration with the expert organisation, they don't need to understand every scientific detail because they can contact them if something they don't understand comes up. They want to learn enough to understand the impact. As Kohrs and Alhacen explain:

> "I did not go into understanding the chemical impact too well, it's very complicated, but the radiation part I think I understand". For instance, presently "to produce the final report we need Rössing data to compare [our results]. Then Bruno [Chareyron] can say if the radiation is manmade or original (natural)" (B. Kohrs, Pers. Comm., 9 February 2013; 9 August 2013).

> "We feel independent from CRIIRAD. Although we still need them, they are not indispensable but they are very necessary" (A. Alhacen, Pers. Comm., 15 March 2013).

7. AMS and Participatory Processes

AMS can be viewed as part of an existing body of scholarship on participatory processes like Community Based Participatory Research (CBPR) where community organisations are given a central role in the research (Minkler and Wallerstein, 2003). A main difference however is that with AMS experts co-produce science with lay people who engage in technical issues and are not limited to a political role. Moreover, with Activism Mobilising Science (AMS) the expert assists the activist not with the objective of carrying out research; hence AMS does not have the word 'research' in it. Moreover, although co-optation can be avoided in CBPR (Cohen et al., 2012; Minkler et al., 2010), with AMS as with Street Science, these inequalities or structural preconditions are generally sidestepped because the process is driven by the local organisations themselves. The divide between the scientific and the local actors that could end in co-optation is in fact acknowledged and valued in AMS. There is no need to define or reach an agreement on the type of research as in each case the experts are contacted by the organisations themselves because of their specific technical expertise, be it on dioxins, water quality or radiation. In Niger experts were contacted by the local organisation and in Namibia through an EU funded project, but with the same objective in mind — to learn about radiological impacts of uranium mining.

Models very close to AMS are Street Science and 'counter-expertise'. With Street Science communities use local knowledge to challenge the conventional use of science (Corburn, 2005). Two important traits make AMS differ from Street Science; i) although local knowledge is important with both processes, in AMS it is the co-production with scientific knowledge – not the questioning of science – that is crucial. ii) Street Science is rooted in urban and western contexts. It seeks to transform professional views about what is happening in the communities with the aim of changing policy. Conversely AMS processes occur generally, though not always, in developing countries and rural contexts. The objective with AMS is to gain knowledge and visibility in order to challenge the knowledge produced or manufactured by the companies. Policy-making is not excluded but is not as crucial as with Street Science because the structures and institutions that would allow community engagement in policymaking are not yet in place and have not been developed as a consequence of AMS. The counter-expertise model (Topçu, 2008) tolerates a blurry frontier in the activist–scientist nexus, with activists becoming themselves scientists and vice-versa. Like Street Science, the counter-expertise model is also situated in the industrial North; the activists can have scientific skills that they have been able to acquire through high education. CRIIRAD itself comes from a counter-expertise model (Topçu, 2008). However, with AMS the roles are very clearly defined and don't change; the local organisation doesn't have scientific capacity having to mobilise external capacity.

From an ecological economics perspective, Street Science, the counter-expertise model or AMS can be seen as the first stage of a Post Normal Science process, where local stakeholders that previously had no say in the issues at stake are given visibility and legitimacy to start engaging in an extended peer review process. Key to these processes is the co-production of scientific and local knowledge that is becoming an activist tool in order to challenge the dominant discourse.

8. Conclusions

The world's growing social metabolism has been pushing the extraction frontier to feed its energy and material consumption in areas sometimes very far from where it is consumed. This extraction has been causing numerous socio-environmental conflicts as communities react to the impacts suffered. The uneven distribution of impacts and risk is a consequence of the unequal power relations. This article has investigated a particular form of confrontation to the expansion of the frontier of extraction and the impacts it causes, it describes a process that contributes to a shift in power relations, thus alleviating the risks and impacts associated.

My task was both empirical and theoretical; empirical in terms of analysing and characterising this particular process, looking at its main characteristics and the reasons why activists engage in this particular way. Theoretical, in terms of understanding this process as part of the knowledge-power interaction whereby the co-production of local and scientific knowledge can challenge unequal power structures.

What is the main contribution of this research? First, the article has drawn attention to the opacity of the nuclear industry and their manufacture of uncertainty. Mechanisms like the ALARA principle – widely used in the industry – that relies on economic aspects of "how much a person is worth the investment in security" (Hecht, 2012), or the lack of statistical certainty to correlate radiation exposure with single case diseases, give the nuclear industry a huge leeway. Key issues such as setting radiation limits, deciding which radiation security measures are obligatory or accepting radiation related occupational health diseases, should not be exclusively decided by experts. Instead, an extended peer community that includes also those actors who are bearing the costs and the impacts of radiation should engage in a Post Normal Science process. Through AMS these actors are gaining visibility and legitimacy and can now engage in wider circles of power contestation.

Second, the paper contributes to two different theoretical frameworks; STS and political ecology. On one hand I have extended the co-production framework of STS shifting attention to the specificities of the co-production of knowledge itself, how local and scientific knowledge can be combined, the results it can produce, and how it can be mobilised in a socio-environmental conflict. The term co-production

allows going beyond the deficit and complementary models used in several participatory processes permitting an open engagement between science and the communities' local knowledge. This framework is valuable because it entails the acknowledgement that all knowledges (including scientific knowledge) are in part socially constructed and can therefore be challenged by other co-produced knowledge. Political ecology has helped me to point to the power and knowledge unequal structures embedded in socio-environmental conflicts that AMS is trying to challenge. It highlights the importance of local knowledge and the "promising idea" (Bryant, 1998) of combining it with scientific knowledge that AMS is doing using a co- production framework.

This article examines what I have termed Activism Mobilising Science (AMS), a process where power is contested by local organisations immersed in socio-environmental conflicts. Grassroots organisations liaise with scientific experts to learn from them the tools and scientific language they need to protect themselves from the impacts of radioactivity (in my case studies). They also want to gain visibility and legitimacy to be able to refute the produced information and manufactured uncertainty of these companies. These processes are locally driven, based on voluntary work by activists who have built related capacities, and engage in a co-production framework with the expert.

The legitimacy acquired by the grassroots organisations has allowed them to challenge the companies and government behind environmental health burdens. These organisations not only co-produce new knowledge but they also transfer it to the local population, thus becoming agents for environmental justice. This in turn has pushed companies (in our case studies uranium mining companies) to change and improve their practices. Even more relevant, is that companies (as well as the state or other elites) have to be more open about the impacts they cause if they are being more skilfully scrutinised, opening a dialogue between local grassroots organisations, the state and the companies about topics that were previously ignored or hidden.

Furthermore, I claim that what has happened in the cases presented can also happen in other places. A case in hand is the work of Bob Moran, a consultant who used to work for mining companies carrying out EIAs. Although it is difficult to ascertain the power balance of these liaisons, he is now being hired by grassroots organisations to critically examine the EIAs produced by the mines. His expertise is sought not only for his technical knowledge but also for the authority and publicity that his work draws upon the cases he reviews (FPIF, 2012; Moran, 2013).

What I offer is a set of generalizable analytical entry points to study activist-scientific relations in the context of socio-environmental conflicts. In this sense, the theoretical framework I offer is more of a heuristic and less of a formal theory and can inform case-study research elsewhere. It could then become theorised as a type of activism as part of social movement theory, participatory or PNS processes.

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