Social Construction of Cyanobacteria Blooms in Quebec: A Matter of Perceptions and Risk Management

Geneviève Brisson¹,²,³ Karine Dubé¹, Sabrina Doyon¹, and Benoît Lévesque¹,³

Abstract
Using a political ecology perspective, this research examines the social issues of cyanobacteria. In Quebec (Canada), public health officials issue warnings concerning water-related activities and water consumption. An ethnographic study was undertaken with the aim of gaining a better understanding of the attitudes of citizens toward cyanobacteria and public health measures. It enabled us to identify both the meanings attached to this phenomenon and the other driving forces behind the attitudes and, in particular, toward compliance with measures prescribed by the authorities. Focus groups and semidirected individual interviews involving several groups of social actors were conducted in 2009 and 2010 on three communities. This study points to the importance of considering natural phenomena such as the proliferation of cyanobacteria as sociocultural constructs, because this approach can be applied to address the impacts of such phenomena from a different perspective and therefore improve management practices to reduce these impacts.

Keywords
cyanobacteria, risk perception, attitudes, social construction, public health

Cyanobacteria are concurrently a natural and sociocultural phenomenon. They are an issue of relevance to both science and society as they have proliferated spontaneously in a number of bodies of water, many of which are located near inhabited areas (Moss, 2007). In recent years, a number of studies in the natural sciences addressed this phenomenon and significant efforts have been made in several countries, particularly in China, Japan, Denmark, and the United States, to take action against the proliferation of cyanobacteria (Guo, 2007; Hampton, Scheuerell, & Schindler, 2006; Jeppesen et al., 2005; Nakano, Lee, & Matsumura, 2001).

Cyanobacteria—commonly known as “blue algae” or “blue-green algae”—are photosynthetic bacteria and are in fact not related to algae. They have been around for more than 2 billion years and occur naturally in most aquatic environments. Blooms are the result of a massive proliferation of cyanobacteria, often visible on the water’s surface. Although not all cyanobacteria blooms produce cyanotoxins (such as microcystins), this does not imply that they are innocuous to animals and human beings. Indeed, the mere presence of cyanobacteria may lead to clinical symptoms. The hypothesis is that those symptoms can be associated in essence to the presence of endotoxins (bacterial lipopolysaccharides), which are a component of the cellular wall. Whether cyanotoxins are present or not, toxicity levels probably increase when higher cyanobacteria concentrations are observed (Lavoie, Laurion, & Vincent, 2007; Lévesque et al., 2014, 2016).

Despite the connections that exist between the microorganisms and society due to their consequences and the actions they set in motion, research done until now has been based mainly in the natural and life sciences (e.g., Chevalier, Pilote, & Leclerc, 2001; Giani, Bird, Prairie, & Lawrence, 2005; Lévesque et al., 2016; Pilotto et al., 1997; Rolland, Bird, & Giani, 2005; Stewart, 2004; Whitton & Potts, 2000). Basically, the social, cultural, and symbolic dimensions of the phenomenon have not specifically been addressed (Levain, 2013).

Yet, it remains relevant to consider naturally occurring phenomena such as cyanobacteria as sociocultural constructs, as the way they are perceived or represented can influence both current practices for managing environmental...

¹Université Laval, Quebec, Canada
²Sociétés, Territoires et Développement, Université du Québec à Rimouski, Canada
³Environmental Health Unit, Institut national de santé publique du Québec, Canada

Corresponding Author:
Geneviève Brisson, Département Sociétés, Territoires et Développement, UQAR—campus de Rimouski, 300, Allée des Ursulines, Rimouski, QC GSL 3A1, Canada.
Email: genevieve_brisson@uqar.ca
issues and the attitudes of citizens toward measures prescribed by the authorities. As it will be shown in this article, economic effects, social tensions, and high-profile controversies may also arise. Science and politics have often overlooked legitimate concerns reflected in the social construction of nature. Uncovering them can include reflexivity when “risk” is associated to particular situations and managed as such (Beauchamp, 1996; Brunet, 2007; Leiss, 2001). For this reason, we addressed the proliferation of cyanobacteria as a sociocultural construct involving several groups of social actors and focused our study on Québec (Canada), given that this phenomenon and the related public actions found themselves recently at the center of media attention. The text aims to show that to better address the management of risks facing a natural phenomenon, the identification of perceptions of this phenomenon is essential.

Our intention with this article is to provide an original contribution to the study of environmental issues, which highlights the importance of using qualitative methods and sociocultural concepts to understanding them, while considering the diversity of their knowledge, values, needs, concerns, and interests. This approach can further strengthen dialogue and cooperation among them while improving management practices, with the aim of increasing our understanding of citizen responses to the various measures taken to eliminate cyanobacteria and ensure that their proliferation does not cause health problems to water users.

We begin by presenting a review of humanities and social science studies conducted on cyanobacteria and similar phenomena, as well as a description of the political ecology theoretical framework on which our study is grounded. We then provide a detailed outline of the methodological approach, which is followed by an account of the principal factors influencing attitudes of social actors regarding the phenomenon of cyanobacteria, by exploring in more depth the role of corresponding risk perceptions. We conclude with a discussion and suggestions for future action on risk management.

The Social Study of Cyanobacteria

Today, the knowledge base regarding social aspects of the phenomenon of cyanobacteria is limited and the primary focus of interest is on socioeconomic issues. Therefore, our study attempts to fill this gap by exploring this phenomenon from the perspective of political ecology and of social representations of nature and risk.

Socio-Economic Impacts of Cyanobacteria

Environmental sciences and management researchers have examined the socioeconomic impacts of cyanobacteria (Blais, 2002; Hoagland, Anderson, Kaoru, & White, 2002; Pretty et al., 2003). Here, the emphasis is on how the phenomenon is affecting tourism, commercial fishing, and the real-estate sector, because of the degradation of water quality and the repulsive visual appearance of the water’s surface during cyanobacteria bloom events, which are known to cause health problems. The expenses incurred to protect human health, monitoring, and managing were estimated for this phenomenon (Steffensen, 2008). These studies found that the extent of the impacts vary in particular according to the type, size, and frequency of cyanobacteria blooms, the size of water bodies where they proliferate, the nature of practices (leisure or other) for which they are used, and the types of available water treatment facilities. However, none of the articles cited refer to the attitudes of managers and citizens faced with this problem, and to factors influencing these attitudes such as, for example, the social representations of risk or the losses and benefits (actual or anticipated) related to the compliance with measures prescribed by the authorities.

Social Representations of Microorganisms

A number of social science researchers have conducted studies into similar phenomena such as cyanobacteria by examining their cultural and symbolic dimensions. Their approach is somewhat different as they take a closer look at how social representations can influence the behavior of social actors. As a result, these researchers offered new insights into the meanings that are ascribed to the proliferation of intrusive algae, which occurred over the past 15 years on the coastal shores of the Mediterranean Sea, Brittany, New England, and Florida (e.g., Bernardina, 2000; Chateauraynaud, 2011; Fall & Mattey, 2011; Kempton & Falk, 2000; Kuhar, Nierenberg, Kirkpatrick, & Tobin, 2009; Le Chêne, 2012; Levain, 2013; Paolisso & Chambers, 2001; Paolisso & Maloney, 2000; Quéré, 2012). These meanings, including the social representations of risk, are associated to the location of algae proliferation; this finding points to the relevance of conducting a context-sensitive analysis. The studies also highlight the importance of gaining a better understanding of the various representations made by the public, particularly to minimize adverse social and economic impacts.

Before implementing any type of red tide control or mitigation strategy, it is important to understand how the public perceives and understands Florida red tides and possible mitigation techniques. It is through the perception of risk events that individuals respond and behave accordingly. However, their knowledge and behavior may not be consistent with the actual risk surrounding the event and can, therefore, have far-reaching social and economic impacts. (Kuhar et al., 2009, p. 964)

A Constructivist Approach for Examining Cyanobacteria

Many disciplinary ways could be useful to study social construction of a natural phenomenon, as environmental
psychology (Clayton, 2013; Marchand & Weiss, 2006), or environmental sociology or anthropology (Demeritt, 2002; Hannigan, 2014). This study examines cyanobacteria in Québec using a constructivist political ecology perspective. Drawing on the work of the anthropologist Arturo Escobar (1996, 1999), we maintain that the natural environment—including natural risk—is closely related to society and culture, and this relation must be understood and taken into account: “. . . nature is simultaneously real, collective, and discursive—fact, power, and discourse—and needs to be naturalized, sociologized, and deconstructed accordingly” (Escobar, 1999, p. 2). Our study lends support to the postulate that though it possesses an objective reality, cyanobacteria phenomenon is also characterized by volatile and dynamic meanings that vary according to each individual and lead to both natural and social consequences (Paolisso & Chambers, 2001). As social construction of nature and risk, cyanobacteria play a role in society.

In that perspective, we attempted to identify the perceptions related to this phenomenon by focusing on the way risks are represented in the discourses held by social actors. For some scientists, risk perception is based upon relation between “in part an objective threat of harm and in part a product of culture and social experience” (Rosa, 2003, p. 49). Others, especially anthropologists, argue that the characteristic of “risk” that scientists attribute to particular activities or natural phenomena could not be based on objective features. Methods, assessment frameworks, indicators, and scales could not be neutrals, and are always mediate by individual or social projections of meanings, values, paradigms, practices, power, and social positions (Joffe & Orfali, 2005; LeBreton, 2002). Adopting this constructivist lens, the concept of risk perception could be understood as differences of appreciation for a same situation or phenomenon (Borratz, 2008). Though, risk perception merge from a subjective point of view, shape by body, experiences, learning, affects, as by institutions, norms, sociocultural constructs, ways of life, and so on. In addition to the perceptions of risk, other factors may shape individual attitudes toward risk and its management: context, media, sociodemographic or individual characteristics, trust in institutions, and so on (Ferreira, 2004; Janz, Champion, & Strecher, 2002; Parker, Baldwin, Israel, & Salinas, 2004; Turbow, Lin, & Jiang, 2004). These factors can influence not only individual behavior but also the way in which they conceptualize risk concerning particular phenomena (Joffe & Orfali, 2005).

For the environmental ethician André Beauchamp, reality is constructed as risky when people want to see it as “a problem to be solved” (Beauchamp, 1996, p. 18). A political ecology perspective especially put attention on this, and raise issues as: How a natural phenomenon as cyanobacteria blooms is problematized, by whom? Which kind of solutions—individual, collective, and politics—merged from this specific problem formulation, and what are their consequences? In that perspective, the concept of risk could be a way to démystify, manage, and control nature, and to help to cope with the uncertainties (Brunet, 2007; Leiss, 2001).

The Issues Addressed in the Study

This study was conducted in the Province of Québec (Canada), where more than 100 bodies of water found within inhabited areas are regularly affected by cyanobacteria bloom events (Ministère du développement durable, de l’environnement et des parcs [MDDEP], 2012). While the phenomenon is not new, it is only recently that it has come to the public’s attention, especially since the watershed year of 2007. The phenomenon received wide media coverage, and several institutional measures were taken to protect public health, remove potential sources, restore shorelines, and so on. Besides, nationwide research programs were launched to tackle this particular issue. Set within the framework of a public health research program, the aim of this ethnographic study was to document the phenomenon of cyanobacteria as a sociocultural construct, to achieve a better understanding of the variety of meanings attached to them and their influence on the attitudes of social actors toward public management measures. In this article, we present the results of our analysis related to the following questions: What are the perceptions of cyanobacteria? Do they pose a direct health risk to the population for whom the public health measures are intended? How do these risk perceptions alter their attitudes concerning this phenomenon, and what are the other key factors of influence?

Method

Qualitative research into risk perceptions is especially appropriate, especially when a phenomenon is largely unexplored. In fact, this approach is used to closely examine a particular topic and to extract the constructs underlying the discourse (Deslauriers, 1991); it places the emphasis on the symbolic dimensions and the understanding of factors most likely to influence attitudes toward the phenomenon of cyanobacteria and public health measures.

Study Sites and Population

An ethnographic fieldwork was carried out in 2009 and 2010 with social actors concerned by the local outbreak of cyanobacteria. The respondents all lived in municipalities located along the shores of the bodies of water identified in a public health research program on cyanobacteria, that is, the Missisquoi Bay of Lake Champlain, Lake William, and Lake Roxton (Figure 1).

Cyanobacteria bloom events have been recorded over a long time on these three bodies of water, where an active
association of local residents has taken root, and which are home to a relatively important and diversified population of permanent residents. This research gives a strong hint of the diversity of attitudes about cyanobacteria blooms. To verify whether we can extrapolate our findings to the level of the province, a large-scale research project should be conducted, with two components: an epidemiologic survey and an ethnographic study. The municipalities agreed to participate in the research program. Of these study sites, Lake William was the focus of the main case study because of the particular efforts made by various groups of social actors at the local and regional levels to prevent the proliferation of cyanobacteria and to improve water quality. This research project and the tools used were approved by the Ethics Committee of the Clinical Research Centre hospitalier de l’Université Laval (CHUL).

Data Collection and Analysis

A variety of qualitative data collection techniques were used to conduct the ethnographic study. We held discussion groups with residents of each of the lakes under study (two groups for each lake, and each group formed by six to 10 residents.). Participants were selected by two ways: First, we stratified the potential participants in the epidemiologic public health survey based to the scientific literature about water attitude factors (Kempton & Falk, 2000; Kuhar et al., 2009; Paolisso & Chambers, 2001): place of residence, gender, and age diversity seem particularly important. Second, we selected at random and contact potential participants. For Lake William, two other discussion groups and 13 individual interviews were also conducted with individuals representing the leading groups of social actors concerned by the local outbreak of cyanobacteria (farmers, owners of recreation and tourism businesses, local and provincial authorities, environmental groups). To refine the existing data set, the analysis was also based on informal interviews and participatory observations. A semistructured interview guide was used to facilitate discussions for focus groups. Its format was subsequently adapted for the other interviews. The interview guide addressed the following topics: sense of belonging, perceptions of risk, of causes and of current management practices, as well as expectations about the future of their environment and about the issues related to the presence of cyanobacteria.

To identify the risk perceptions about cyanobacteria and the factors influencing the attitudes of social actors regarding this phenomenon, a thematic content analysis of the entire database was performed and assisted by the software package N’Vivo 7. Difference between types of social actors was note when they appeared significative. Each focus group was analysis as an entity, and was analysis as that, to recognize the importance of the discussion in this type of data collect process (Caillaud & Kalampilikis, 2013). In the same spirit, a particular attention was paid to identify intergroup dynamics but here it proved low-significant, especially for the live construction of perceptions.

Finally, a focus group was set up in spring 2011 to validate the preliminary results from the study. Drawing together Missisquoi Bay and Lake Roxton stakeholders from the municipal, governmental, environmental, and agricultural sectors, it was attended by 10 representatives from local and regional social actor groups concerned by the cyanobacteria issue.

Results

The proliferation of cyanobacteria is a social problem constructed, among other factors, through forms of knowledge and meanings ascribed to it by affected communities. As revealed in our study, perception of the phenomenon as a risk is an important factor, but is not shared by all the participants; other factors may also influence the attitudes of social actors toward the proliferation of cyanobacteria and with respect to the management of this phenomenon.

Description of the Perceptions of Cyanobacteria

In the course of our research, we found a number of different perceptions of cyanobacteria. A comparative analysis shows that although they appear in all three study sites, some (cyanobacteria viewed as something disgusting and a source of potential risks) seem to dominate in places where bloom events are apparently more frequent, essentially in a section of Missisquoi Bay and on Lake Roxton.

Throughout the study, attention was paid to understanding these social constructs by examining them from the perspective of risk, and to identifying those factors that may contribute to their construction. This enabled us to identify various perceptions of the phenomenon (Table 1). First, some respondents emphasized the negative aspects related to microorganisms to identify them as risk: For them, something so disgusting is obviously a source of potential risks, and evidence of degradation of aquatic
ecosystems. In fact, research participants more often elicited the risk perception found in this category. For another group of respondents, cyanobacteria are perceived as having a neutral effect with how they relate to the environment, being either a “natural” occurrence, or something harmless. Finally, the last category includes the range of knowledge about the phenomenon.

The majority of participants perceive cyanobacteria above all as something disgusting, mainly because of their appearance. They say that when toxins are released and blooms occur, cyanobacteria can take the appearance of pea soup, green paint or gelatine spills, forming even sometimes a thick crust on the water’s surface. The smell they produce also triggers disgust: “The major inconvenience for me is the odor. Because when you go out to take a rest, then this awful smell really makes you gag. I find that terrible. For me it is the biggest inconvenience for the moment.”

Cyanobacteria are also evidence of water quality degradation: “When cyanobacteria are found in a lake, it is like the sound of an alarm telling us that water quality is deteriorating and that the lake is in a state of eutrophication (premature ageing).” This environmental qualification seems to be especially common with local authorities and environmental groups in each of the lakes selected for this study. However, at Lake William, “water quality degradation” was not directly mentioned by local authorities, but they have implemented in recent years a series of measures to improve water quality and eliminate cyanobacteria.

Responses from another subset of participants suggested that cyanobacteria are a source of potential health risks. Respondents who refer to this risk within their discourse claimed, for example, that cyanobacteria could release various toxins that may affect the skin, the liver, or the nervous system, in particular when they are highly concentrated, that is, when cyanobacteria blooms occur: “. . . as long as the algae is not transformed, it is okay. I think that it is when the algae dies and turns blue that it releases its toxins and that is what makes it dangerous.” Furthermore, the level of vulnerability may be higher in children than in adults. According to some respondents from Missisquoi Bay and Lake William, this perception of cyanobacteria is more likely to be found with new residents, that is, those who have lived for a short time in the area.

For the majority of participants in all locations (except for Missisquoi Bay), cyanobacteria rather represent a harmless organism: “We may say that it is dangerous, but people swimming in the lake do not become ill. So I ask, where’s the danger?” The long-time residents, in particular, seem to care very little about risks related to cyanobacteria. More specifically regarding swimming, some respondents stated that in their view, even when cyanobacteria are present, this activity poses no immediate threat as long as certain precautions are followed (do not swallow water and take a shower after going into the water).

Moreover, for some participants from Lake William, particularly environmental group members, and for residents of Missisquoi Bay and Lake Roxton, cyanobacteria are a natural occurrence: “. . . cyanobacteria can be found in almost all the lakes and rivers in the world. . . . They will always be around, but there is no problem as long as there are no blooms.” Meanwhile, a high concentration level of cyanobacteria found in a body of water would be considered “abnormal”: “. . . humans must be part of the equation, since it is not natural that there is so much of it.”

### Table 1. Perceptions of Cyanobacteria and Elements on Which They Are Based.

| Category       | Type of perception | Main factors used for constructing the risk perception | Actors behind the risk perception |
|----------------|--------------------|-------------------------------------------------------|----------------------------------|
| Risky          | Something disgusting | Sensory experience: appearance and smell | All groups of actors; All lakes |
|                | Evidence of water quality degradation | Broadcasted information | Local authorities and environmental groups; All lakes |
|                | Potential health risks | Broadcasted information (media, government, community-based groups, scientific literature); Experience of symptoms: personal or family history of symptoms | All groups of actors; Lake William and a section of Missisquoi Bay |
| Neutral        | Harmless            | Experience: absence of personal or family history symptoms | All groups of actors; All lakes (aside from a section of Missisquoi Bay) |
|                | Natural occurrence  | Broadcasted information | Environmental groups from Lake William and residents from the other lakes |
| Uncertainty    | Unknown: ignorance of its nature, appearance, risk | Surplus or lack of information; Conflicting messages; Scientific uncertainty | All groups of actors (except for environmental groups); All lakes |
Finally, many participants from Lake William and some from the other sites selected in the study (with the exception of the environmental groups), recognize mostly cyanobacteria as an unknown organism. This is due to the uncertainty of their nature and appearance, of what causes their proliferation, and what are the associated risks. In certain cases, the overload of information sent to residents explains the confusion surrounding the cyanobacteria issue: “One year, they claim we are all going to die. Another year, we are half dead. While the following year, things are not so bad. . . . To my knowledge, I read about all that was published by Public Health, including all health advisories that were sent to me and as a result, I am unable to find a clear answer myself and make up my mind on the issue.”

Table 1 illustrates the two principal elements on which are based the various perceptions of the risk. First, some are related to the information that the media, local and governmental authorities, and environmental groups provide, which is basically drawn from scientific studies. Second, the observations made by participants and their lived experiences also contribute to the social construction of cyanobacteria. For example, in Missisquoi Bay, some people reported seeing animals becoming ill after having drunk lake water covered with blue-green algae. Others saw dead fish along the shorelines of Roxton Lake and believed that cyanobacteria were the cause. In addition, some participants claimed having experienced symptoms or mentioned they knew someone exposed to cyanobacteria who experienced them (nausea caused by the smell, diarrhea, ear infections, leg sores), while others claimed the opposite. These elements thus have an influence on the way cyanobacteria and the risks related to this phenomenon are perceived.

Finally, the negative perceptions about cyanobacteria (something disgusting, source of potential risks and evidence of water quality degradation) could be useful in improving the understanding of the rationale behind the implementation of a series of measures to eliminate the algae and therefore protect the health of the population. A survey with those in charge of managing this phenomenon at the provincial and regional levels would surely be a way to validate this hypothesis. Besides, the population specifically targeted by these measures has expressed a range of attitudes toward them, which we will now examine in the following section.

**Attitudes Toward Risk Management**

During the past 10 years, a number of measures have been introduced to protect water users against cyanobacteria in spite of the uncertainties about the risks associated with this phenomenon. Warnings were issued a few times to residents of Lake William, Missisquoi Bay, and Lake Roxton about taking part in water-related activities, but swimming was not prohibited in each of these three bodies of water. Moreover, in certain places, a drinking water advisory was put in place.

For this study, we tried to identify the various factors influencing the attitudes of the social actors toward cyanobacteria and the measures taken to manage this phenomenon. Without surprise, we found that their perceptions play an important role. Consequently, the majority of residents that we met in each of the study sites said that the risk management measures that were introduced are suitable, as cyanobacteria represent for most of them a source of potential health risks and something disgusting. In addition, these perceptions alter their attitudes, particularly relating to water uses. Indeed, those for whom the appearance or the smell of cyanobacteria causes disgust avoid generally all contact with water during bloom events. However, those for whom they represent a source of potential or unknown risks avoid swimming in some cases or take a shower immediately afterwards, but they never (or seldom) put a stop to activities that do not bring them in direct contact with water. In short, individuals often rely on their own perceptions of cyanobacteria to estimate the risks of water-related activities, rather than strictly follow public health advisories: “I carry on and trust my own judgment. When I look at the water and it is green, I do not jump in. Then, even if it is not green, although they would impose me . . . Hey! Sometimes, they sent us advisories when the water was so beautiful, it made no sense.” Moreover, those who regard cyanobacteria as simply harmless organisms do not take any precaution, even when the warning comes from a public health advisory.

Our analysis has shown that other factors can also influence the attitudes of individuals with respect to public health measures introduced as a response to cyanobacteria, in particular the pros and cons of complying with these measures. For example, some participants avoid any contact with water during cyanobacteria bloom events because they consider that it is beneficial to comply to protect their own health and the health of their children. Yet, others disregard public health advisories or sidestep them by engaging in activities that require little or no direct contact with water because it would be far too disappointing for them to not be able to enjoy being out on the water.

Among the other factors influencing attitudes, we found that scientific uncertainty concerning the risks of exposure to cyanobacteria was a significant basis for some users to trust their own judgment instead of public health advisories to decide whether or not they will come into contact with water during bloom events. However, a number of respondents claimed that they would be more prepared to follow the recommendations of public health authorities if it could be proven scientifically that cyanobacteria are in fact hazardous to health.

The level of trust in institutions mandated to manage risks is one of the key factors of influence regarding compliance with public health protection measures. On this point, a number of participants appeared to have developed a feeling of distrust toward government authorities, accusing them of sometimes using fear mongering tactics, as it was the case in
2007, or of acting with negligence. In fact, since 2008, public health officials no longer systematically issue warnings or advisories when cyanobacteria bloom events occur in a body of water, which is a cause for concern for some respondents: “Did they make a mistake? They never tell us whether they made a mistake or not. However, suddenly, what you were required to do is no longer necessary . . . by doing so, they lack credibility in the minds of citizens. That is for me a definite cause for concern.”

However, it should be mentioned that the approval rate by the population is generally greater for measures spearheaded by local groups as the level of trust in grassroots organizations seems higher than in governmental agencies. Those local measures usually stand by volunteer comities of waterfront citizens. Our research samples were too small to draw solid conclusions about their specific risk perceptions, but it is clear that most of their actions are oriented to environmental protection, and especially waterfront revitalization. For example, on William Lake, the local committee tries to convince local authorities and the neighborhood to revegetate lakeshores with indigenous plants, and it organizes community activities for this issue (information stand on the public market, Day of Lake, etc.).

**Discussion**

The results of this study confirm that various types of perceptions exist about cyanobacteria, which in turn influence the attitudes of citizens toward measures recommended or prescribed by the authorities. Our review of the literature reveals that the way such phenomena are represented can also have an influence on risk management approaches (Brunet, 2007; Nedelcu & Hainard, 2006). We can assume that the case of Québec is no different regarding risk management of cyanobacteria since the provincial government imposed mandatory restrictions on swimming and water consumption in several places during 2007, considering them as a source of potential health risks even though there was insufficient knowledge about the nature of the hazards associated with cyanobacteria. Furthermore, a series of measures were implemented at the provincial, regional, and local levels to limit cyanobacteria from the bodies of water affected by their proliferation. Perception of cyanobacteria as harmful organisms was necessary to carry these measures out because of the existing uncertainties about the causes of this phenomenon.

The perceptions of these microorganisms thus play a part in the social construction of nature and, more particularly, of natural risk, by describing the proliferation of cyanobacteria as a social and environmental problem. Clearly, such a natural phenomenon is not in itself a problem as long as it does not affect human beings in one way or another. In the case of cyanobacteria, our study shows that the impacts that are attributable to this phenomenon arise mainly from the various management and prevention measures that were introduced and from attitudes of citizens toward them, which are largely influenced by their perceptions of blue–green algae. This finding supports the conclusions drawn from other studies concerning similar phenomena (Kempton & Falk, 2000; Kuhar et al., 2009; Paolisso & Chambers, 2001).

The way that risk perceptions act upon society is not new (Beck, 1992). Cyanobacteria offer another case to observed them at an individual level (by having a direct bearing on quality of life and leisure activities) and at the political and economic level, and are thus a reflection of the interactions between nature and culture (Escobar, 1999). From the data obtained in our study, it appears that when informants perceive cyanobacteria as something disgusting and a source of potential risks or as unknown organisms, they talk more about impact citizen’s quality of life, anxiety about uses of water and the local economy, and social tensions between and within various groups of social actors. We observed some of these tensions, and they are the result not only of their points of view concerning the identification of those presumed to be responsible for the proliferation of cyanobacteria but also of the opinions they hold on the measures taken to address the problem, which are sometimes at odds. Paolisso and Maloney (2000) have made the same observations in Chesapeake Bay Region. Furthermore, we can assume that authorities may decide to do nothing to protect citizens by defining cyanobacteria as something neutral, natural or harmless, which could likely reduce the negative effects resulting from the proposed risk management measures. Respondents who stated that cyanobacteria represent harmless organisms confirmed that they have suffered less from the consequences because they do not sense any fear and they have never stopped pursuing water-related activities, even during bloom events.

Another impact of this phenomenon is a direct result of the ambiguous nature of the scientific evidence concerning the health risks of cyanobacteria exposure. Based on the literature review, controversies can arise in particular when people judge public health protection measures to be excessive or insufficient, without knowing with certainty the possible risks from being in contact with algae. This can cause confidence levels with public institutions responsible for coordinating these measures to fall (Ferreira, 2004). We found in our study that the scientific uncertainties surrounding this issue give rise to a certain degree of distrust toward authorities charged with overseeing risk management of cyanobacteria. Since residents received contradictory information, they decided simply to use their own judgment, which combines their experiences and local knowledge, to assess water-related risks instead of relying on the authorities and scientific experts, as was found in another study, which focused on a similar phenomenon (Martin & Pendleton, 2008).

In short, we were able to identify certain meanings attached to a phenomenon, which is still partly unknown, by showing how the proliferation of cyanobacteria is closely
related to society and culture. Another objective of this research was to further the knowledge of the various factors influencing the attitudes of social actors regarding this phenomenon and, consequently, to improve the understanding of the related impacts. As they can be very harmful, we have demonstrated the importance of studying what drives these impacts to limit the scope of damage.

However, there are some limitations to this research. First, we did not document the social perceptions of the authorities charged with overseeing the management of cyanobacteria at the provincial and regional level, as the focus was primarily on social actors facing this phenomenon locally. Second, it is possible that our findings merely reflect the specific study sites or the groups involved. To verify whether we can extrapolate our findings to the level of the province, a large-scale research project should be conducted.

Conclusion

The objective of this article was to show that it is useful—indeed essential—to address natural phenomena such as the proliferation of cyanobacteria as sociocultural constructs. In considering the impacts of such phenomena from another perspective, this approach provides the opportunity to explore the influence of risk perceptions on the attitudes of social actors and the resulting effects. To summarize, we present the major findings of this study:

- The term cyanobacteria is assigned diverse meanings that vary according to each group of social actors, and risk perceptions found in each of the study sites are declined in various ways.
- Risk perception is a major influencing factor to shape the attitudes of the social actors regarding this phenomenon, particularly toward risk management and compliance with public health measures. Other factors can also influence the attitudes of the individuals toward the health protection measures, including the assessment of the pros and cons of compliance, the scientific uncertainty concerning the risks, and the level of trust in public institutions.

Finally, the study of risk perceptions and of the attitudes associated with such phenomena can help increase the understanding of their impacts at the individual, social, and economic levels to refine risk management and communication practices and adapt them more effectively to the distinct features of each context. It can also help improve the interactions between the stakeholders (e.g., environmental groups, government, and municipal officials), promote citizen involvement in the management of environmental issues, and play a role in building resilience capacity (e.g., Plante, Boisjoly, & Guillemot, 2006). These social and cultural aspects should therefore be taken into consideration in the practices to ensure the protection of public health (Belleville et al., 2009).

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research and/or authorship of this article: This research was supported by Fonds de recherche sur la nature et les technologies, Grant 2009-CY-130572 awarded to Benoît Lévesque.

Notes

1. Some of these researchers have adopted the expression “cultural model,” which refers to the “shared, simplified, formal representations of explicit and implicit knowledge, interests, beliefs, and values that help individuals to understand the world and their behavior in it” (Paolisso & Chambers, 2001, p. 3), while others have found it more useful to draw on concepts such as “representation” or “social perception.” These terms all share in common the meanings that are ascribed by social actors to poorly understood phenomena, such as the proliferation of invasive algae, so that they can be understood more easily and correct attitudes toward them be adopted.

2. This study is part of a research program, whose purpose is to assess how cyanobacteria adversely affect the health and quality of life of local residents of three bodies of water in Québec. This has a direct bearing on the methodology, particularly regarding the selection of study sites and of data collection techniques used in our research. Included in the second part of this study, our research was initially intended at identifying the factors influencing compliance with public health recommendations on cyanobacteria. However, we decided to include other objectives besides this one and target other groups of social actors to gain a better understanding of the phenomenon of cyanobacteria by addressing its social and cultural dimensions. Research materials related to this article could be accessed by contacting the contact researcher. Note that another article was published in French about complementary topic.

3. This research project and tools were approved by the Clinical Research Ethics Committee of the Université Laval affiliated teaching hospital (CHUL), certificate of approval 119.05.01, effective May 28, 2008.

References

Beauchamp, A. (1996). Gérer le risque, vaincre la peur [Manage risk, overcome fear]. Saint-Laurent, Quebec, Canada: Bellarmin.

Beck, U. (1992). Risk society: Towards a new modernity. London, England: Sage.

Belleville, D., Brisson, G., Chevalier, P., Dubé, K., Gauvin, D., Gervais, M.-C., . . . Phaneuf, D. (2009). Mémoire déposé à la Commission des Transports et de l’Environnement concernant les effets potentiels sur la santé liés à la présence des algues bleu-vert (cyanobactéries) [Submission to the Committee on Transportation and the Environment regarding potential health effects associated with the presence of blue-green algae (cyanobacteria)]. Québec, Canada: Institut national de santé publique.
du Québec (INSPQ), Direction de la santé environnementale et de la toxicologie. Retrieved from http://www.inspq.qc.ca/pdf/publications/1043_MemoireCyanobactéries.pdf
Bernardina, S. D. (2000). “Algues tueuses” et autres fléaux. Pour une anthropologie de l’imaginaire écologique en milieu marin: le cas de Caulerpa taxifolia (“Seaweed killers” and other plagues. For an anthropology of the ecological imaginary in the marine environment: The case of Caulerpa taxifolia). La Ricerca Folklorica, 42, 43-55. doi: 10.2307/1479976
Blais, S. (2002). La problématique des cyanobactéries (algues bleu-vert) à la baie Missisquoi en 2001 [The problem of cyanobacteria (blue-green algae) at Missisquoi Bay in 2001]. Agrosol, 13, 103-110. Retrieved from http://www.mdddep gouv.qc.ca/eauc/co_aqua/cyanobactéries/articlesb.pdf
Borraz, O. (2008). Les politiques du risqué [Risk policies]. Paris, France: Presses de Sciences Po. Retrieved from http://www.cairn.info acces.bibl.ulaval.ca/les-politiques-du-risque-9782724610741.htm
Brunet, S. (2007). Société du risque: quelles réponses politiques? [Risk society: Which kind of politic answers?] Paris, France: L’Harmattan
Caillaud, S., & Kalampalikis, N. (2013). Focus groups and ecologoci society practices: A psychosocial approach. Qualitative Research in Psychology, 10, 382-401. doi:10.1080/14780887.2012.674176
Chateauuraynaud, F. (2011). Argumenter dans un champ de forces. Essai de balistique sociologique [Argument in a field of forces. Sociological Ballistic Essay]. Paris, France: Petra
Chevalier, P., Pilote, R., & Leclerc, J. M. (2001). Risques à la santé publique découlant de la présence de cyanobactérimes aux algues bleues toxiques et de microcystines dans trois bassins versants du sud-ouest québécois tributaires du fleuve St-Laurent [Public health risks arising from the presence of toxic cyanobacteria (blue algae) and microcystins in three watersheds in southwestern Quebec that are dependent on the St. Lawrence River]. Québec, Canada: Saint-Laurent Vision 2000, en collaboration avec l’Unité de recherche en santé publique du Centre hospitalier de l’Université Laval (CHUL) et l’Institut national de santé publique (INSPQ).
Clayton, S. (2013). The handbook of environmental and conservation psychology. New York, NY: Oxford University Press
Demeritt, D. (2002). What is the “social construction of nature?” A typology and sympathetic critique. Progress in Human Geography, 26, 767-790. doi:10.1191/0309132502ph402oa
Deslauriers, J. P. (1991). La recherche qualitative [Qualitative research]. In J. P. Deslauriers (Ed.), Recherche qualitative: guide pratique [Qualitative research: Practical book] (pp. 5-22). Montréal, Québec, Canada: McGraw-Hill
Escobar, A. (1996). Constructing nature: Elements for a poststructuralist political ecology. In R. Peet & M. Watts (Eds.), Liberation ecologies: Environment, development, social movements (pp. 46-68). London, England: Routledge
Escobar, A. (1999). After nature: Steps to an antiessentialist political ecology. Current Anthropology, 40, 1-30. doi:10.1086/515799
Fall, J., & Mattey, L. (2011). De plantes digestes et d’ invasions barbaires: les sociétés au miroir du vegetal [Barbaric invasions of plants: Societies in the mirror of plants]. Vertigo. doi:10.4000/vertigo.11046. Retrieved from http://vertigo.revues.org/11046
Ferreira, C. (2004). Risk, transparency and cover up: Media narratives and cultural resonance. Journal of Risk Research, 7, 199-211. doi:10.1080/1366987042000171294
Giani, A., Bird, D. F., Prairie, Y. T., & Lawrence, J. F. (2005). Empirical study of cyanobacterial toxicity along a trophic gradient of lakes. Canadian Journal of Fisheries and Aquatic Sciences, 62, 2100-2109. doi:10.1139/F05-124
Guo, L. (2007). Doing battle with the green monster of Taihu Lake. Science, 317, 1166. doi:10.1126/science.317.5842.1166
Hampton, S. E., Scheuerr, M. D., & Schindler, D. E. (2006). Coalescence in the Lake Washington story: Interaction strengths in a planktonic food web. Limnology and Oceanography, 51, 2042-2051. Retrieved from http://www.jstor.org/stable/3841044
Hannigan, J. A. (2014). Environmental sociology (3rd ed.). London, England: Routledge
Hoagland, P., Anderson, D. M., Kaoru, Y., & White, A. W. (2002). The economic effects of harmful algal blooms in the United States: Estimates, assessment issues, and information needs. Estuaries, 25, 819-837. doi:10.1007/BF02804908
Janz, N. K., Champion, V. L., & Strecher, V. J. (2002). The health belief model. In K. Glanz, B. K. Rimer, & F. M. Lewis (Eds.), Health behavior and health education: Theory, research, and practice (pp. 45-66). San Francisco, CA: Jossey Bass
Jeppesen, E., Søndergaard, M., Jensen, J. P., Havens, K. E., Anneville, O., Carvalho, L., . . . Winder, M. (2005). Lake responses to reduced nutrient loading—An analysis of contemporary long-term data from 35 case studies. Freshwater Biology, 50, 1747-1771. doi:10.1111/j.1365-2477.2005.01433.x
Joffe, H. M., & Orfali, B. (2005). De la perception à la représentation du risque: le rôle des médias [From perception to risk representation: The role of the media]. Hermès, 41, 121-129. Retrieved from www.cairn.info/revue-hermes-la-revue-2005-1-page-121.htm
Kempton, W., & Falk, J. (2000). Cultural models of Pfiesteria: Toward cultivating more appropriate risk perceptions. Coastal Management, 28, 273-285. doi:10.1080/0892750505133548
Kuhr, S. E., Nierenberg, K., Kirkpatrick, B., & Tobin, G. A. (2009). Public perceptions of Florida red tide risks. Risk Analysis, 29, 963-969. doi:10.1111/j.1539-6924.2009.01228.x
Lavoie, I., Laurion, I., & Vincent, W. (2007). Les fleurs d’eau de cyanobactéries. Vulnerabilité des prises d’eau [Flowers of water of cyanobacteria. Vulnerability of water intakes]. JVRIS Eau, Terre et Environnement, rapport 919 (v). Retrieved from https://oraprdnt.uqtr.uquebec.ca/pls/public/docs/GSC1423/F557248662_Cyanobactériennes_vulnerabilité_des_prises_d_eau.pdf
LeBreton, D. (2002). Conduites à risqué [Risk attitudes]. Paris, France: La Découverte
Le Chêne, M. (2012). Algues vertes, terrain glissant [Green algae, slippery place]. Ethnologie française, 42, 657-665
Leiss, W. (2001). In the chamber of risks: Understanding risk controversies. Montréal, Québec, Canada: McGill-Queen’s University Press
Levain, A (2013). Faire face aux “marées vertes,” penser les crises du vivant [Copying with “green tides,” thinking about the crises of the living]. Ethnographiques.org, 27. Retrieved from http://www.ethnographiques.org/2013/Levain
Lévesque, B., Gervais, M. C., Chevalier, P., Gauvin, D., Anassour-Laouan-Sidi, E., Gingras, S., . . . Bird, D. (2014). Prospective study of acute health effects in relation to exposure to cyanobacteria. The Science of the Total Environment, 466-467, 397-403
Lévesque, B., Gervais, M. C., Chevalier, P., Gauvin, D., Anassour-Laouan-Sidi, E., Gingras, S., . . . Bird, D. (2016). Exposure to
cyanobacteria: Acute health effects associated with endotoxins. *Public Health*, 134, 98-101.

Marchand, D., & Weiss, K. (2006). *Psychologie sociale de l'environnement* [Environmental social psychology]. Rennes, France: Presses universitaires de Rennes.

Martin, N., & Pendleton, L. H. (2008). *Perceptions of environmental quality and risk in beach recreation*. Los Angeles: Wrigley Institute for Environmental Studies, University of Southern California.

Ministère du développement durable, de l’environnement et des parcs. (2012). *Bilan des lacs et cours d’eau touchés par une fleur d’eau d’algues bleu-vert au Québec de 2004 à 2010* [Assessment of lakes and rivers affected by a blue-green algae bloom in Quebec from 2004 to 2010]. Retrieved from http://www.mddep.gouv.qc.ca/eau/algues-bv/bilan/liste_comparative.asp

Moss, B. (2007). The art and science of lake restoration. *Hydrobiologia*, 581, 15-24. doi:10.1007/s10750-006-0524-2

Nakano, K., Lee, T. J., & Matsumura, M. (2001). In situ algal bloom control by the integration of ultrasonic radiation and jet circulation to flushing. *Environmental Science & Technology*, 35, 4941-4946. doi:10.1021/es010711c

Nedeleu, M., & Hainard, F. (2006). *Pour une écologie citoyenne: risques environnementaux, médiation et politiques publiques* [For a citizen ecology: Environmental risks, mediations and public policies]. Paris, France: L’Harmattan.

Paolisso, M., & Chambers, E. (2001). *Culture, politics, and toxic Dinoflagellate blooms: The anthropology of Pfiesteria*. *Human Organization*, 60, 1-12. Retrieved from http://www.metapress.com.acces.bibl.ulaval.ca/content/7dxhxbx87fm34q9/

Paolisso, M., & Maloney, R. S. (2000). Recognizing farmer environmentalism: Nutrient runoff and toxic Dinoflagellate blooms in the Chesapeake Bay region. *Human Organization*, 59, 209-221. Retrieved from http://www.metapress.com.acces.bibl.ulaval.ca/content/g7627r437p745710/fulltext.pdf

Parker, E. A., Baldwin, G. T., Israel, B., & Salinas, M. A. (2004). Application of health promotion theories and models for environmental health. *Health Education & Behavior*, 31, 491-509. doi:10.1177/1090198104265601

Piloto, L. S., Douglas, R. M., Burch, M. D., Cameron, S., Beers, M., Rouch, G. J., . . . Attewell, R. G. (1997). Health effects of exposure to cyanobacteria (blue-green algae) during recreational water-related activities. *Australian and New Zealand Journal of Public Health*, 21, 562-566. doi:10.1111/j.1467-842X.1997.tb01755.x

Plante, S., Boisjoly, J., & Guilleminot, J. (2006, December). Gestion intégrée des îles habitées de l’estuaire du Saint-Laurent (Québec) et développement territorial: l’expérience de la mise en œuvre d’un comité de gestion intégrée à l’Île-aux-Coudres [Integrated management of the inhabited islands of the St. Lawrence Estuary (Québec) and territorial development: The experience of implementing an integrated management committee at Isle-aux-Coudres]. *VertigO—La revue électronique en sciences de l’environnement*, 7, do:10.4000/vertigo.209

Pretty, J. N., Mason, C. F., Nedwell, D. B., Hine, R. E., Leaf, S., & Dils, R. (2003). Environmental costs of freshwater eutrophication in England and Wales. *Environmental Science & Technology*, 37, 201-208. doi:10.1021/es020793k

Quéré, L. (2012). Le travail des émotions dans l’expérience publique. Marées vertes en Bretagne [The work of emotions in public experience. Green tides in Brittany]. In D. Cefai & C. Terzi (Eds.), *L’expérience des problèmes publics* (pp. 135-162). Paris, France: EHESS.

Rolland, A., Bird, D. F., & Giani, A. (2005). Seasonal changes in composition of the cyanobacterial community and the occurrence of hepatotoxic blooms in the Eastern townships, Québec, Canada. *Journal of Plankton Research*, 27, 683-694. doi:10.1093/plankt/bfi042

Rosa, E. (2003). The logical structure of the social amplification of risk framework (SARF): Metatheoretical foundations and policy implications. In N. Pidgeon, R. E. Kasperon, & P. Slovic (Eds.), *The social amplification of risk* (pp. 47-79). Cambridge, UK: Cambridge University Press.

Steffensen, D. A. (2008). Economic cost of cyanobacterial blooms. In H. K. Hudnell (Ed.), *Cyanobacterial harmful algal blooms: State of the science and research needs* (pp. 855-866). New York, NY: Springer.

Stewart, I. (2004). Recreational exposure to freshwater cyanobacteria: Epidemiology, dermal toxicity and biological activity of cyanobacterial lipopolysaccharides (Doctoral thesis, University of Queensland, Brisbane, Australia). Retrieved from http://espace.library.uq.edu.au/view/UQ:9880

Turbow, D., Lin, T. H., & Jiang, S. (2004). Impacts of beach closures on perceptions of swimming related health risk in Orange County, California. *Marine Pollution Bulletin*, 48, 132-136. doi:10.1016/S0025-326X(03)00371-0

Whitton, B. A., & Potts, M. (Eds.). (2000). *The ecology of cyanobacteria: Their diversity in time and space*. Boston, MA: Kluwer Academic.

**Author Biographies**

**Geneviève Brisson** is a jurist and environmental anthropologist, professor of social and territorial development at the Université du Québec à Rimouski. She is closely associated with the multidisciplinary work of the Environmental Health Team of the National Institute of Public Health. His research addresses the social and political dimensions of environmental risks, including social representations of nature and disaster management.

**Karine Dubé** holds a master’s degree in anthropology from Laval University. As a research professional, she has worked on several projects about social dimensions of health and environment. She is currently an analyst and advisor in social impact assessment at the Department of strategic and environmental assessment of the Ministry of Sustainable Development, Environment and Fight against Climate Change (province of Quebec).

**Sabrina Doyon** (PhD U. McGill) is a full professor in the department of anthropology at Université Laval. She works on the social aspects of environmental changes in Latin America, Spain, and Québec, focusing more particularly on issues of environmental conservation, nature extraction, and food production.

**Benoit Lévesque** is a medical specialist in public health and preventive medicine. He is a medical consultant in environmental health at the Institut national de santé publique du Québec, clinical researcher at the CHUQ Research Center, and clinical professor in the Department of Social and Preventive Medicine of the Faculty of Medicine of Laval University. His research interests are related to environmental microbiology and health issues related to drinking water and recreational water, as well as indoor air quality.