Chaos Theory and Emergent Behavior in the West Virginia Water Crisis

Morgan Getchell

School of English, Communication, Media, and Languages, Morehead State University, Morehead, Kentucky, USA

ABSTRACT

Chaos theory holds that systems act in unpredictable, nonlinear ways and that their behavior can only be observed, never predicted. This is an informative model for an organization in crisis. The West Virginia water contamination crisis, which began on January 9, 2014, fits the criteria of a system in chaos. This study employs a close case study method to examine this case through the lens of chaos theory and its tenets: sensitivity to initial conditions, bifurcation, fractals, strange attractors, and self-organization. In particular, close attention is paid to emergent organizations and how their embodiment of strange attractor values spurred the self-organization process for this chaotic system.

KEYWORDS: Chaos theory; crisis communication; water contamination; West Virginia water crisis

Crises, regardless of the form they take, present unique and challenging circumstances for those affected to overcome. Be they natural disasters or organizational crises, they are defined by three characteristics that set them apart from other nonroutine events: threat, surprise, and a short response time (Seeger, Sellnow, & Ulmer, 2003). An environmental disaster in the form of a leak, spill, or contamination meets these requirements because there is little to no warning before it happens, affected stakeholders are not expecting this departure from the norm, and there is the added pressure of not only stopping the leak/spill but also dealing with the contaminated area quickly to avoid exposure to large numbers. The Bhopal disaster, BP Deepwater Horizon oil spill, and *Exxon Valdez* oil spill are examples of previous accidental

CONTACT Morgan Getchell, PhD • E-mail: m.getchell@moreheadstate.edu • School of English, Communication, Media, and Languages, 303A Breckinridge Hall, Morehead, KY 40351, USA

© 2018 by Journal of International Crisis and Risk Communication Research. All rights reserved.

contamination events studied from a crisis communication perspective. A crisis in this form poses unique challenges, and those are only compounded if the contamination affects the local food and/or water supply. In addition to cleaning up the initial contamination, there are also concerns about the long-term effects on the environment and on those individuals exposed to the contaminant.

In January 2014, Charleston, West Virginia, experienced its environmental crisis in the form of a chemical spill that contaminated the water supply and left 300,000 residents unable to do anything but flush their toilets with the water in their homes. This water use ban lasted approximately 2 weeks and required people to find alternate sources for drinking water and ways to perform basic functions like bathing, brushing their teeth, washing dishes and clothes, and providing water for their pets. The organizations that should have provided pertinent messages for self-protection failed to do so in a timely and clear manner, leaving affected stakeholders confused and unsure of how best to protect themselves and loved ones. The bulk of the crisis communication tasks were taken up by small emergent organizations formed by concerned and frustrated citizens. This unique circumstance, combined with the magnitude of the event (it was the largest drinking water contamination in U.S. history at that time), makes the West Virginia case ideal to study from a risk and crisis communication perspective. More specifically, this case is examined through the lense of chaos theory because its description of an unpredictable system and its tenets are an insightful metaphor to apply to crisis events, which are nonlinear and the complexity of which appears unpredictable (Tsoukas, 2005).

Chaos theory has long been used by scientists and mathematicians to describe the systems and phenomena they observe. Chaos theory, stated simply, holds that systems act in nonlinear, unpredictable ways. The behavior they exhibit is dependent on the conditions surrounding them, and this behavior can only be observed and described, never predicted (Murphy, 1996). This makes sense when describing complex weather patterns, ecosystems, and difficult mathematical models, hence why chaos theory is widely used by researchers in those fields. However, as of late, it has come to the attention of social scientist researchers that chaos theory is a good model for describing the systems

they study. Human systems act in just as unpredictable ways as other systems. More specifically, crisis communication researchers see that chaos theory is an excellent model for describing an organization in crisis. The tenets of chaos theory—sensitivity to initial conditions, bifurcation, fractals, strange attractors, and self-organization—can all be observed throughout the life cycle of a crisis. Thus crisis communication researchers have created a body of literature that applies chaos theory to crisis events (Freimuth, 2006; Horsley, 2014; Liska, Petrun, Sellnow, & Seeger, 2012; Murphy, 1996; Seeger, 2002; Sellnow, Seeger, & Ulmer, 2002). Though chaos theory did not originate in the social sciences, communication scholars see the heuristic value in the application of a scientific perspective to human systems (Berger & Chaffee, 1987). The nature of the West Virginia water contamination makes it a unique case to observe through the lens of chaos theory. This study pursues two related research questions. First, to what extent were the tenets of chaos theory observable during this crisis? Second, how does a case with such a broad and lasting impact further advance our understanding of crisis communication in chaotic circumstances? The remainder of this article provides a review of literature, a summary of the case, description of methods, and analysis of the case and ends with a discussion of implications and conclusions that can be drawn from this study.

Chaos and Crisis Communications

Chaos Theory

Chaos theory has its origins in the math and science disciplines. One of its first uses was by the scientist Edward Lorenz, who used it to map and explain complex weather patterns and systems. The main tenet of chaos theory is that systems act in nonlinear and unpredictable ways. Because of their inherent random behavior, it is impossible to accurately predict the behavior of a chaotic system. Perhaps the best-known tenet of chaos theory is the system's sensitivity to initial conditions, which is often referred to as the butterfly effect. Put simply, this supposition implies that something as small and seemingly insignificant as the flapping of a butterfly's wings can have a much greater impact and can

start a chain of events that leads to a large-scale event, such as a tidal wave that devastates a coastal area.

This theory fits well when describing complex systems like the weather, biological systems, and complex mathematical models, but as of late, social scientist researchers are seeing the applicability of chaos theory and the idea of unpredictable behavior to the systems they study. As Murphy (1996) stated, “chaos theory attempts to understand the behavior of systems that do not unfold in a linearly, predictable, conventional, cause-and-effect manner over time” (p. 96). Murphy wrote her seminal piece, published in the *Journal of Public Relations*, and showed the clear connections between the tenets of chaos theory and the systems often studied by social scientists and made a call for researchers to extend this body of literature and use chaos theory in their future research. Seeger (2002) echoed her sentiments in a follow-up piece published in the same journal. He argued that organizations experiencing a crisis are an ideal model of a chaotic system and said the field of risk and crisis communication was ideal for the application of this theory. He pointed to each element of chaos theory—fractals, bifurcation, strange attractors, and self-organization—and showed how an organizational crisis contained each element across the crisis life cycle. Herein, each of these components will be defined, explained, and expanded—particularly in regard to strange attractors and self-organization. Finally, chaos theory is applied to the 2014 West Virginia water contamination as an example of an ideal case that clearly exhibited all tenets of a system in chaos.

Fractals. Mandelbrot (as cited in Murphy, 1996) defined fractals as self-similar and repeating mathematical patterns. He often explained the intricacy of fractals by asking his students to measure the coast of Britain in various quantitative measures. When the coast was measured in miles, there was a different measure than when done in feet, inches, centimeters, grains of sand, and so on. This example demonstrated the problem with using quantitative units of measurement. Rather, Mandelbrot (as cited in Murphy, 1996) suggested fractals as a qualitative measurement that can describe “the relative degree of complexity of an object” (p. 100). Murphy also addressed the importance of considering scope and scale and said that

the difficulty of perceiving pattern in chaos relates to the scale at which one views a phenomenon. . . . Chaos theorists note significant differences in the very structure and dimensionality of an object depending on the observer's standpoint and measuring tools. (p. 98)

Thus the object can look very different depending on the standpoint of the individual. Horsley (2014) described fractals as changing with each successive iteration, but the evolution of the pattern from beginning to end can be observed when looking at the whole picture. In her examination of the Washington, D.C., sniper attacks, she said that at first it was difficult to determine a fractal pattern among the sniper victims because they were of different genders, ages, races, and so on, and the killings happened at random times and in different places. However, by observing the fractal sets from the point of view of the sniper who was targeting his wife (who had a restraining order against him), it became clear that he was targeting places like shopping malls and craft stores, where he thought she would be, thus revealing the pattern to his attacks (Horsley, 2014).

Sellnow, Seeger, and Ulmer (2002) noted the key difficulty with fractals by observing their role in the case of the historic Red River floods that affected residents in North Dakota and Minnesota. According to them, the problem was "the communication of excessive confidence in a measurement system that lacked the precision needed" (p. 276). In this case, they referred to the imprecise measurement tools and system that had been previously used to estimate flood levels but in this case did not account for the sensitivity to initial conditions, such as ice blockages, that had rendered the measurement system imprecise and irrelevant. However, because all the predictions had shown that flooding would be at a certain level, this was communicated with confidence by meteorologists and a number of other officials. Because of this, the area was wholly unprepared to deal with the record-setting flood levels, exacerbating the chaos and representing a failure of viewing a fractal pattern from the wrong perspective. These examples demonstrate the complexity of fractals and the potential consequences of viewing the system from an incorrect perspective.

Bifurcation. According to Freimuth (2006), “bifurcation is associated with a collapse of sensemaking. At these points, observers realize that the routine ways of operating have collapsed” (p. 145). These are points at which the system deviates from the established path and routine operations. In relation to the crisis life cycle, bifurcation could be considered the beginning or initial phases of the crisis and the point at which the system begins to act in a chaotic, unpredictable way. As Seeger (2002) stated, “organizational crises are points of system bifurcation or radical change where a system’s direction, character, and/or structure is fundamentally disrupted or departs from the previous path” (p. 332). In some cases, this collapse in sense making can result in what Weick (1993) referred to as a cosmology episode. A cosmology episode is one in which people feel that “I’ve never been here before, I have no idea where I am, and I have no idea who can help me” (p. 634). In some instances, people and organizations respond to bifurcation by sticking with routine procedures or what has worked in the past, but as history and the literature have shown, for a system to pull itself out of bifurcation/chaos, it must acknowledge that the current conditions are new and unfamiliar and that the old ways of operating and functioning must be abandoned before the system can begin the process of self-organization. As Venette, Sellnow, and Lang (2003) contended, “crisis is a process of transformation in which the old system can no longer be maintained” (p. 224). Thus bifurcation is marked by the system deviating from normal operations and a failure of previously effective interventions to get the system back on track. This was true of the Tennessee Valley Authority (TVA) after it experienced a disaster in the form of a coal ash spill that rained down tons of coal ash on the town of Kingston, Tennessee, destroying many homes, displacing many residents, and creating a sense of chaos for the affected area. In hindsight, CEO Tom Kilgore and others at the TVA were able to recognize six points of bifurcation that took them off the established path and eventually led to the spill (Liska et al., 2012). Most of these bifurcation points dealt with information siloes and a lack of communication between departments within the organization. Because they were able to recognize how these bifurcation points put them on the path to disaster, the organization went through a self-organization

process and established new procedures and practices that would (it hoped) prevent the same thing from happening in the future (Liska et al., 2012). Bifurcation points mark the system's departure from the norm and the beginnings of chaos. It is important to recognize these points and to remember that bifurcation, though highly disruptive to the system, is temporary.

Strange attractors. Strange attractors are

the fundamental points of connection and order, or lines of force and influence that exert a continual regulation on the form and behavior of a system regardless of the specific conditions. They are the points to which a complex system naturally and continually returns. (Seeger, 2002, p. 334)

Strange attractors are elements that help a system in chaos begin the process of self-organization and start to emerge from bifurcation. Seeger said that attractors can take many forms, including family, community, and economic ties that lead to rebuilding after a disaster. As Freimuth (2006) said, "an attractor is an organizing principle such as a common set of values to which a system will return even as it moves through bifurcation" (p. 145). In this sense, strange attractors are those things present in the chaotic system that help it find a new order and begin the process of self-organization. It is because of strange attractors that a chaotic system begins to move away from bifurcation. Murphy (1996) referred to attractors as "an inherent shape or state of affairs to which a phenomenon will always tend to return as it evolves, no matter how random each single moment may seem" (p. 98). Thus organizations that experience a crisis that throws them into chaos and bifurcation should seek out those strange attractors that can help them begin self-organization and moving out of chaos.

Sellnow et al. (2002) described the presence of the National Guard and the Federal Emergency Management Agency (FEMA) after the historic Red River floods as embodying the organizing principles that helped citizens begin to move from bifurcation to self-organization. As they described it, the presence of these two organizations gave the confused, disoriented citizens something/someone to look to as

they began the recovery and rebuilding phase (Sellnow et al., 2002). Horsley (2014) pointed to a similar strange attractor in her analysis of the chaos surrounding the D.C.-area sniper attacks. She claimed that the police chief at the helm of the case, Chief Moose, “personified the investigation and became a strange attractor” (p. 310). He embodied the principles of a strange attractor, as he was the one leading the case, handling the press conferences and media interactions, and using his position of authority to speak directly to the suspects. His presence was reassuring and helped give the community a sense that things would eventually return to normal (Horsley, 2014).

Strange attractors are present before the crisis and will exist after the crisis. That is why all chaotic systems eventually emerge from bifurcation. However, applying this concept metaphorically to a human system in crisis allows those strange attractors to manifest in different forms and be embodied by different individuals or groups. They help a system begin the process of moving from bifurcation and a cosmology episode into the process of self-organization that eventually pulls the system out of chaos. The system that emerges often looks and functions differently than it did prior to bifurcation because of the changes that the system underwent during the chaos and self-organization periods, which will be described later.

Self-organization. Self-organization is often referred to as the “anti-chaos” mechanism. In the crisis life cycle, this is the point at which the recovery and renewal phases begin as the system moves away from chaos/bifurcation and toward stability. Seeger (2002) defined self-organization as “a natural process whereby order re-emerges out of the chaotic state brought on through bifurcation. This reordering process is sometimes characterized as the antithesis of chaos and as the outgrowth or consequence of bifurcation” (p. 332). Wheatley (2006) described the nature of self-organizing systems as adept and said that “self-organizing systems are never passive, hapless victims forced to react to their environments. . . . [The system] uses available resources more effectively, sustaining and strengthening itself” (p. 83). Vicki Freimuth was at the helm of the Centers for Disease Control and Prevention (CDC) when the 2001 anthrax attacks occurred, and she described the self-organizing process that the organization had to go through to handle such an unprecedented event. Though the CDC

handles disease outbreaks and epidemics regularly, never had such an instance (what many felt was the first major instance of bioterrorism on American soil) occurred that required such a large response. Freimuth (2006) described how every part of the CDC communication branch underwent a change—from the way calls from the public were received and handled to the way media requests and statements were handled. In some instances, entire new teams/organizations/structures needed to be assembled to handle tasks never before handled by the organization. These emergent structures were created in response to meet these new needs. As she stated, “the other new structures created were not modifications of previous ones but were new and filled gaps made apparent during the anthrax crisis . . . new structures emerging out of the chaos” (p. 146). Self-organization often results in the emergence of new structures and organizational policies. Horsley (2014) also saw this in her analysis of the D.C. sniper shootings. She described new behaviors, such as citizens standing between car doors as they pumped gas, schools going into lockdown mode, and people cancelling extracurricular activities and avoiding going outside unless absolutely necessary. These behaviors emerged in response to the unique situation.

For a system experiencing bifurcation to survive, it must go through the process of self-organization. If this does not occur, the system will succumb to chaos. To avoid this and reap the benefits of self-organization requires effort; otherwise, the system will dissolve. The nature of this process is largely dependent on the nature and type of strange attractors present in the system. When the system partners with its environment, it will develop new capacities that make it more resourceful and allow it to seek out a new form as a response to the environmental changes (Wheatley, 2006). Regardless of the nature, self-organization must occur to get the system back on track. As Wheatley stated,

the viability and resiliency of self-organizing systems comes from its great capacity to adapt as needed. . . . Neither form nor function alone dictates how the system is organized. Instead they are process structures, reorganizing into different forms in order to maintain their identity. . . . It is capable of organizing into whatever form it determines best suits the present situation. (p. 82)

Chaotic systems do not remain in chaos forever because of the process of self-organization and the presence of strange attractors. In other words, these systems can be self-healing. Self-organization is not inherent in chaotic systems, however, and sometimes strange attractors fail to produce the necessary conditions for self-organization to occur. These concepts are closely related, and they are the reasons why organizations emerge from bifurcation, often looking very different than they did before the chaos began.

Case Summary

On January 9, 2014, residents of Charleston, West Virginia, and the surrounding counties began noticing an unusual smell in the air and in their homes, particularly when the water was running. The first formal complaint to this effect was registered with the Department of Environmental Protection (DEP) at 8:15 AM; however, the West Virginia American Water Company was not made aware of the situation until noon and, at that time, was under the impression that the water treatment facility's carbon filtration system would be able to handle the problem. However, it soon became apparent that the contamination exceeded the system's capabilities, and at 5:45 PM, a full 9.5 hours after the first complaint was registered with the DEP, a "do not use" ban was issued to 300,000 customers (Ward & Gutman, 2014).

The source of the contamination was the Freedom Industries plant, which is located on the banks of the Elk River. This company stores chemicals for use in the mining, cement, and steel industries. Workers at the plant noticed a leak coming from a 1-inch hole in a tank that contained the chemical 4-methylcyclohexylmethanol (MCHM). This is a chemical used in the coal-cleaning process to remove grit and dirt from the outside of coal. Employees reported first noticing the leak at 10:30 AM; they reported taking all the appropriate steps to stop the leak and clean up the damage to the best of their abilities (Ward, 2014). However, there was nothing to be done about the 7,500 gallons that had already leaked into the Elk River.

The "do not use" ban instructed the 300,000 affected residents not to drink, bathe, cook with, or wash with the water. Although this

information was pertinent for self-protection, because of the almost 10-hour span between the beginning of the contamination and the issuing of the ban, 122 residents had already sought treatment for nausea, vomiting, and/or diarrhea, which are common symptoms of exposure to MCHM. By January 14, nearly 700 people had contacted the poison control hotline reporting symptoms including nausea and rashes, and 14 people were hospitalized (Heyman & Fitzsimmons, 2014).

Authorities began lifting the ban on January 13; however, shortly after the initial announcement, officials quickly amended the statement based on recommendations from the CDC to exclude pregnant women and the immune compromised “out of an abundance of caution” (T. Frieden, personal communication, January 15, 2014). Before resuming normal water use, residents were informed that they first needed to flush their pipes to ensure that all the contaminated water had been cleared out of their systems (Plummer, 2014). This is where the confusion began, as clear, explicit instruction on how to properly flush one’s pipes was not given. For example, how long should the water run? Should I open my doors and windows while doing this? What about external spigots? It was also imperative that the residents shut off their hot water heaters before beginning this process, but this instruction was not always explicit (Whelton et al., 2015). Thus, when people ran their hot water taps, the MCHM was transformed into a noxious gas that filled people’s homes, causing headaches, nausea, and nosebleeds. The ambiguity of the information given only served to heighten uncertainty among the affected population, precisely the opposite of the intended goal of emergency/crisis communicators.

Despite the fact that the ban was lifted and all federal aid in the form of bottled and potable water deliveries had ceased, 6 weeks postcontamination, many residents still refused to drink or use the water in their homes. When they attempted to resume regular use, the odd smell and funny taste remained, continuing the distrust in the safety of the water (Goldenberg, 2014). Besides the obvious frustrations of having to use bottled water for consumption and for all basic household functions, West Virginians also faced the added challenge of finding the bottled water on their own. Most grocery stores and supermarkets could not keep shelves stocked with water, further complicating matters.

On July 3, 2014, the Occupational Safety and Health Administration (OSHA) leveled fines against Freedom Industries that totaled \$11,000. The company was fined \$7,000 for not having a liquid-tight wall surrounding its tanks and \$4,000 for not having standard railings on an elevated platform (Boucher, 2014). On February 17, 2016, Freedom Industries's president, Gary Southern, was sentenced to 30 days in jail and was ordered to pay a \$20,000 fine for his negligence and role in the Elk River spill. Four other Freedom Industries officials received probation-only sentences (Ward, 2016a).

Method

Because of the time and attention paid by the researcher, this study qualifies as a robust and in-depth case study of an event. According to Yin (2013), a case study approach is most appropriate when three conditions are met: the main research questions are "how" and "why," the researcher has little to no control over behavioral events, and the focus of the study is a contemporary rather than a historical phenomenon. Others who have applied chaos theory to crises have employed this interpretive method as well (Horsley, 2014; Liska et al., 2012; Sellnow et al., 2002).

This was a public crisis that elicited a response from organizations at the local, state, and federal levels. From the outset, there was a large amount of uncertainty surrounding the case. Though the spill and subsequent water ban only lasted approximately 2 weeks, the consequences of the event were felt for more than 2 years. Because of its impact, the event garnered national news coverage, in addition to the large amount of social media activity surrounding it, creating a large body of data for exploration. These characteristics, combined with the observable behavior of individuals and groups in response to this event, make it optimal for study from a social science case study perspective. According to Yin (2013),

whatever the field of interest, the distinctive need for case study arises out of the desire to understand complex social phenomena. . . . A case study allows investigators to focus on a "case" and retain a holistic and real-world perspective. (p. 4)

Tracking of this event began the week after the spill happened and has continued for the 3 years following. The case was tracked by observing the traditional media and new media for updates about the unfolding event. This case differed from other cases in which chaos theory has been applied because the established organizations were either absent from the crisis response or failed to provide useful information and pertinent messages for self-protection in a timely manner. Thus affected citizens turned to other sources for information. These sources took the form of emergent organizations using social media. To identify emergent organizations, the following definition was employed: an organization that did not exist prior to the contamination of the Elk River on January 9, 2014, but was formed in response to that event and used some form of information communication technology to carry out the majority of its functions. Using this definition, the tracking process revealed five emergent organizations: three Facebook pages, a blog, and a Twitter account. The content posted to these sites was closely tracked in addition to coverage of the spill in traditional media. These two sources provided ample data for constructing a rich case description, which Yin (2013) described as an “analysis organized on the basis of description of the general characteristics and relations of the phenomenon in question” (p. 5). Tracking of this case was undertaken with the goal of understanding the complex interactions surrounding this spill and its implications for those affected.

Analysis

Chaos theory holds that systems act in nonlinear and unpredictable ways (Murphy, 1996). Chaos theory comprises several components: sensitivity to initial conditions, bifurcation, fractals, strange attractors, and self-organization. Each of these plays a part in the life cycle of a system in chaos. As has been established, an organization experiencing a crisis is an excellent fit for the metaphorical application of chaos theory (Seeger, 2002). The West Virginia water crisis is no exception. There are unique facets of this incident that align clearly with the tenets of chaos theory and demonstrate how this system experienced several points of bifurcation and descended into chaos before strange attractors appeared and spurred the process of self-organization and anti-chaos.

Sensitivity to Initial Conditions

Because of a system's sensitivity to initial conditions (i.e., the butterfly effect), simple things that might seem insignificant (like the flapping of a butterfly's wings) can have a much larger impact on the system (Murphy, 1996). For example, in the West Virginia crisis, the hole that developed in the bottom of the tank was not due to corrosion from the chemical it held but rather from rainwater that entered through the top of the tank. According to Chemical Safety Board inspectors, "corrosion from water pooling inside the leaky tank likely caused the holes. The substances traveled through soil, gravel and water systems under the Freedom site before hitting the Elk River" (Mattise, 2014). Thus two commonplace natural phenomena (rainwater and freezing temperatures) set off a chain of events that resulted in the largest drinking water contamination in American history at that time.

The proximity of the plant to the Elk River, Freedom Industries's lax attitude toward safety, the absence of a proper plant safety inspection in more than 20 years, the unfortunate trajectory of the chemical flowing toward the river, and the use of the river as a drinking water source all combined to create a complex system with a greater potential for bifurcation. Systems/organizations with higher levels of complexity are more susceptible to instability and are more likely to experience crises (Seeger, 2002). This is precisely what happened to the complex system in West Virginia.

Bifurcation

Bifurcations are the points at which the larger system begins to deviate from the norm and head down another path (Murphy, 1996). It is at these points that the system begins its descent into chaos. In West Virginia, there are several points of bifurcation to note. The point at which the hole developed in the bottom of the storage tank marks the beginning of the problems. Obviously, these tanks are meant to contain the chemicals, so the failure to do so marks a departure from the norm. When the DEP officials arrived at the scene, they described what they saw at tank 396:

They found a 400-square-foot pool of chemical that had leaked from the tank into a block containment area. Pressure from the material leak-

ing out of the tank created what DEP officials called an “up-swelling,” or an artesian well, like a fountain of chemical coming up from the pool. (Ward, 2014)

Because of the dike failure, the chemical flowed freely into the Elk River, and “they saw a 4-foot-wide stream of chemicals heading for the containment area’s wall, and disappearing into the joint between the dike’s wall and floor” (Ward, 2014). At this point, several changes in the direction and structure of the system resulted in bifurcation and a departure from standard operating procedures. The chaotic system grew when the West Virginia American Water Company decided to issue the “do not use” order to 300,000 of its customers. The failures at the Freedom Industries site combined with the contamination of the Elk River and with it the drinking water supply for a major city created a chaotic environment and marked the point of bifurcation.

The issuing of the “do not use” ban also marks a cosmology episode for the affected residents. Cosmology episodes are a condition spurred by bifurcation. They occur when a person is in uncharted territory, does not know how to respond to this unknown situation, and does not know where to seek help. Weick (1993) described these incidents as a collapse in sense making and noted that individuals typically make sense of events by comparing them to past events. However, crises are unique events that often do not bear much resemblance to prior events. Instead of feeling *déjà vu* (I feel like I have been here before), a cosmology episode causes feelings of *vu jade* (I have never been here before). For the 300,000 residents, it is highly unlikely that many (if any) had experienced a water ban like this before. One West Virginia resident, identified only as Sarah, said, “In all my 25 years of life this is the first time I have ever had to deal with something like this” (Bryson, 2014). Another affected resident, Nate Halstead, was quoted in a *Washington Post* article: “I drank a 32-ounce glass of it right before they put it on TV . . . I don’t know what to do, honestly” (Achenbach, 2014). Boil water advisories are more common and are easier to contend with than a complete and total inability to use the water in the home for any purpose other than flushing the toilet. Thus this was likely a new and unsettling situation the stakeholders found themselves in and one that caused great uncertainty and left them with few options of where

to turn for answers. In addition to affected residents, those involved in the response were also blindsided because “there was no testing method immediately available to determine how much MCHM was in the water, and no limit set by any regulatory agency or public health official for how much of the material was dangerous” (Ward, 2016b). This was unfamiliar territory and complicated the response efforts, as decision makers had no previous experience to guide them and were unsure where to begin.

Approximately 10 days after it had been introduced, officials began lifting the “do not use” ban. Affected residents were told it was safe to resume normal water use as long as they flushed their pipes for a certain amount of time to ensure the stagnant contaminated water was cleaned out of the system. People followed the instructions that were given by the established organizations. However, even after flushing, they found that their water still had a funny smell and odd taste. This instance of a prescribed intervention failing to yield the desired results represents another bifurcation point. Because the odd smell and taste lingered, many people chose to continue using bottled water and did not resume normal use of their tap water as the established organizations had expected them to do. Resident Melanie Kipp said,

Even after flushing, the water continued to smell like MCHM and whatever other chemicals were in the mix. It left an oily film on dishes and the skin. We continued to avoid it. Showering resumed, but they were quick and followed with a final rinse of heated bottled water. (Gerken, 2015)

These signs were obvious to stakeholders and were clear indicators that problems persisted, despite reassurances from established organizations. What was meant to be the point at which things began to return to normal actually became a point at which things continued in chaos.

Fractals

A third component of chaos theory is the idea of fractals. Fractals are concerned with the measurement of systems and are the larger observable patterns within the overall system (Murphy, 1996). Fractals are

sometimes difficult to observe and are largely dependent on perception. When the DEP alerted the West Virginia American Water Company to this chemical contamination around noon, it was initially

working under the assumption that it was a flocculent, common in water treatment. Officials there did not learn the correct identity of the chemical until two hours later. . . . The company's standard and emergency water treatments are applicable to chemicals commonly found in water and were not effective on the chemical that leaked. (Ward, 2014)

Because these decisions were based on a pattern and measurement that only applies in normal operating conditions, they did not recognize the abnormal conditions created by a system experiencing bifurcation. Relying on standard operating procedures is largely ineffective in a chaotic system. It was not until several hours later, after observing the failure of the filtration system to operate effectively in these abnormal conditions, that the company recognized its error in judgment and issued the "do not use" ban. Unfortunately, the amount of time that had elapsed before people were warned meant a greater number of people were exposed to this chemical.

A second example of reliance on an imprecise measure revolves around the creation of an acceptable threshold for MCHM in drinking water. No such threshold existed prior to this event; thus the CDC and several other organizations worked together to quickly come up with a recommendation for an acceptable level of MCHM in drinking water. The original recommendation the team gave was one part per million (Ward, 2014). However, after publicly announcing that as an appropriate level, they had to quickly amend that statement to exclude pregnant women, infants, and the immune compromised "out of an abundance of caution" (T. Frieden, personal communication, January 15, 2014). The CDC made this initial recommendation based on a study done on rats by the Eastman Kodak Company in 1990 (Zwerdling, 2014). But Lynn Goldman, the former director of the Environmental Protection Agency's toxic chemical division, said there was not sufficient data to make a recommendation. A major issue with the study was that

it looked only at how MCHM might affect adults, in this case by testing it on grown rats. The researchers didn't consider how the chemical might affect fetuses or newborns. . . . A lot of chemicals that don't hurt adults can wreak havoc on the young. (Zwerdling, 2014)

This is the same issue experienced by officials making predictions about the flood levels for the Red River, who used the traditional measurement methods without accounting for the sensitivity to initial conditions. As Sellnow et al. (2002) stated, "the key problem associated with fractals in this case involved the communication of excessive confidence in a measurement system that lacked the precision needed" (p. 276). This was also the issue in West Virginia and was compounded by the fact that little was known about MCHM, as it had never been the culprit in a contamination event like this one. Because of the time constraints and the lack of any preexisting test to measure MCHM levels in drinking water, the teams charged with creating such a test made the mistake of relying on imprecise measures, which ultimately did more harm than good and exacerbated the uncertainty surrounding the situation.

Strange Attractors

Strange attractors are those things which "emphasize order and pattern within chaos. An attractor is an organizing principle such as a common set of values to which a system will return even as it moves through a bifurcation" (Freimuth, 2006, p. 145). For as much as a system is sensitive to initial conditions and seemingly minuscule events can cause it to descend into chaos, it is also susceptible to the presence of those things that cause it to move out of bifurcation and toward a more organized and less chaotic state. Strange attractors can take many forms. However, in West Virginia, no immediately observable force provided the reassurance necessary for the affected stakeholders to move toward a sense of normalcy. Freedom Industries had closed its doors, and its officials refused to cooperate with the media or investigators and never offered an official apology. The West Virginia American Water Company was focused on shifting blame, constantly reminding stakeholders that it was not the source of the spill and, therefore, was just

as much a victim of Freedom Industries as they were. While its lack of fault for the spill is true, the victims were looking for answers and help getting clean water, not more corporate blame shifting. As for the state government, it, too, failed to meet the needs of the people. In a notable and cringe-worthy press conference on January 12, 2014, Governor Earl Ray Tomblin fumbled and failed to provide satisfactory answers to questions about how the spill happened and what was being done to make it right (Vingiano, 2014). Again, an established organization that should have been prepared to handle the event more effectively proved to be incapable of doing so.

When Governor Tomblin and President Obama declared an emergency at the state and federal level, respectively, the affected area was given access to special funds and services set aside for use in such a disaster. Immediately following these declarations, the National Guard arrived on-site with tanker trucks full of potable water and other supplies. Additionally, FEMA was dispatched to the area. These organizations worked alongside local FEMA and Red Cross chapters to distribute water and provide necessary aid to the victims. According to a FEMA spokesperson, it provided approximately 7 million liters of water and 130,000 meals during the initial response (Marks, 2014). When the water company began lifting the “do not use” ban and provided flushing instructions, this signaled the end of acute phase of the crisis. However, as was described previously, people found that even after following the flushing guidelines, the water still had the funny smell and taste that were present at the outset of the crisis. Therefore they continued to distrust the water and sought alternative sources for water. However, a new obstacle was now introduced, because the National Guard and other relief organizations had left the area. When the water company proclaimed the water to be safe again and the “do not use” order was lifted, so, too, were the emergency declarations put in place by Governor Tomblin and President Obama. Thus the state’s access to disaster relief funds and the reassuring presence of FEMA and the National Guard and their trucks full of bottled water had vanished. At this point, the chaotic system experienced another period of bifurcation, and the organizations that could have functioned as strange attractors and created points of self-organization were no longer present in the system. Those

affected found themselves with a set of unique needs precipitated by a crisis that those in power felt was no longer an issue.

Self-Organization

Self-organization is referred to as the anti-chaos mechanism. It is the antithesis of bifurcation. It is because of self-organization that a system in chaos does not remain in chaos indefinitely. One cannot discuss self-organization without discussing strange attractors. According to the literature, self-organization cannot happen without the presence of strange attractors in the system. Eventually, for the system to move out of bifurcation, the strange attractors present within the system must begin the self-organization process (Seeger, 2002). In West Virginia, the self-organization process happened in a unique way. Typically, established organizations express the values that represent strange attractors. However, the established organizations in West Virginia failed to do this and therefore did not spur the self-organization process. To compensate for this, West Virginians self-organized in such a way as to represent these strange attractor values and become the catalyst for self-organization. While this sounds redundant, when one takes a closer look at the emergent organizations that formed in the wake of the crisis, it becomes clearer the role they played in moving the chaotic system away from bifurcation and toward self-organization.

Because affected stakeholders could not rely on the established organizations to do their part, nor could they rely on the reassuring presence of the relief organizations, they had to find alternate ways to respond and create order within the chaotic system. They did this by self-organizing into emergent organizations that performed a variety of relief functions and worked to meet the previously unmet needs of the affected stakeholders. They harnessed the power of social media and other information communication technologies to form quickly and coordinate efforts for maximum effectiveness. One of these groups, the WV Clean Water Hub (n.d.), created a Facebook page. The “About” section describes its purpose:

We have been coordinating deliveries of water and needed supplies through direct response to requests from community members as well

as establishing relationships with particular communities in need . . . and we are working with community leaders to see how we can help address the long-term needs of the community.

This is just one example of several groups that emerged in the wake of this crisis to fill a variety of unmet needs within the affected community. These groups, usually through the connective power of social media and information communication technologies, provided necessary information and instructions for self-protection, solicited donations of supplies, and disseminated supplies among victims. These activities were necessary for those affected not only to get the water they desperately needed but also to feel like there was a proverbial light at the end of the tunnel. These roles were no longer being filled by the relief organizations and were being ignored by the established organizations; therefore the emergence and presence of these organizations was the driving force behind the self-organization process in the West Virginia water crisis.

Chaos theory has been applied to a number of different crisis events, and this case represents another instance where the tenets of chaos theory are present through the crisis life cycle. This application builds on the existing body of literature and extends it to a new crisis type. When the tank at Freedom Industries began leaking on the morning of January 9, 2014, it marked the first in a series of departures from the norm that would put this system into chaos and a point of bifurcation. Because the established organizations were largely unaware of these points of bifurcation, they failed to respond appropriately or effectively. On two occasions, a failure of perspective caused them to misread the fractal patterns and rely on imprecise measures. The first occasion was when the water company learned that its water uptake source had been contaminated but did not shut the system down because it felt the purification system would be sufficient to handle the contamination. This was later to prove to be an incorrect assumption. The second instance occurred when the CDC, working in conjunction with the National Guard and the water company, made an initial recommendation of one part per million as an appropriate threshold for MCHM in drinking water. Further research proved this to be imprecise and incorrect.

Thus the CDC amended its recommendation to be one part per billion. However, the damage to its credibility was already done, and people continued to distrust the water and rely on alternate sources. This kept the system in bifurcation rather than moving it toward self-organization, which was contrary to the goals of the organizations.

Strange attractors are common values and points of organization to which a system in chaos is naturally drawn. The established organizations usually represent these values, and they provide stakeholders with a sense of order and the reassurance of an eventual return to normal. In West Virginia, the established organizations failed to represent these values and sense of order. Freedom Industries failed to cooperate and offer any helpful information or even a simple apology. The water company failed to acknowledge the lack of normal operating procedures and made several missteps that sent the system back into bifurcation. Though the National Guard and FEMA were able to provide relief for a short period of time, they left the system before order was restored and the crisis had ended. Because of these failings, it fell to the stakeholders to take on this role. Motivated by community ties and strong values, they self-organized into emergent groups and became the strange attractors that spurred the system toward self-organization and away from bifurcation. They represented the strange attractor values and provided the much-needed sense of order. Because of this, they connected as strange attractors and precipitated self-organization.

Conclusion

Organizations that experience a crisis fit the model of a system in chaos. The body of literature cited herein shows its successful application to a number of different crisis events, from natural disasters to criminal activity (Freimuth, 2006; Horsley, 2014; Liska et al., 2012; Sellnow & Seeger, 2001). However, this case is the first application of chaos theory to an environmental contamination event of this nature and the first application to a water contamination crisis. Thus this work builds on the existing body of literature and applies the theory in a new context. This case also highlights a situation in which a system did not “right itself” through modes of self-organization seen in previous cases but rather

required the intervention of important stakeholder groups to spur that process. This case could serve as an example to others experiencing a crisis who feel that established organizations are not doing their part to move the system from bifurcation to self-organization. The actions of the West Virginia residents provide a good model for others to follow if they find themselves in a similar situation, as the citizens of Flint, Michigan, did. Their water was contaminated not by an accidental spill but rather due to negligence in the water treatment process, allowing the water to be contaminated with high levels of lead. As this case drew more media attention, citizen groups formed in response to the crisis, and several groups in West Virginia have posted messages of solidarity on social media. This is one example, but it demonstrates the potential for stakeholders in the midst of a chaotic system to become participants in the self-healing process.

In the same vein, for relief organizations and those called to respond to a crisis, this case shows the willingness of certain stakeholders to be involved in their own recovery process. It could be beneficial for all to expand their view of the affected population from simply being “victims” who require service and aid to realize that some could be willing to be active participants in the response. Having additional hands on deck to help with the many tasks necessitated by a crisis is helpful, but the local knowledge and connections that these people bring to the table can prove invaluable to those coming from the outside to provide assistance.

From the moment the hole developed in the bottom of the tank at Freedom Industries, a chain of events and points of bifurcation began that set the system into chaos. When the water company issued the “do not use” ban to its 300,000 customers, it created a large amount of uncertainty and fear for those individuals. Given that most, if not all, had not experienced a water ban of this magnitude before, they most likely experienced a collapse in sense making. Weick (1993) referred to this as a cosmology episode, because people experience the feeling of having never been in that situation before and having no idea where to turn for answers.

Fractals allow the observer to see the overlying patterns in an otherwise chaotic and disordered system. However, observing the pattern is difficult if one relies on an imprecise measurement system. This was

the case in West Virginia on two occasions. First, the water company failed to issue the “do not use” ban immediately after learning of the contamination because it assumed the filtration system would take care of the problem. However, this failed to realize the absence of normal operating conditions due to the system experiencing bifurcation. The second failure occurred when the team charged with creating an acceptable recommended threshold for MCHM in drinking water made an initial recommendation of one part per million. The team quickly retracted this recommendation when they realized it did not take into account the safety of pregnant women, small children, and the elderly. After adopting a more precise measurement tool, they made a new recommendation of one part per billion.

Strange attractors and self-organization go hand in hand in a chaotic system. Strange attractors are those things present within the system that spur the self-organization (anti-chaos) process. In previous studies, strange attractor values have been expressed by official relief organizations, such as FEMA and the National Guard or a top law enforcement official (Horsley, 2014; Sellnow et al., 2002). In West Virginia, the established relief organizations and top officials who should have led the response and functioned as strange attractors failed to perform their duties effectively. Therefore the system had to create other strange attractors to pull itself out of chaos. This process occurred through self-organization among the concerned citizens and victims themselves.

Future Directions

The application of chaos theory to organizations in crisis is a budding area of research that calls for more widespread use and careful observation. Particularly, this study calls for more exploration of the self-organization component of chaos theory and how crisis communication messages can help or hinder that process. Observing messages that are successful at meeting the informational needs of stakeholders and how they can move the system away from bifurcation can strengthen the link between effective communication and self-organization.

The MCHM contamination of the Elk River created a crisis for the 300,000 affected residents whose health and well-being were threatened

and daily routines were upended by this event. The unique characteristics of the event made it ideal for studying from a crisis communication and chaos theory perspective. This in-depth case study adds to the growing body of crisis communication literature using chaos as a theoretical lens, and it is the first to focus on a crisis in the form of a water contamination. This study also contributes to the literature by closely examining how a chaotic system moves from bifurcation toward self-organization when established organizations fail to exhibit the values of strange attractors.

Morgan Getchell, PhD, is an assistant professor in the School of English, Communication, Media, and Languages at Morehead State University in Morehead, Kentucky. She recently completed her PhD at the University of Kentucky, where she focused her scholarship on risk and crisis communication. Her dissertation, which examined emergent organizations in the 2014 West Virginia water contamination crisis, was funded by a grant from the National Center for Food Protection and Defense, a Department of Homeland Security center of excellence. She has also worked on funded projects through the Centers for Disease Control and Prevention and the U.S. Department of Agriculture.

ORCID

Morgan Getchell <https://orcid.org/0000-0002-9779-8025>

References

- Achenbach, J. (2014, January 12). West Virginia residents cope, with days of water woes still ahead after chemical spill. *Washington Post*. Retrieved from https://www.washingtonpost.com/national/health-science/west-virginia-water-emergency-nears-fifth-day-with-no-end-in-sight/2014/01/12/9d0959bc-7b88-11e3-9556-4a4bf7bcbd84_story.html?utm_term=.bfcedf17a1c2
- Berger, C. R., & Chaffee, S. H. (1987). *Handbook of communication science*. Newbury Park, CA: Sage.
- Boucher, D. (2014, July 7). OSHA fines Freedom Industries \$11,000 for chemical

- spill. *Charleston Gazette-Mail*. Retrieved from <http://www.wvgazettemail.com/article/20140707/DM01/140709517>
- Bryson, K. (2014, January 11). *Sarah, Malden, Kanawha County* [Blog post]. Retrieved from <https://wwwatercrisis.com/2014/01/11/sarah-malden-kanawha-county/>
- Freimuth, V. S. (2006). Order out of chaos: The self-organization of communication following the Anthrax attacks. *Health Communication*, 20, 141–148. https://doi.org/10.1207/s15327027hc2002_5
- Gerken, J. (2015, January 9). On the anniversary of the Elk River chemical spill, West Virginians tell their stories. *Huffington Post*. Retrieved from http://www.huffingtonpost.com/2015/01/09/west-virginia-spill-anniversary_n_6437352.html
- Goldenberg, S. (2014, February 14). West Virginia after the spill: We do not drink it. My pets do not drink it. *The Guardian*. Retrieved from <http://www.theguardian.com/world/2014/feb/14/west-virginia-after-the-spill-residents-still-feeling-chemical-leaks-effects>
- Heyman, D., & Fitzsimmons, E. (2014, January 11). Wait continues for safe tap water in West Virginia. *New York Times*. Retrieved from <http://www.nytimes.com/2014/01/12/us/the-wait-continues-for-safe-tap-water-in-west-virginia.html>
- Horsley, J. S. (2014). The method in their madness: Chaos, communication, and the DC snipers. *Journal of Communication Management*, 18, 295–318. <https://doi.org/10.1108/JCOM-01-2010-0003>
- Liska, C., Petrun, E. L., Sellnow, T. L., & Seeger, M. W. (2012). Chaos theory, self-organization, and industrial accidents: Crisis communication in the Kingston coal ash spill. *Southern Communication Journal*, 77, 180–197. <https://doi.org/10.1080/1041794X.2011.634479>
- Marks, R. (2014, February 12). Tomblin to appeal FEMA decision on water crisis help. *Charleston Gazette-Mail*. Retrieved from <http://www.wvgazettemail.com/News/201402120019>
- Mattise, J. (2014, July 16). Feds: Holes in tank likely factor in W. Va. leak. *Washington Examiner Magazine*. Retrieved from <https://www.washingtont Examiner.com/feds-holes-in-tank-likely-factor-in-wva-leak>
- Murphy, P. (1996). Chaos theory as a model for managing issues and crises. *Public Relations Review*, 22, 95–113. [https://doi.org/10.1016/S0363-8111\(96\)90001-6](https://doi.org/10.1016/S0363-8111(96)90001-6)

- Plummer, B. (2014, January 21). Five big questions about the massive chemical spill in West Virginia. *Washington Post*. Retrieved from https://www.washingtonpost.com/news/wonk/wp/2014/01/21/five-big-questions-about-the-massive-chemical-spill-in-west-virginia/?utm_term=.24fc4df3ce7e
- Seeger, M. W. (2002). Chaos and crisis: Propositions for a general theory of crisis communication. *Public Relations Review*, 28, 329–337. [https://doi.org/10.1016/S0363-8111\(02\)00168-6](https://doi.org/10.1016/S0363-8111(02)00168-6)
- Seeger, M. W., Sellnow, T. L., & Ulmer, R. R. (2003). *Communication and organizational crisis*. Westport, CT: Greenwood.
- Sellnow, T. L., & Seeger, M. (2001). Exploring the boundaries of crisis communication: The case of the 1997 Red River Valley flood. *Communication Studies*, 52, 153–167. <https://doi.org/10.1080/10510970109388549>
- Sellnow, T. L., Seeger, M. W., & Ulmer, R. R. (2002). Chaos theory, informational needs, and natural disasters. *Journal of Applied Communication Research*, 30, 269–292. <https://doi.org/10.1080/00909880216599>
- Tsoukas, H. (2005). *Complex knowledge: Studies in organizational epistemology*. Oxford, England: Oxford University Press.
- Venette, S. J., Sellnow, T. L., & Lang, P. A. (2003). Metanarration's role in restructuring perceptions of crisis: NHTSA's failure in the Ford-Firestone crisis. *Journal of Business Communication*, 40, 219–236. <https://doi.org/10.1177/002194360304000303>
- Vingiano, A. (2014, January 13). West Virginia water crisis nears end, says Gov. Earl Ray Tomblin. *BuzzFeed News*. Retrieved from <http://www.buzzfeed.com/alisonvingiano/water-in-west-virginia-remains-contaminated-after-a-chemical#.hsrbOBL27>
- Ward, K. (2014, January 13). DEP inspectors describe early scene at freedom leak site. *Charleston Gazette-Mail*. Retrieved from <http://www.wvgazette.com/News/201401130118>
- Ward, K. (2016a, February 17). Ex-Freedom official Gary Southern sentenced to 30 days, \$20k fine. *Charleston Gazette-Mail*. Retrieved from <http://www.wvgazettemail.com/news/20160217/ex-freedom-official-southern-sentenced-to-30-days-20k-fine>
- Ward, K. (2016b, October 1). Lots of problems, few solutions in CSB report on WV water crisis. *Charleston Gazette-Mail*. Retrieved from <http://www.wvgazettemail.com/water-crisis/20161001/lots-of-problems-few-solutions-in-csb-report-on-wv-water-crisis>

- Ward, K., & Gutman, D. (2014, January 10). 300,000 lack water in southern W. Va. *Charleston Gazette-Mail*. Retrieved from <http://www.wvgazette.com/News/201401100028>
- Weick, K. E. (1993). The collapse of sensemaking in organizations: The Mann Gulch disaster. *Administrative Science Quarterly*, 38, 628–652. <https://doi.org/10.2307/2393339>
- Wheatley, M. J. (2006). *Leadership and the new science: Discovering order in a chaotic world* (3rd ed.). San Francisco, CA: Berrett-Kohler.
- Whelton, A. J., McMillan, L., Connell, M., Kelley, K. M., Gill, J. P., White, K. D., . . . Novy, C. (2015). Residential tap water contamination following the Freedom Industries chemical spill: Perceptions, water quality, and health impacts. *Environmental Science and Technology*, 49, 813–823. <https://doi.org/10.1021/es5040969>
- WV Clean Water Hub. (n.d.). *About us*. Retrieved from https://www.facebook.com/pg/WVCleanWaterHub/about/?ref=page_internal
- Yin, R. K. (2013). *Case study research: Design and methods*. Thousand Oaks, CA: Sage.
- Zwerdling, D. (2014, January 31). *Weeks later, more questions than answers in W.Va. chemical spill*. Retrieved from <http://www.npr.org/2014/01/31/269006655/weeks-later-more-questions-than-answers-in-w-va-chemical-spill>