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Applying Anthropology to Water Quality Assessment: An Investigation of pH and Nitrates in Drinking Water

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Abstract

Anxiety disorders affect roughly 40 million American adults in a given year. Those suffering from anxiety disorders often experience additional stress-linked illnesses, such as depression. Previous research has shown that stress exposure increases levels of the endogenous neuropeptide dynorphin, which the kappa opioid system is selectively activated by. This study examined the role of the kappa opioid system in regulating stress-related behavior using the elevated plus-maze. Behavioral stress responses were examined in male Wistar rats following i.p. administration of opioid agonist U-50,488 (0 or 10 mg/kg). Subjects were pretreated with the kappa opioid antagonist nor-binaltorphimine (nor-BNI) 24 hours prior to testing in the elevated plus-maze (0 or 20 mg/kg). Injections of 10 mg/kg U-50,488 significantly decreased percent open arm time compared to controls, an effect reversed by pretreatment with 20 mg/kg nor-BNI ($F(1,44) = 6.10$, $p < 0.05$). A main effect of nor-BNI was found on the total number of arm entries ($F(1,44) = 11.73$, $p < 0.05$). Further analysis revealed that pretreatment with nor-BNI led to an increased number of arm entries in rats injected with U-50,488. The nor-BNI sensitivity of the behavioral responses suggests an activation of the kappa opioid receptors by a stress-induced release of dynorphin. The results indicate a relationship between kappa opioid receptors and stress-related behaviors and illustrate the potential therapeutic value of targeting the kappa opioid system in the treatment of anxiety and other stress-related disorders. Introduction

Introduction

This study focuses on the demographic factors that influence people's perceptions of their drinking water quality in West Michigan. According to the World Health Organization (WHO) and UNICEF, approximately 2.6 billion people worldwide are without improved water sanitation facilities, and 884 million do not use improved sources of drinking water (WHO/UNICEF 2008). Water quality is a global concern, as contamination of water sources occurs in both underdeveloped and industrialized countries. For example, in underdeveloped regions, thousands die each year from preventable waterborne disease due to the ingestion of contaminated water. In industrialized countries such as the United States, one would assume there would be no water quality issues, yet this is not the case. Across the country, people are exposed to certain contaminants above the safety ranges set by the EPA. This pilot study examines 105 drinking water samples and corresponding homeowner surveys collected from households throughout West Michigan. The water was tested for pH and presence of nitrates, and homeowner survey responses were examined for demographic factors, as well as knowledge and perception of water quality. These results can be used to critique public policy and determine areas for improvement. In this study, I address a global problem at a community level.

Health Concerns of pH and Nitrates

An immediate question one may ask is, why is investigating for the presence of nitrates and pH levels in drinking water necessary? The appropriate pH of a water sample is very important because serious health problems can result if it is not within the standard limit set forth by the EPA. For example, if a sample of water is below the EPA's standard limit, then the sample is acidic, thus having the potential to cause serious tissues damage to the body. The same idea applies when the pH of a water sample is well above the standard limit.

Although studies remain inconclusive as to the health effects of excessive levels of nitrate, a number have discovered that nitrates might cause what is commonly referred to as "Blue Baby Syndrome." Infants below the age of six months are especially susceptible. Blue Baby Syndrome occurs when the oxygen-carrying capacity of red blood cells is significantly reduced because of high levels of nitrates in the body. The veins and skin of the individual appear blue, which is how the disorder acquired its name. According to the United States Geological Survey (USGS), nitrates are the most common inorganic contaminant from man-made sources (DeSimone et al. 2009:48). Nitrates are present in rainwater and can leach through the soil and into the groundwater, which can contaminate water from private wells. Undoubtedly the most prevalent source of nitrates is nitrogen-based fertilizers used in agricultural activity widely practiced throughout the country. Other sources of nitrates include wastewater treatment plants and the erosion of natural deposits, which include decaying plant and animal residues.

Research Questions and Hypotheses

This study focuses on how people's perceptions can influence their water use. Each day people are unknowingly exposed to contaminants in their drinking water, and because of this unawareness, they still consider it safe to drink. One of the goals of this research is to evaluate the quality of drinking water in West Michigan by assessing the pH and nitrate levels. Nitrate is a naturally occurring ion that is colorless, odorless, and tasteless. Because it does not produce an odor or any aesthetic problems, people may be unaware of its presence in their drinking water and the potential health impact it can have at significant levels. This study also hopes to address improvements to public policy and awareness.

The research project has three main hypotheses:

1. The pH and nitrate levels will exceed the maximum contaminant level (MCL).
2. Households will overall be satisfied with the quality of their drinking water.
3. The perception of water quality is positively correlated with homeowner educational level and household income.

Methodology

The study area of West Michigan includes Ottawa County, Kent County, Allegan County, and Muskegon County. A larger anthropological survey conducted by Grand Valley State University anthropologists in 2008 and 2009 investigated both water quality and radon levels to inform public outreach in West Michigan. It included over 300 households. From this larger sample, 105 households were randomly selected for this study, and household drinking water samples were tested for pH levels and the presence of nitrates. Each household was given a de-identification number. In addition, the water quality specific survey questions from the project were tabulated for these 105 households for qualitative data on their perception of water quality.

Testing for the presence of nitrates was done using a standard nitrate kit, and the pH was measured using a pH meter. The accepted range for the pH of drinking water is 6 to 8.5. After a bar-coded vial was prepared, it was inserted into a spectrophotometer. The machine would read the barcode on the vial, select the appropriate measurement test, and then a nitrate value would appear. For the one water sample that exceeded 10 mg/L, a color change occurred. This action was not observed with the rest of the samples.

Coding of the survey data was done by assigning numerical values to close-ended questions and open-ended questions. For example, when homeowners were asked to select "male" or "female" to indicate gender, "male" was assigned the number 1 and "female" was assigned the number 2. The numerical assignment was used for other socioeconomic data responses and responses concerning environment and health. Because the responses came from a larger survey about radon and water quality, for this study I only looked at the questions that were relevant to water quality. The open-ended responses were entered into an Excel spreadsheet verbatim as they were answered by respondents.

Drinking water systems

Drinking water systems in the United States are divided into two main categories: public water systems and private water systems. In addition, 1.12 million Michigan households are supplied by private wells (Figure 1).

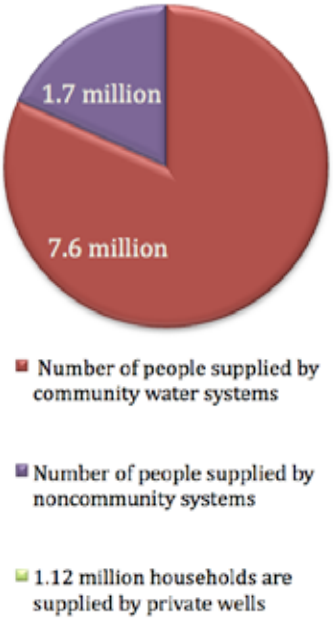

Figure 1: Michigan's Drinking Water Systems.

According to the EPA, public water systems are categorized as community or non community systems. Community water systems supply water to the same population year round, whereas non community systems do not supply water on a regular basis to the same population (USEPA 2011). Michigan has 1,500 community water supply systems serving 7.6 million people and 11,000 non community systems serving 1.7 million people (Michigan Department of Natural Resources and Environment [DEQ] 2003). Individual water systems are comprised of privately-owned wells, springs, or other surface water sources (DEQ 2003). Currently Michigan has 1.12 million households using private wells. Michigan's numbers are not inconsistent with the United States as a whole; 15% (43 million people) in the U.S. use drinking water from private wells (Hutson et al. 2004:46).

Results

Water Testing

Testing for the presence of nitrates was done using a standard nitrate kit, and the pH was measured using a pH meter. The accepted range for the pH of drinking water is 6 to 8.5. There were six samples that exceeded 8.5 (Figure 2). The standard range for nitrates in drinking water is 0 to 10 mg/L. Only one sample, which came from a private well, contained nitrates above the USEPA safety range, measuring at 12mg/L (Figure 3).

Water Survey

One hundred and five drinking water samples were collected from homes throughout West Michigan. Of the 105 households surveyed, seven are from Allendale, 34 from Grand Rapids, 15 from Jenison, and nine are from Kalamazoo. The educational level of each household surveyed is represented (Figure 5) below. Out of the 105 households, nine have a high school diploma, 34 have "some college" background, another 34 hold a four year college degree, and 26 households hold a graduate school degree. From the 105 homeowners surveyed, 47% are female, and 53% are male. The ages of the respondents range from 19-81 years. 9.7% of the homeowners are between 19-24 years of age, 12.6% are 36-32 years, 17.4% are 33-39 years, 9.7% are 40-45 years, 12.6% are 47-52 years, 17.4% are 53-59 years, 8.7% are 60-66 years, 7.8% are 67-72 years, and lastly, 3.9% of the homeowners are 75-81 years of age.

As to the primary source of drinking water, 57 households use municipality/city water as their primary source, and out of those households, 49% filter their drinking water while the remaining 51% do not filter their water. Nineteen households primarily use well water. Seventy-nine percent of the homeowners filter their well water, whereas 21% do not filter their water. There are also 20 households that use a combination of municipality/city water and bottle water as their primary drinking water source. Only 15% of these households filter their drinking water, while 85% do not filter their drinking water.

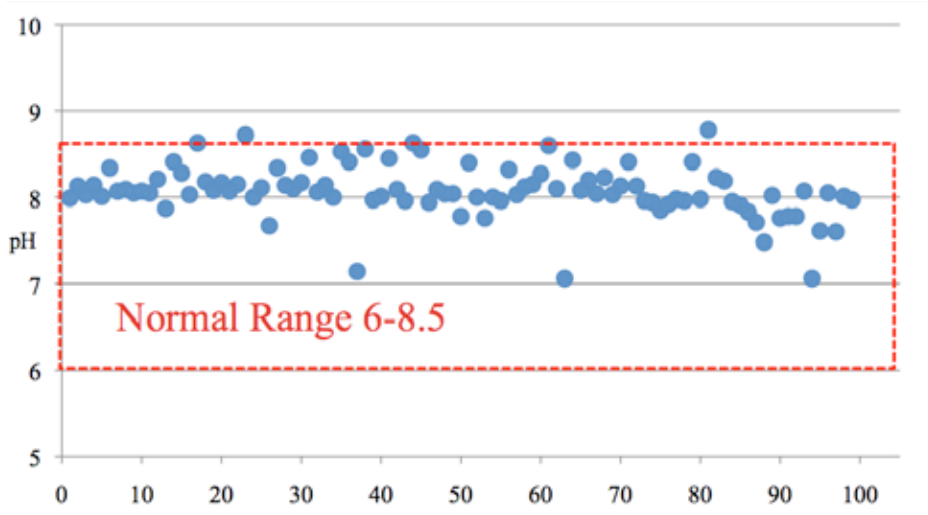

Figure 2. pH Results

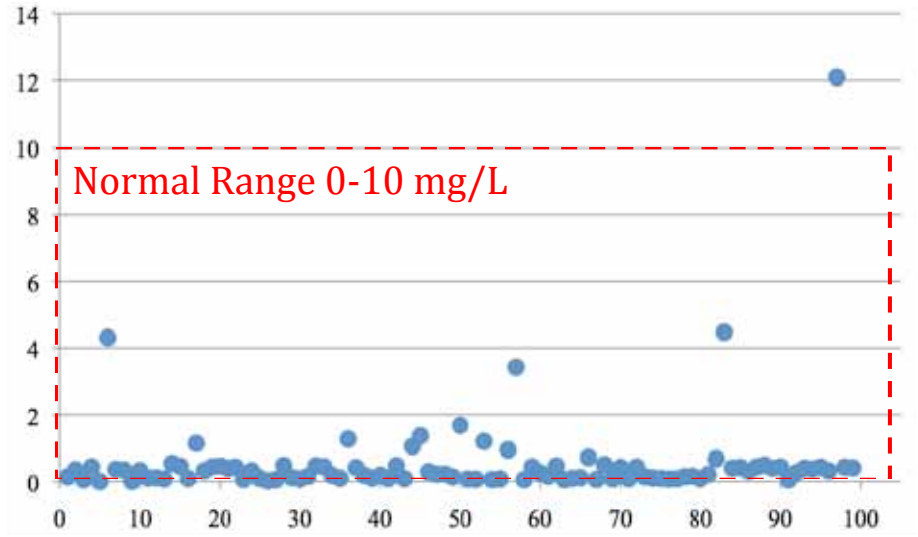

Figure 3. Nitrate Results

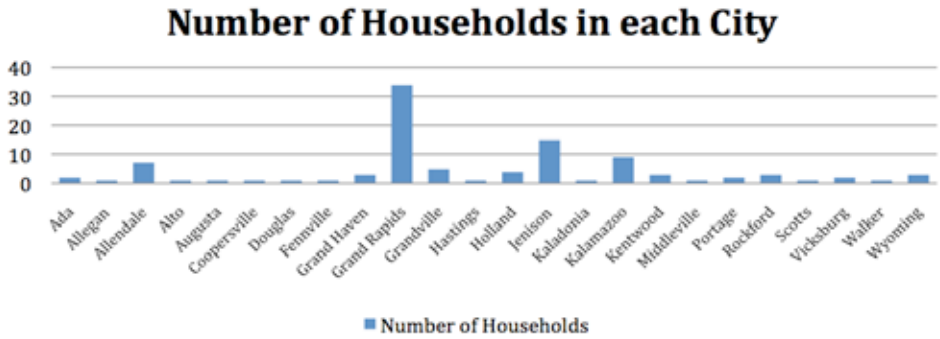

Figure 4. Number of Households in each City

Survey Analysis

For this study, 105 surveys were used, and responses to certain questions were analyzed. Unfortunately, due to mislabeling and unclear paperwork, some surveys were eliminated. Therefore, 103 surveys are included in the analysis. Homeowners were asked in the survey, "What, if anything, do you want to convey to policy makers about drinking water?" The responses to this question can be grouped into three main concerns.

- "Drinking water should be tested/ people should be concerned."
- "Not applicable," "No comment," or left blank.
- "Satisfied" or "Not concerned."

The responses to this question in particular were especially important because it gave me an idea of the level of awareness homeowners have about the quality of their water. Subsequently, I was able to compare their level of awareness with their demographic information, such as location, educational level, owning or renting the home, source of drinking water, etc., to see if there were any identifiable relationships which would help answer my research questions.

Of the 103 households surveyed, 35% of the respondents felt their drinking water should be tested and that there should be increased concern for the quality of their drinking water. In addition, 10% of the respondents were satisfied or not concerned with the quality of their water. Interestingly, 31% of respondents had no comment or left the response blank. Only 15% of the respondents felt that there was a need to increase public awareness and educate people about water quality and testing. But only 3% of the respondents felt that this information was important enough to be conveyed to policy makers.

Surprisingly, while concern was expressed about testing, only 44% of these respondents filter their water (55% do not). In addition, 72% do not test their own water, whereas only 38% test their water for contaminants. Moreover, 44% of these respondents did not give any response when asked if they know of any government or private agency that tests for water.

All of the respondents who were either satisfied or not concerned about the quality of their drinking water own their homes. It is important to note that 60% of these respondents do not filter their water (40% do), and 90% do not test their drinking water for contaminants. Additionally, 70% of the respondents did not give a response when asked if they know of any government or private agency that tests for water. Five of these homeowners who gave no response have not had their water tested for contaminants. If half of the respondents who are satisfied with their water quality have not had their water tested and do not know where to have it tested, then how can they be certain their water is indeed safe to drink? It is clear that the respondents are confident that someone is safeguarding their water quality, even if they do not precisely know who that would be or what the hazards are.

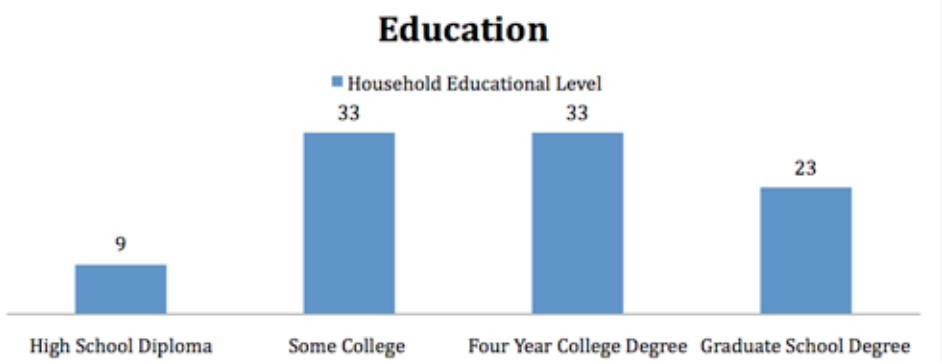

Figure 5. Distribution of Household Educational Level

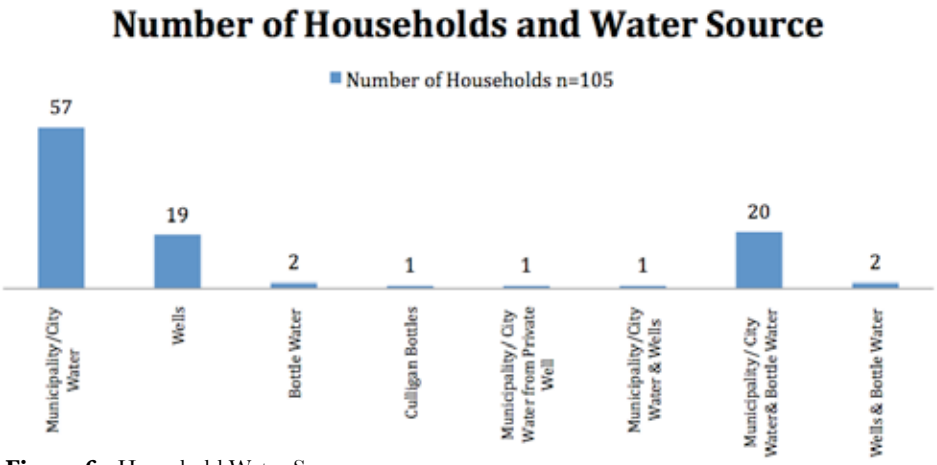

Figure 6. Household Water Sources

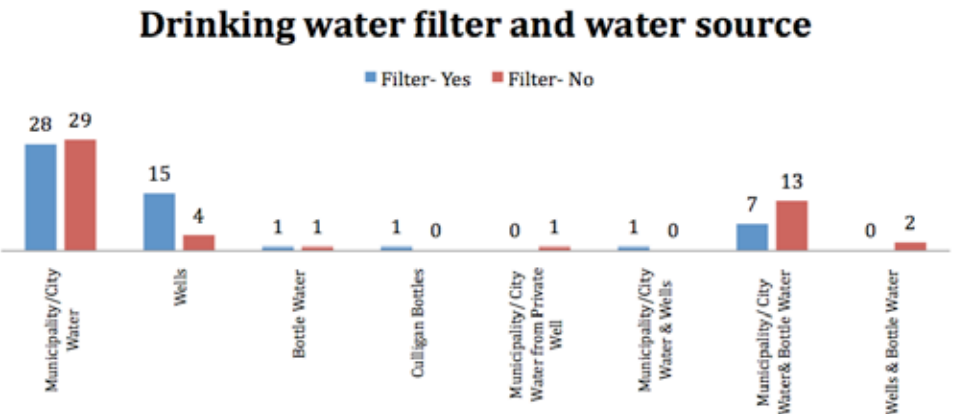

Figure 7. Households that filter or do not filter their drinking water

As stated earlier, out of the 103 households surveyed, 31% of the respondents had no comment when asked if there was anything they would like to convey to policymakers about water quality. Of these respondents, 65% do not test their water, whereas only 31% do test their drinking water. Conversely, over half of the respondents (56%) filter their water and 44% do not.

Upon reviewing the data, I wondered if homeownership was a factor that could influence people's perception of their water quality. Of those respondents who felt their drinking water should be tested, the majority own their home (89%). In comparison, 87% of all respondents own their home. All of the respondents who were either satisfied or not concerned about the quality of their drinking water own their homes. There were simply not enough respondents who rent their homes out of the total sample to determine if homeownership is a factor. Nevertheless, this is still an avenue worth pursuing in future research.

Out of the 103 households surveyed, 28% of the respondents' household income was less than $47,000 per year, and 70% of the respondents' household income was greater than $47,000. According to the survey the data have been drawn from, $47,000 is the average household income per year in Kent County, Michigan. Based on these data, it appears that income level is not positively correlated with the respondents' perceptions of their water quality.

The majority of the respondents who felt testing and increased concern for water quality were important have at least some college and above. Of the respondents who had no comment or left the response blank, all have a high school diploma while the majority have some college and above. All of the respondents who were satisfied with the quality of their drinking water have some college and above. Based on these data, it appears that education level is not a factor that influences people's perceptions of their drinking water quality.

Summary and Conclusions

The second and third hypotheses introduced earlier are not supported by the data. My second hypothesis was that overall, households would be satisfied with the quality of their drinking water. After analyzing the data, this hypothesis was not supported. Furthermore, I was surprised by the number of people with no comment concerning their drinking water. The third hypothesis was that the perception of water quality is positively correlated with homeowner educational and household income. This hypothesis was not supported by the data because almost all of the respondents have the same educational level—the majority answered "some college" and above. Household income per year also did not have an influence on people's perceptions of their water quality. It would have helped if the income in the survey was displayed as ranges instead of "less than" or "greater than" $47,000 because it could give a better indication of socioeconomic status.

The results of people's awareness and knowledge of water quality issues may be different if the questions were tailored more specifically for this study. For example, instead of asking about the institutions that are helpful in alerting people to problems in their area, the question should ask the respondents if they know of institutions that are helpful in alerting them to water quality problems/issues in their area. There were a number of bizarre responses to the original question in the survey. For example, several respondents suggested their school newsletter is helpful in educating them about problems in their area. One respondent wrote "Grand Valley," and another suggested Fox News as sources of education. The variability of responses may have been due to the nature of the question—because it was so open for interpretation and did not specifically address the problems about water.

Overall, there is a lack of education concerning drinking water quality. Out of the 68 respondents who expressed a need for water testing and increased concern for water quality in addition to those who did not have a response, a total of 41 households do not filter their drinking water. In an effort to increase awareness and knowledge of safe drinking water, we need to adjust how people are being presented with the information along with its contents. Local and state agencies need to promote strategies to improve drinking water.

Information about drinking water quality needs to be better circulated to the masses, for example, by publishing the findings in township newsletters or distributing informational pamphlets to every household in each city. While I was reviewing the surveys, a number of bizarre responses came to my attention. Respondents were asked to list the institution(s) that are helpful in informing them of problems in their area. A number of respondents cited their school newsletter as a source of information concerning their community. Even though the suggestion from the survey initially seemed odd, it may be a good indication of where people do expect to find information. Therefore, the lesser thought of forums, such as school newsletters, may be a good way to provide water quality data. In any case, these sources of information should also include regional and national data so that they can all be compared. In addition, agencies should also mail out "reminder" flyers to households, reminding them to have their drinking water tested, and what agencies/alternative methods are available to conduct the tests at affordable prices. This information needs to be easily accessible to the public. Moreover, to improve public outreach, I would recommend additional education about the agencies that test for water.

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