Health Consultation

Evaluation of Methane in Private Drinking Water Wells

MANISTEE COUNTY,
MICHIGAN

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Prepared by:

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Contents

Disclaimer:

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1. Summary

Concerns about potential methane in private drinking water wells were raised to the Michigan Department of Health and Human Services (MDHHS) from the Michigan Department of Environment, Great Lakes, and Energy (EGLE) and the city manager for Manistee on August 8, 2024. After gathering information about the area, MDHHS recommended drinking water sampling, which was conducted on August 17, 2024. The sampling area was expanded after high levels of methane were detected in the initially sampled homes. Based on data collected, MDHHS was able to make the following public health conclusions.

Conclusion 1	MDHHS concludes that there is the potential for physical hazards from the dissolved methane found in some of the tested private wells.
Basis for Conclusion	The conclusion is based on modeled estimates of air concentrations that used available information about the amount of methane in household water samples. The maximum concentration of methane observed in water samples collected from homes in Manistee was 46 milligrams per liter (mg/L). Modeled estimates predict that air concentrations would exceed 1% of the lower explosive limit (LEL) (0.1% by volume of methane) at water concentrations greater than 10 mg/L. Above 1% of the LEL, a buildup of methane in the indoor air is possible, which could present a physical hazard concern (i.e. explosion) if it occurs in small, confined areas.
Conclusion 2	MDHHS also concludes that there is no chemical health hazard from ingestion or inhalation of methane found in the drinking water and indoor air from the dissolved methane found in some of the tested private wells.
Basis for Conclusion	This conclusion is based on information from the available toxicological literature that indicates that dissolved methane is not known to have systemic toxicity in humans when ingested or inhaled.
Next Steps	MDHHS recommends that homes with private wells with dissolved methane concentrations greater than 10 mg/L take steps to reduce the risk of physical hazards from methane by: ○ Increasing ventilation in the home with fresh outdoor air as much as possible. This will help avoid methane building up in indoor air, especially in small, confined spaces (like bathrooms). ○ Install a treatment system to remove methane concentrations at the well. This will prevent (or reduce) methane from entering indoor air.
For More Information	If you have questions about this document, call our toll-free number 1-800-648-6942 during business hours, 8a.m.-5p.m., Monday through Friday.

2. Background

2.1. Statement of Issue and Purpose

The purpose of this health consultation is to document the MDHHS public health evaluation of and response to methane in private drinking water wells in an area of Manistee, Michigan. This document focuses on the timeframe leading up to and following the private drinking water well sampling and response conducted by MDHHS in Summer and Fall 2024. This document is intended to serve as a reference for partner agencies and the public.

2.2. Site Description and Timeline

Manistee is a city located in the northwestern area of Michigan's Lower Peninsula along Lake Michigan. Concerns about potential methane in a private drinking water well were raised to MDHHS' Public Health Drinking Water Program (PHDWP) from EGLE and the city manager for Manistee on August 8, 2024. The concern was raised after a new homeowner north of Bar Lake near Bar Lake Swamp (Figure 1) noticed bubbles in their water. Gas bubbles in the water, a "sputtering" faucet or a gurgling noise in the well may indicate the presence of methane or other dissolved gases [MDH 2024]. After gathering information about the area as well as obtaining additional situational awareness from EGLE Oil and Gas staff and the city manager, MDHHS recommended drinking water sampling, which was conducted by PHDWP on August 17, 2024. The sampling area was expanded after methane was detected in the initial homes.

Figure 1. Map of the area of investigation near Bar Lake in Summer 2024.

Figure 2. EGLE GeoWebFace map of drinking water wells (green dots) and oil fields (red shading) near Bar Lake (map was accessed in January 2025).

The investigation of this concern identified that shallow groundwater in the area is not the source of methane. The methane likely originates from deeper levels of the aquifer and is trapped by the confining clay layers that can migrate up through the installed wells. The private drinking water wells of concern are installed below clay confining layers. Sources of methane in the area can include microbial methanogenesis, and may correspond to septic systems, oil wells, gas wells, landfills and wetlands [U.S. Department of Interior 2001]. It should be noted that about 0.5 miles northeast and north of the area of investigation, there is an oil and gas well. The oil and gas well is identified by EGLE as the Part 201 contamination site BGHL Investments 2-18 (PN 31636), categorized under the business type of Oil and Gas Production and Transportation. The potential contaminants listed at this site include petroleum-based volatile and semi-volatile organic compounds. Figure 2 shows a map of drinking water wells and oil fields near Bar Lake. Additionally, the sampling area evaluated in this report is situated at the southern end of the Bar Lake Swamp, recognized as a documented wetland by the U.S. Fish and Wildlife Services.

3. Sampling Data

In the Summer and Fall of 2024, MDHHS conducted several sampling events in the north Manistee area near Bar Lake where methane was a concern. A total of 8 homes were sampled on August 17, as part of the initial sampling event. On September 26, the investigation area was expanded, and 21 homes were sampled. A total of 29 homes were sampled August-September 2024. Samples were typically collected from the bathroom faucet, but in some cases were collected from the kitchen faucet or outside spigot. No home had installed any treatment system specifically for reducing methane, but many had iron and sediment removal filters. No treatment system was bypassed prior to sample collection. The samples were analyzed for methane, ethane and ethylene using U.S. Environmental Protection Agency (EPA) Method 8015 (modified).

4. Scientific Evaluations

4.1. Exposure Pathway Analysis

Accumulation of methane in indoor air via volatilization from groundwater used as household water can result in physical hazards due to methane's flammability [MDH 2024]. The physical hazards of methane (e.g., explosion, asphyxia) are the primary concerns evaluated when methane is found in indoor air or water. Although human exposure can occur from ingestion of dissolved methane or inhalation of volatilized methane, methane is not thought to pose a chemical health hazard either following ingestion or inhalation and thus is not considered a toxic chemical [CCOHS 2023].

Exposure to and accumulation of methane in homes may have occurred in the past, may be currently occurring and may occur in the future (**Table 1**). There can be many sources of the methane in the groundwater, in this evaluation the source was confirmed by laboratory analysis of methane isotopes to be primarily microbial methanogenesis naturally occurring in the groundwater (**Appendix 1**). Even with treatment to reduce methane concentrations in drinking water, it is unlikely methane accumulation in indoor air can be eliminated in this area. Rather, methane should be reduced below a level associated with physical hazards (i.e., explosion).

Table 1: Exposure Pathways Table							
Chemical	**Source**	**Environmental Medium**	**Exposure Point**	**Concerns**	**Exposed Population**	**Time Frame**	**Exposure***
Methane	Predominantly Microbial Methanogenesis	Groundwater	Private Water Well	Flammability, Ingestion, Inhalation	Children Adults	Past Present Future	Complete
*The exposure pathway is considered complete if there is evidence, or a high probability, that these elements are, have been, or will be present at a site (this indicates some level of exposure was likely).							

4.2. Household Water Evaluation

4.2.1. Screening Analysis

From the 28 sampled private wells, methane was detected (0.05 mg/L reporting limit) in all but 1 well. Ethane (0.10 mg/L reporting limit) and ethylene (0.01 mg/L reporting limit) were tested for but never detected.

A screening analysis was performed for methane in drinking water. The screening analysis is a process to compare maximum concentrations of a chemical of concern to the appropriate comparison value (CV) to determine if further evaluation is needed (**Table 2**). Concentrations higher than the recommended CV are not an indication of a health concern.

Table 2: Screening Analysis						
Analyte	**Unit**	**Max concentration**	**ATSDR CV (Type)**	**EPA RSL**	**EGLE FAESL**	**Further evaluation needed**
Methane	mg/L	46	NA	NA	10 mg/L	Yes

For methane in drinking water, there is no applicable Agency for Toxic Substance and Disease Registry (ATSDR) CV or EPA Regional Screening Level available for this evaluation. EGLE has a criterion for methane in drinking water of 10 mg/L which is a flammability and explosivity screening level (FAESL) and is the most appropriate CV for this evaluation [EGLE 2016]. These screening levels are calculated for hazardous substances using the lower explosive limit (LEL) (5% to 15% by volume of methane in air [CAMEO Chemicals 2024]) and address the potential for physical hazards rather than chemical hazards from methane. As discussed further in the document, the CV is most appropriate for drinking water and is designed to be protective of 1% by volume of methane in air (20% of the LEL). It should also be noted that recommendations to reduce flammable gas concentration by MDHHS and by fire departments when measurements have been taken in indoor air would typically occur at 0.5% by volume of methane in air (10% of the LEL) which could translate to a dissolved methane concentration of 5 mg/L.

The maximum measured methane concentration of 46 mg/L in the sampled wells is greater than the CV of 10 mg/L indicating further evaluation of methane in drinking water is required.

4.2.2. Evaluation of Drinking Water

To further evaluate exposure to dissolved methane in drinking water, it's important to distinguish between the physical and chemical hazards.

Physical hazard evaluation of dissolved methane in well water.

The physical hazards from methane are its flammability and explosive properties along with its ability to act as an asphyxiant (i.e., it displaces oxygen). Even though methane can easily volatilize, the methane that is dissolved in water is not explosive [EGLE 2016]. As water is agitated or reduced in pressure, small bubbles may form and appear to make the water milky or translucent. The water will quickly clear as the gas escapes into the atmosphere. When water containing dissolved methane comes in contact with the atmosphere, some of the methane exsolves from the water and mixes intimately with the air [U.S. Department of Interior 2001]. This gas mixture, if liberated in a confined space, could possibly ignite or, if allowed to accumulate, explode. In a house, the most common places water would be exposed or aerated in large volumes are showers or clothes washing machines, which are typically located in smaller areas of the home (e.g., bathrooms and laundry rooms).

The U.S. Department of Interior has compiled additional information underlying the flammability and explosive potential for dissolved methane which is subsequently used as the basis for the EGLE criteria referenced above. "Explosive levels of atmospheric methane resulting from dissolved methane are influenced by the size of the confined area exposed to the water and the volume of water available. For example, a small shower stall is 3' X 3' x 8' for a total volume of 72 cubic feet. Assuming no air exchange in the stall, an explosive atmosphere (5% methane in air) would be obtained at 28 mg/L with 779 gallons of water (equivalent to a 390-minute shower assuming a 2 gallon per minute flow rate)" [U.S. Department of Interior 2001]. Action is recommended at 1% by volume of methane in the atmosphere. In a shower stall with a volume of 72 cubic feet, this action level is attained at 10 mg/L and about 130 gallons of water (equivalent to a 65-minute shower assuming a 2 gallon per minute flow rate).

More info on suggested recommendations for dissolved methane in well water from the U.S. Department of the Interior is provided in **Table 3**.

Table 3. Methane concentration dissolved in well water and the respective action levels as well as recommendations. Summarized from U.S. Department of Interior, 2001.

Methane Concentration Dissolved in Water (mg/L)	Recommendations
<10	• No immediate action is required. • Periodic monitoring should be conducted.
>10 but <28	• Gas is present and the concentration could be increasing. • Warn the occupant about the level and recommend actions to decrease the level, including ventilating the home.
>28	• The quantity of gas being liberated could be explosive or flammable in the well or areas of the home that are confined. • Well head and home should be ventilated immediately.

To get additional information on the potential concentrations for methane in a whole home setting at observed concentrations and if whole home monitoring of methane in air would be recommended, the ATSDR SHOWER model 4.0.1 was used. This model uses similar physicochemical properties for methane and shower volume as the U.S. Department of Interior calculations but expands this by considering more water uses (clothes washer), additional compartments in a home and air exchange between them. From the ATSDR SHOWER model, assuming the default four-person household scenario, the maximum methane concentration by volume is shown in Table 4 with different concentrations of dissolved methane in the well water.

Table 4: Maximum methane concentration per compartment (% by volume) from the ATSDR SHOWER MODEL.				
Methane in well water	**1 mg/L**	**5 mg/L**	**10 mg/L**	**46 mg/L**
Shower	0.01	0.03	0.11	0.46
Bathroom	9.84×10^{-4}	4.52×10^{-3}	0.02	0.07
House	4.82×10^{-5}	2.36×10^{-4}	5.51×10^{-4}	2.4×10^{-3}

These concentrations are observed immediately after both 10-minute showering events from the scenario in the morning and concentrations gradually decrease with time (Figure A-1). More subsequent showering events or longer times per event could increase these concentrations. While estimated concentrations of methane in the shower, bathroom, or home are never greater than the 10% LEL (0.5% by volume of methane in air) at which MDHHS or a fire department would recommend actions based on indoor air results, the estimated concentrations when dissolved methane is 10 mg/L or greater do exceed 1% of the LEL (0.1% by volume of methane). This 1% of the LEL indicates a significant buildup of methane in the shower scenario.

Although residential flammable gas monitors are available to alert against explosive atmospheres, high ambient humidity can affect their performance. Installation of these monitors in a bathroom is generally not recommended[1]. Therefore, no recommendation to use these monitors in this situation is made. Instead, prevention is focused on increasing indoor fresh air and installing vents at the well head to prevent methane from coming into the homes.

Chemical hazard evaluation of dissolved methane in drinking water

From the available information, dissolved methane is not known to be directly toxic to humans [CCOHS 2023]. Additionally, methane dissolved in water does not impact the potability of water or the odor, taste and color [U.S. Department of Interior 2001]. There is no known link between methane and increased cancer risk [CCOHS 2023].

4.3. Summary of Limitations and Uncertainties.

The main limitation for this health consultation is that there could be additional homes in the area that were not able to be sampled so additional data could not be evaluated. Additionally, it is possible not all impacted wells have been identified, though this is unlikely given the limited number of homes and geographic area that was identified with methane levels greater than 10 mg/L (Figure A-2).

5. Conclusions

MDHHS concludes that there is the potential for a physical hazard from the dissolved methane found in some of the tested private wells. Methane concentrations in indoor air could approach the explosive range when well water concentrations are greater than 10 mg/L. When dissolved methane in water is 10 mg/L or greater, the modeled air concentration exceeds 1% of the LEL (0.1% by volume of methane), indicating there could be a buildup of methane, which could be concerning in small, confined areas. Typically, if methane was measured in the air, MDHHS would be concerned at 10% of the LEL (0.5% by volume of methane in air) for a high risk of explosion. The estimated concentrations of methane in the shower, bathroom and home air modeled from the drinking water data collected in Manistee were

[1] Residential Gas Detector GS101 user guide Installation instructions, locations to avoid. https://resource.milesight.com/milesight/iot/document/gs101-user-guide-en.pdf

never greater than 10% of the lower explosive limit (LEL, 0.5% by volume of methane in air), showing that there is unlikely to be a *high* explosion risk. Levels did, however, reach an estimated 1% of the LEL, which, if allowed to build up in a small or confined space like a bathroom or laundry room, could be of concern. For this evaluation, only modeled estimates were available. Accounting for the differences in modeling and variability with actual household water use, lowering the dissolved methane concentration in water below 10 mg/L is recommended to remain protective.

MDHHS also concludes that there is no chemical health hazard from ingestion or inhalation of methane found in the drinking water and indoor air from the dissolved methane found in some of the tested private wells. This conclusion is based on information from the available toxicological literature that indicates that dissolved methane is not known to have systemic toxicity in humans.

6. Public Health Recommendations

MDHHS recommends that homes with private wells tested in the identified Manistee area with dissolved methane concentrations greater than 10 mg/L:

- Increase ventilation of homes with fresh outdoor air as much as possible to avoid areas where methane can build up until a permanent solution to reduce methane levels can be installed.
- Install a treatment system to remove methane concentrations at the well.

Homes with concentrations of dissolved methane greater than 5 mg/L but less than 10 mg/L were provided with the same information from Attachment B, but a treatment system was not directly recommended.

7. Public Health Action Plan

The following actions have been completed:

- MDHHS immediately communicated results via phone calls to all homes who have been sampled and answered questions about the risks of methane. All residents were educated on the physical hazard risks identified. Evacuations were not necessary and all residents indicated they were comfortable with the information provided including the recommendations to immediately increase ventilation.
- To those with results greater than 10 mg/L, MDHHS immediately provided an email with resources compiled by District Health Department 10 for well drilling companies in the area who can help install treatment systems (See Attachment B).

Ongoing actions include:

- MDHHS continues to sample residences in this area, as needed, to understand risk from methane.
- The MDHHS Environmental Hotline (1-800-648-6942) is always available to area residents with questions about this investigation and how it impacts their home or health.
- The conclusions and recommendations in this report may be updated if additional information becomes available.

8. Who Prepared the Document

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Measurement of the methane isotopes were done by the Michigan State University Stable Isotope laboratory. MDHHS greatly appreciates the contribution of Dr. James Moran and Dr. Hasand Gandhi who performed this analysis and contributed to Attachment C of this document to describe the results.

9. References

MDH 2024	Methane in Well Water Minnesota Department of Health (MDH), 2024 https://www.health.state.mn.us/communities/environment/water/wells/waterquality/methane.html
U.S. Department of Interior 2001	Technical Measures for the Investigation and Mitigation of Fugitive Methane Hazards in Areas of Coal Mining United States (U.S.) Department of Interior Office of Surface Mining, Published September 2001 https://semspub.epa.gov/work/05/936303.pdf
CCOHS 2023	Methane Chemical Profile, Canadian Centre for Occupational Health and Safety (CCOHS), 2023 https://www.ccohs.ca/oshanswers/chemicals/chem_profiles/methane.html
CAMEO Chemicals 2024	Methane. Computer-Aided Management of Emergency Operations (CAMEO) Chemicals, Accessed in January 2025 https://cameochemicals.noaa.gov/chemical/8823
EGLE 2016	Cleanup Criteria and Screening Levels Development and Application, Michigan Department Of Environment, Great Lakes, and Energy Draft, June 2016. Copy of document available upon request from MDHHS.
EGLE 2025	Development on or Near Methane Generating Sources, Michigan Department Of Environment, Great Lakes, and Energy, April 2025 https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/RRD/Remediation/Resources/Development-On-or-Near-Methane-Sources.pdf

10. Attachments

Attachment A: Figures and Tables

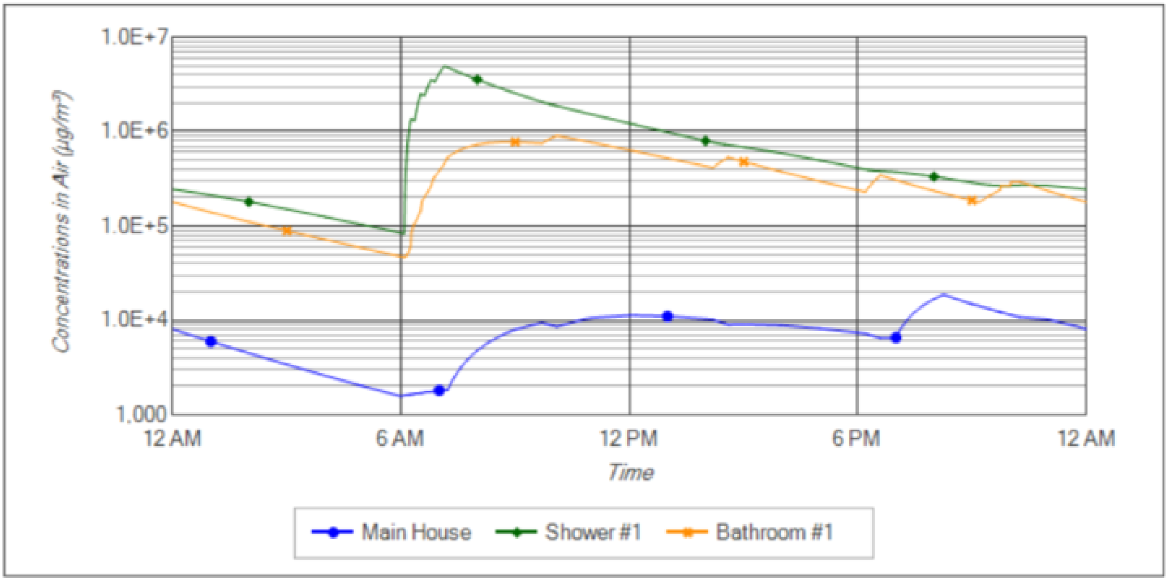

Figure A-1. Calculated air concentrations in the shower, bathroom and main house compartments for a 4-person household from the ATSDR SHOWER Model (Version 4.0.1) with dissolved methane concentration of 46 mg/L.

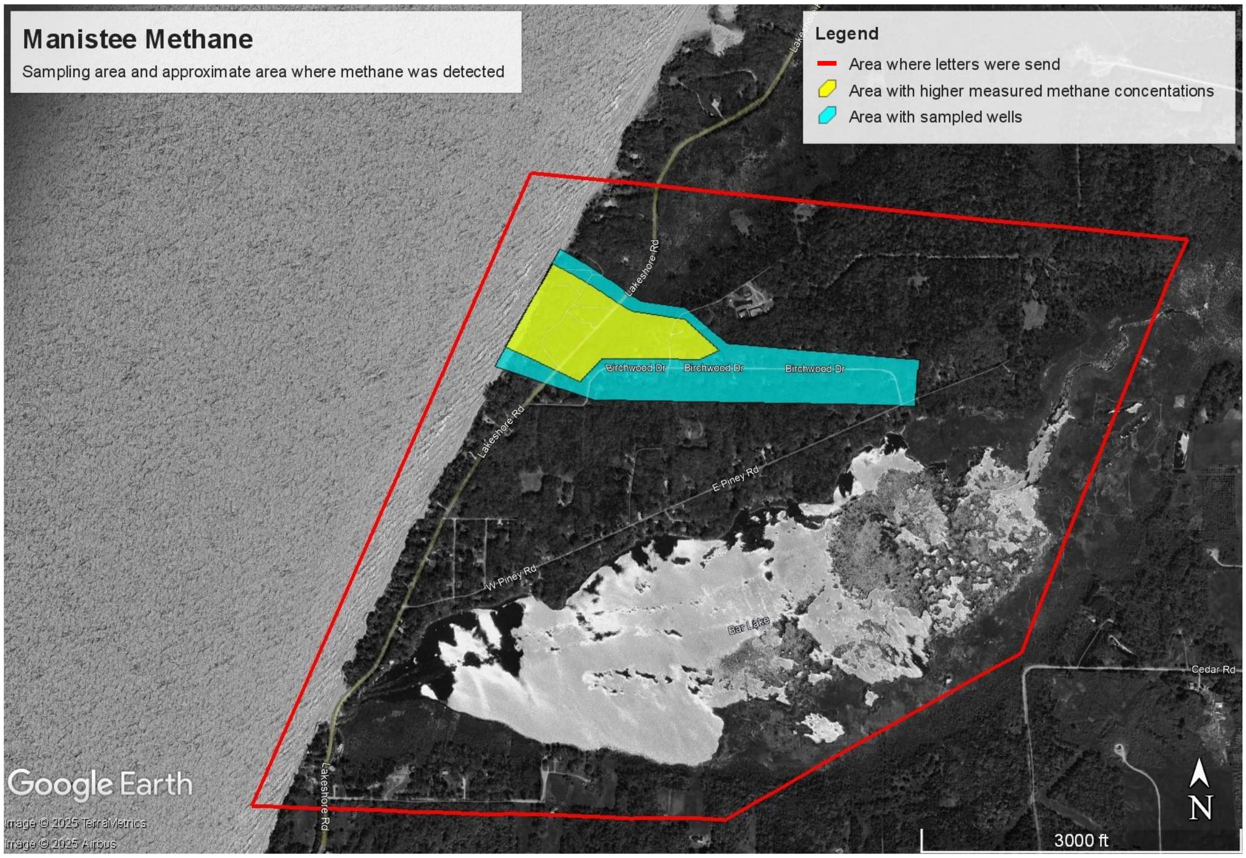

Figure A-2. Map of the area where sampling took place in relation to the approximate location where homes with higher (greater than 10 mg/L) methane concentrations were found.

Attachment B: Resident Recommendations

An email was sent to residents following their sampling appointment if there was a recommendation to install a treatment system:

Hello,

We are following up from our sampling visit with more information on treatment systems for methane. Your local health department, District Health Department #10, provided a list of well drillers that are familiar with methane treatment systems in the area and are willing to work in the area. We recommend installing a treatment system as soon as possible and continue to ventilate your home.

The well drilling companies you can reach out to are the following:

- Flint and Sons - https://www.flintwelldrilling.com/
- King Water Wells – https://kingwaterwells.com/
- Cameron Bros Well Drilling - phone number: (231) 464-5801
- Kraai Well Drilling - https://kraaiwelldrilling.com/

If you have any questions, please let us know.

Attachment C: Dissolved Methane Isotope Analysis

Background

After the first round of data collection confirmed the presence of high levels of dissolved methane in several private drinking water wells, MDHHS started an investigation following questions from all residents on the source of the methane. "

From consultation with EGLE oil and gas, the Manistee area was already known for having "gas" in water wells (**Figure 1**) but the source was not known. However, the immediate investigation area is in an area with several active oil and gas wells. It seemed logical, especially to residents, that the dissolved methane might come from the oil and gas activities in the area which could result in a responsible party being identified for the contamination and actions being recommended to reduce contamination.

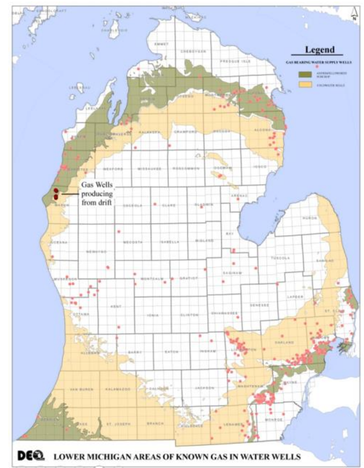

Figure 1: Map of known wells with potential for gas in water. [provided through email]

When investigating further, there is an alternate explanation for high dissolved methane in groundwater. There are two processes that form methane: thermogenic which is likely being introduced from the oil wells, or microbial [EGLE 2016 and EGLE 2025]. Thermogenic methane occurs from geologic processes where rocks are compressed and heated. Biogenic or microbial methane is formed from the bacterial decomposition of organic materials in the subsurface. Anaerobic conditions may also produce biogenic methane. By simply measuring the concentration, contribution of these two processes cannot be distinguished.

The method to distinguish between the two formation processes is by stable isotope analysis, as each process has different isotopic signatures. Microbial methane is isotopically lighter in their stable carbon (C) isotope ratios ($^{13}C/^{12}C$) compared to natural gas from thermogenic sources (**Figure 2**). In collaboration with the Michigan State University Stable Isotope Core Facility, well water samples from 19 homes were analyzed with Gas Chromatography Isotope Ratio Mass Spectroscopy (GC-IRMS) to determine their $\delta^{13}C\text{-}CH_4$ value.

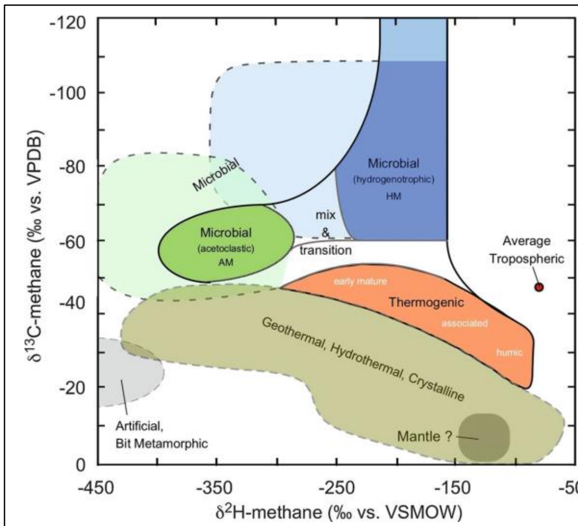

Figure 2: $\delta^{13}C\text{-}CH_4$ in relation to expected source [Whiticar, 2020. The Biogeochemical Methane Cycle]

Sample Collection Method

MDHHS Sanitarians collected drinking water samples at the same time as samples for quantitation were collected from 20 homes. Samples for stable isotope analysis were collected in 60 mL clear glass vials (4 per homes) with Teflon septum. Four drops of the lab provided HCl was added to each bottle as a preservative. Bottles were filled to avoid any air bubbles be present when the vial is closed. Samples were kept refrigerated while being transported to the Michigan State University Stable Isotope Core Facility within two days of collection.

Sample Processing and Analysis

Sample processing (establishing helium headspace): sample bottles were pulled out of the refrigerator and allowed to equilibrate to room temperature overnight clamped upside down in a laboratory stand. A syringe filled with helium and fitted with a needle (22G) was inserted into the vial. An empty syringe with a needle (22G) was also inserted in the sample vial, so that it barely passed through the septa. Four mL sample was removed from the vial and replaced with helium.

Sample analysis: The sample bottle was shaken vigorously for 30 seconds and then let it equilibrate (Septa side up) for 10 minutes before sampling the helium headspace in the bottle. The sample was injected into the GC-IRMS for isotope analysis. Sample isotope value was calibrated using a CO_2 standard of known isotope value.

Results

Stable isotope analysis was successful in 19 of the 20 homes sampled. One home selected for this analysis had no detectable concentration of methane. In general, the multiple samples collected from a home provided similar δ13C values giving great confidence in the results. The mean δ13C values range from -87.85 to -52.58 which are all in the range expected for the source process being microbial methanogenesis. While the δ2H value was not measured for these samples to fully confirm, a δ13C greater than -50 would be expected if a thermogenic source was responsible for the generation of the methane.

When plotting δ13C with dissolved methane concentration of the drinking water sample, a definite trend is observed. Very negative δ13C values are observed at low concentrations with an increasing trend up to around a concentration of around 6 mg/L, after which the isotope value is stable. This data could be consistent with a pulse of substrate entering the system with this substrate being largely consumed by microbial action in areas with the higher methane concentrations. If this interpretation is correct, it would be expected that the substrate to have a δ13C value roughly around -60‰.

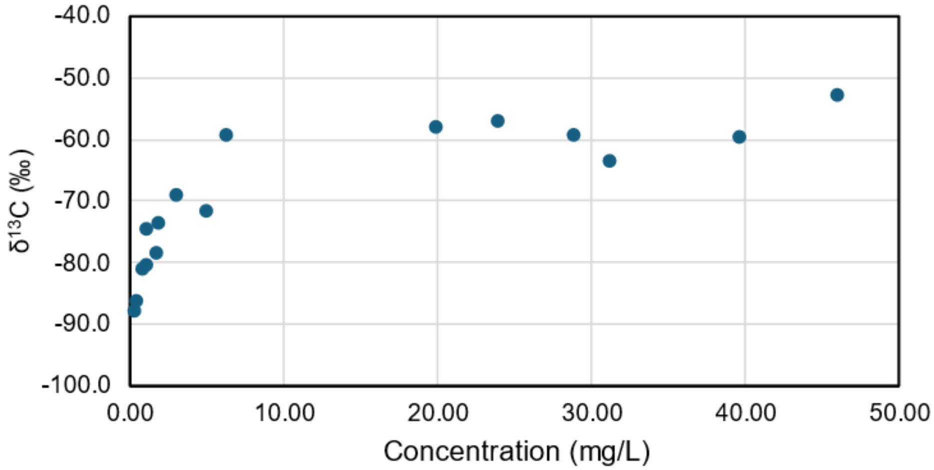

Figure 3: Correlation between δ13C of dissolved methane and its concentration in the drinking water well samples.

Conclusion

From the collected data, it is most likely that the dissolved methane is produced through microbial methanogenesis especially when concentrations are above the 10 mg/L flammability and explosion screening value.