**Memorandum**

To: Deborah Sills, Ph.D.

From: CENG Laboratory Team Devinci: Deborah Sills, Matt Higgins, and Kevin Gilmore

Date: September 3, 2013

Re: Results of Marcellus Shale Wastewater Treatment Evaluation

**INTRODUCTION**

Marcellus Shale is a geologic formation found approximately one mile beneath the northeastern United States. The formation contains significant reserves of natural gas, which constitutes a valuable natural resource for the U.S. (Kargbo et al., 2010). This natural gas is extracted by drilling and fracturing the shale with high-pressure water, which allows gas to flow out of the well. However, large quantities of water are needed for this process, and the wastewater that is generated is very salty. In addition, this wastewater is often sent to domestic wastewater treatment plants (Urbina, 2011) before discharge to rivers and streams. But current regulations mandate a total dissolved solids (TDS) concentration of 500 mg/L or less in waters received at Publicly Owned Treatment Works POTWs.

The objective of this experiment was to determine if a treatment process was effective in reducing the amount of salt in the wastewater. It is hypothesized that the chemical treatment process should result in a significant reduction in salt. But it is not known if the reduction in salt concentration will be sufficient such that the wastewater can be received at a POTW for subsequent treatment.

**METHODS**

Samples of Marcellus wastewater, before and after the treatment process of interest, were evaporated to leave only residual salt or total dissolved solids (TDS). The masses of four replicates of each sample (container plus dry salt) were measured using an analytical balance, and the masses of the empty containers were subtracted to determine the masses of salt. Mass values were converted to concentration by dividing by the initial sample volume. An example calculation is shown in Appendix A. Results were recorded, and statistical analysis was performed using spreadsheet software (Microsoft Excel, Redmond, WA).

**RESULTS AND DISCUSSION**

The results of the measurements are shown in Figure 1 (with raw data provided in Appendix B). The data presented in Figure 1 show that the average concentration of salt in the treated samples was 48% less than the average in the untreated samples. This difference was statistically significant with P < 0.05. Thus, the hypothesis was confirmed, that the treatment process significantly reduced the salt content of the samples. Visual observations of the dry samples also suggested that the treatment process had an effect on the samples, as the untreated samples had a brown, rust-like color while the treated samples did not. It is possible that the treatment process removed the iron and other heavier metals from the wastewater, causing the change in color. Both sample sets had nearly identical variability, with confidence intervals of less than 1% of the mean for both sets.

On the other hand, even though the treatment resulted in a significant reduction in salt content of the samples, the concentration of TDS in the treated samples is approximately two orders of magnitude larger than the concentrations allowed to be received by Publicly Owned Treatment Works (POTWs) in Pennsylvania (500 mg/L).



**Figure 1. Average salt content of untreated and treated wastewater samples. Error bars represent 95% confidence intervals**

*…or, if you chose to present this summary data as a table ( note location of titles )…*

**Table 1. Average salt content of untreated and treated wastewater samples.**

|  |  |
| --- | --- |
| **Sample Type** | **Average TDS Concentration, mg/L** |
| Untreated | 148,642 ± 812 |
| Treated | 77,412 ± 964 |

a Values in parentheses represent 95% confidence intervals.

**CONCLUSIONS**

By confirming the effects of the treatment process, the objective of the experiment was achieved. However, the treated samples still have much more salt than is allowed in wastewaters received by POTWs or fresh bodies of water, so additional treatment should be investigated. Furthermore, the economic viability of the process must be investigated prior to broader implementation.

**APPENDIX A: SAMPLE CALCULATION**

Mass of salt in sample, g = Dry mass of dish & salt after drying, g – Initial dry mass of empty dish, g

Example, Dish 1UT: 1.747 g – 0.9987 g = 0.7483 g

**APPENDIX B: RAW DATA**

Untreated Samples

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Dish # | Mass of Dish, g | Dry Mass With Salt, g | Mass of Salt, g | Average Mass of Salt, g | Standard Deviation, g | 95% Confidence Interval, g |
| 1UT | 0.9987 | 1.747 | 0.7483 | 0.7439 | 0.004 | 0.74 ± 0.004 |
| 2UT | 0.9982 | 1.7413 | 0.7431 |
| 3UT | 0.9978 | 1.7381 | 0.7403 |
| 4UT | 0.9958 | 1.7356 | 0.7490 |

Treated Samples

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Crucible # | Initial Dry Mass, g | Dry Mass With Salt, g | Mass of Salt, g | Average Mass of Salt, g | Standard Deviation, g | 95% Confidence Interval, g |
| 1T | 0.9987 | 1.3888 | 0.3891 | 0.3863 | 0.004 | 0.39 ± 0.004 |
| 2T | 0.9982 | 1.3777 | 0.3808 |
| 3T | 0.9978 | 1.3962 | 0.3891 |
| 4T | 0.9958 | 1.3821 | 0.3860 |

**REFERENCES**

Last Name, First Name. (Year) Title of journal article or equivalent document. J. Haz Waste and Soc. Volume(**Issue Number**): startpage – end page.

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