NM WRRI Student Water Research Grant Progress Report Form

Progress Report due November 1, 2019
Draft Final Report due April 30, 2020
Final Report due May 31, 2020

1. **Student Researcher:** Moticha Franklin

   Faculty Advisor: Dr. Antonio Lara

2. Project title: Surface Area of a Local Clay Material to Elucidate Uranium Abatement for Potable New Mexico Water Management

3. Description of research problem and research objectives.

Uranium contamination in drinking water in the northwestern region of New Mexico is an ongoing problem, especially for the Navajo Nation. Due to complexity, expenses, and energy demands, technologies such as reverse osmosis are inappropriate for the region; therefore, an appropriate solution is needed, i.e., inexpensive, simple to implement and needed materials are readily available. Clays are the answer to address these operational parameters. Because of their inherent cation exchange capabilities, clays in their natural form bind and sequester heavy metals from water. However, clays in their characteristic muddy state are difficult to manage. Therefore, a fabrication process has been developed in our laboratory to produce clay ceramic pellets that do not disintegrate in water. *Most specifically for this grant, the capacity for clays to sorb heavy metals is directly related to the surface area of the clay sorbent.* Due to its proximity to the affected region, a clay from Gallup, New Mexico was chosen to be analyzed. Ultimately, this investigation will aid in the determination of the efficacy of clays for uranium sorption. This study will elucidate a more comprehensive understanding of clay sorption in the various states: powder, non – porous pellet, and porous pellet. We hypothesize that clay powder transformed to pellet form decreases available surface area – the essence of the study. Furthermore, the degree of surface area reduction will play a vital role in future studies, especially when the selection is extrapolated to other clays. For application purposes, it is important to identify the best clay sorbet material for the abatement of aqueous uranium. One of the key steps in this identification process is to ascertain the porosity and surface area of our clay materials.

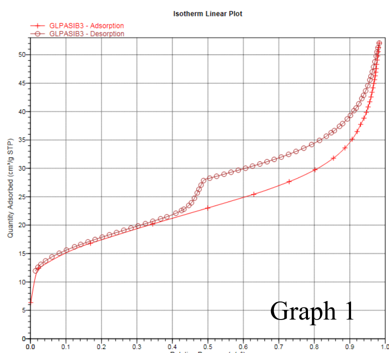
4. Description of methodology employed.

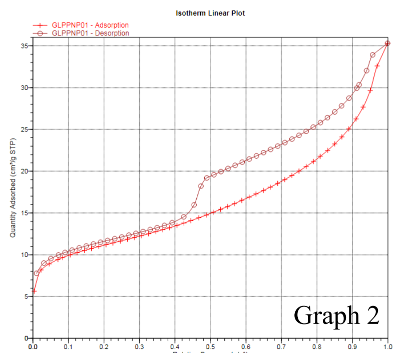
A Gallup, NM clay was used because the location is juxtaposed to a uranium-threatened area in New Mexico. From this location, a sufficient sample lot has been established for the entire experiment. Furthermore, we have the technology to ‘prep’ raw clay, fabricate pellets, and statistically analyze pellet properties (clay-water ratios, molding/casting, pre-firing/dehydrating, firing temperature/duration).

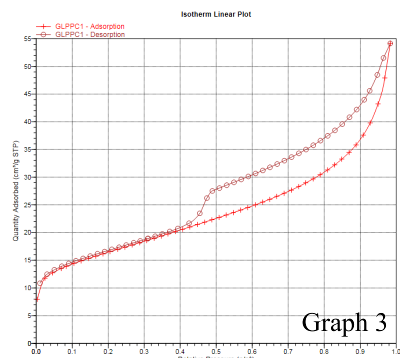
With NMSU Freeport-McMoRan Water Quality Laboratory assistance, we used the ASAP 2050 Xtended Pressure Sorption Analyzer for surface area and pore size/volume analyses. This instrument uses established Brunauer–Emmett–Teller (BET) sorption models to measure the clay surface area and provide isotherms based on sorption of inert gases, typically nitrogen. However, to better understand the sorption process of toxic uranium with our clay pellets, we used nitrogen, carbon dioxide and argon gas to probe various sorption parameters. Nitrogen is a standard sorbate for analysis but due to its shape it may not best ‘mimic’ the aqueous uranium cation (UO_2^{2+}) that is actually present in the water. Conversely, argon is spherical, and due to its small size, it may represent maximum sorption potential of the clay material. Carbon dioxide, however, has a linear structure with two peripheral oxygens and has the potential to ‘mimic’ aqueous uranium (CO_2 vs. UO_2^{2+}). The pore size/volume measurements are crucial parameters because they will elucidate the clay’s capacity properties for sorption.

5. Description of results; include findings, conclusions, and recommendations for further research.

Gallup N_2 Isotherm Plots

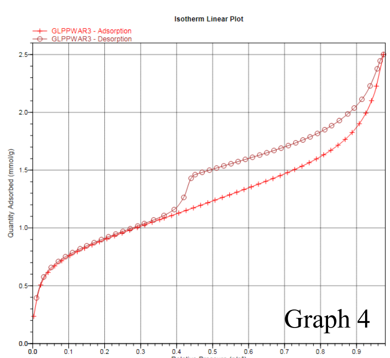


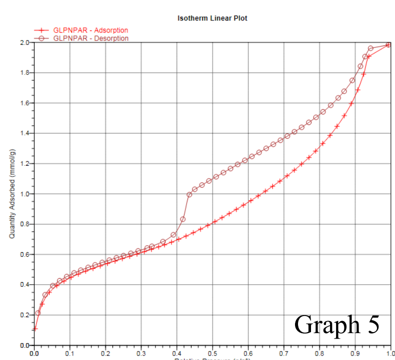


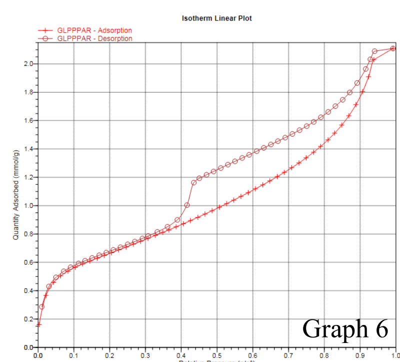


Graph 1: Isotherm Linear plot for Gallup powder
Graph 2: Isotherm Linear plot for Gallup non - porous pellet
Graph 3: Isotherm Linear plot for Gallup porous pellet

Gallup Ar Isotherm Plots

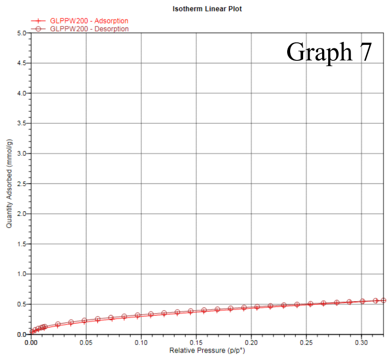


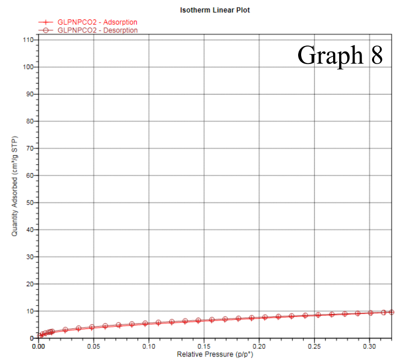


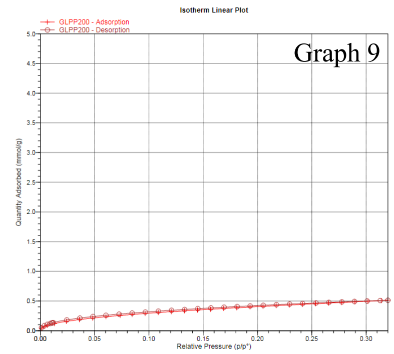


Graph 4: Isotherm Linear plot for Gallup powder
Graph 5: Isotherm Linear plot for Gallup non - porous pellet
Graph 6: Isotherm Linear plot foe Gallup porous pellet

Gallup CO_2 Isotherm Plots







Graph 7: Isotherm Linear plot for Gallup powder
Graph 8: Isotherm Linear plot for Gallup non – porous pellet
Graph 9: Isotherm Linear plot for Gallup porous pellet

Gallup Surface Area: BET

	Powder $(\frac{m^2 area}{g\ of\ clay})$	**Non – porous pellets** $(\frac{m^2 area}{g\ of\ clay})$	**Porous pellets** $(\frac{m^2 area}{g\ of\ clay})$
N_2	62.4567	37.6538	57.3168
CO_2	42.2562	31.4721	37.7396
Ar	63.0481	38.2939	47.1927

For BET data, three different sorption gases were used (Ar, N_2, CO_2); N_2 and Ar penetrated the micropores of the clay in its various states. The hysteresis loops in the isotherm linear plots verify the micropores of the various states of the clay. Furthermore, the microporosity appears to be a function of the clay and not the pellet fabrication process. For the two non-oxygenated sorbates (N_2 and Ar) the data shows a trend between the different states. By converting the clay powder to a non – porous pellet form, the surface area is decreased by at least half. However, for the powder to porous pellet conversion there is only a small decrease in surface area.

N_2 has a molecular cross – sectional area of 0.162 nm^2 and argon has a molecular cross – sectional area of 0.143 nm^2, and this translates to a slightly larger exposure surface area for argon. Argon was small enough to channel its' way into the micropores of the clay in its different forms. The size comparison data further supports the CO_2 data. The CO_2 molecule with a molecular cross – sectional area of 0.170 nm^2 is bigger than the other two sorbates cross – section plus the longer molecular structure. By a similar argument, this decreases the available surface areas in the different states. Pellet fabrication processes reduce the surface area. However, the reduction is not enough to significantly suppress uranium sorption (data from other research efforts in our laboratory).

Gallup Pore Size/Volume

		Pore Opening Size (Å)	Pore Volume (cm^3/g)
N_2	Powder	50.1580	0.047645
	Non – Porous Pellet	43.3920	0.054459
	Porous Pellet	77.131	0.070580
CO_2	Powder	N/A	N/A
	Non – Porous Pellet	N/A	N/A
	Porous Pellet	N/A	N/A
Ar	Powder	69.530	0.055732
	Non – Porous Pellet	72.798	0.04948
	Porous Pellet	65.889	0.050504

The smaller gases (N_2 and Ar) channel their way into the clay and its micropores. We hypothesize that the uranyl ion sorption is taking advantage of this porosity in the sorption process. For CO_2 studies, the correct pore size and volume could not be obtained due to an error in the ASAP 2050 software and the samples will need to be reanalyzed. In the future, the first step is to reanalyze the CO_2 studies to obtain this information by attempting to circumvent the software issue.

6. **Provide a paragraph on who will benefit from your research results. Include any water agency that could use your results.**

Those who will benefit the most from this research are the people in the northwestern region of New Mexico, who have long been plagued with the uranium contamination issue. Clean water is scarce, especially in the economically limited Navajo Nation. Current methods such as piping and trucking have proven to be ineffective; hence, people often have to consume heavily contaminated water. On the other hand, our clay pellets are appropriate, cost-effective and simple to implement. This novel technology can be implemented in individual houses where any water source, regardless of the impurities, may be an issue. Clays can be easily obtained locally, thus, providing a means to clean water. Even though our main target is people in the Navajo Nation and the Pojoaque Basin, the potential of clay pellets is geographically limitless. In addition, preliminary tests have given us sorption results for heavy metals other than uranium, e.g. lead and cadmium. For all pollutants tested, the resulting pollutant level are well below the EPA standards for safe drinking water.

7. **Describe how you have spent your grant funds. Also provide your budget balance and how you will use any remaining funds. If you anticipate any funds remaining after May 31, 2020, please contact Carolina Mijares immediately**. (575-646-7991; mijares@nmsu.edu)

All funds should be used by June 30, 2020

Salary **$6,000.00**
Fringe Benefits **$63.60**
Travel, WRRI Conference.. **$300.00**
Supplies, Surface Analyses **$136.40**
Services (Provided by Research Laboratory)
Equipment (Secured and arranged with Freeport-McMoRan Water Quality Laboratory)

8. **List presentations you have made related to the project.**

NM WRRI 64th Annual New Mexico Water Conference at Pojoaque, New Mexico
URCAS 2020, New Mexico State University, Las Cruces, New Mexico (Abstract submitted)
Clay Mineral Society 57th Annual Meeting, Richland, Washington (Abstract submitted)

9. **List publications or reports, if any, that you are preparing. For all publications/reports and posters resulting from this award; please attribute the funding to NM WRRI and the New Mexico State Legislature by including the account number: NMWRRI-SG-2019.**

The sorption data presented will be included in a manuscript that is in preparation for 2020

10. **List any other students or faculty members who have assisted you with your project.**

Faculty members:
Dr. Antonio Lara, PI, NMSU Department of Chemistry & Biochemistry
Mark Chisdester, Lab Manager, NMSU Freeport-McMoRan Water Quality Laboratory

Students:
Jeremy Jones, Ph.D. candidate, NMSU
Nhat Nguyen, Graduate student, NMSU
Joshua Herrera, Undergraduate student, NMSU

11. **Provide special recognition awards or notable achievements as a result of the research including any publicity such as newspaper articles, or similar.**

Abstract was accepted to the NM WRRI 64th Annual New Mexico Water Conference
Will present at the International Conference: Clay Mineral Society 57th Annual Meeting, Richland, Washington in October 2020

12. Provide information on degree completion and future career plans. Funding for student grants comes from the New Mexico Legislature and legislators are interested in whether recipients of these grants go on to complete academic degrees and work in a water-related field in New Mexico or elsewhere.

I am currently earning a degree in chemistry. Most importantly, I am developing the scientific concepts and laboratory techniques which will aid me in a career that pertains to water quality and environmental issues in New Mexico. My expected graduation date is May of 2021. I am planning on applying for either a graduate program in chemistry or a veterinarian program after the completion of my bachelor's degree. In either case, these events will help me improve the quality of life in my Navajo community.

You are encouraged to include graphics and/or photos in your draft and final report.

Final reports will be posted on the NM WRRI website.