

Uranium Abatement  
for  
Contaminated Water from Unregulated Sources

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# Four Corners

~ 30 % of the population have unregulated water  
(54,000 people - 14,300 households)

Case studies for unregulated water sources

12 % - Uranium concentrations > 30 ppb (EPA-MCL)

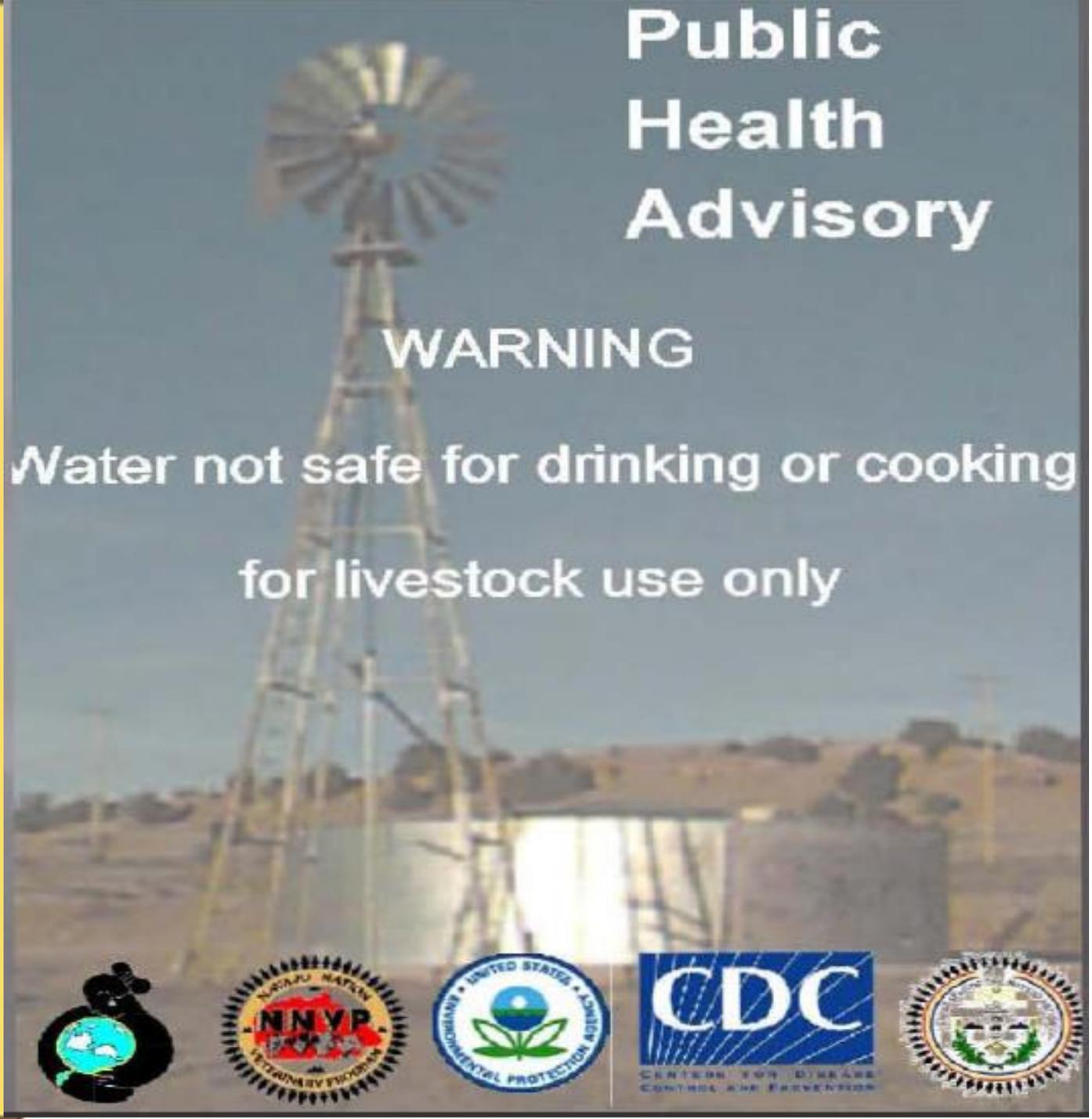
Economically Limited People  
Isolated, Remote, No Electricity



**WATER FROM  
THIS WELL  
IS NOT SAFE  
TO DRINK**

This water has been tested and found to exceed Navajo EPA and U.S.EPA human drinking water standards for uranium or other contaminants.

Navajo Nation policy is that livestock-use-only wells are not to be used for human drinking water.



**Public  
Health  
Advisory**

**WARNING**

**Water not safe for drinking or cooking  
for livestock use only**





10T-573

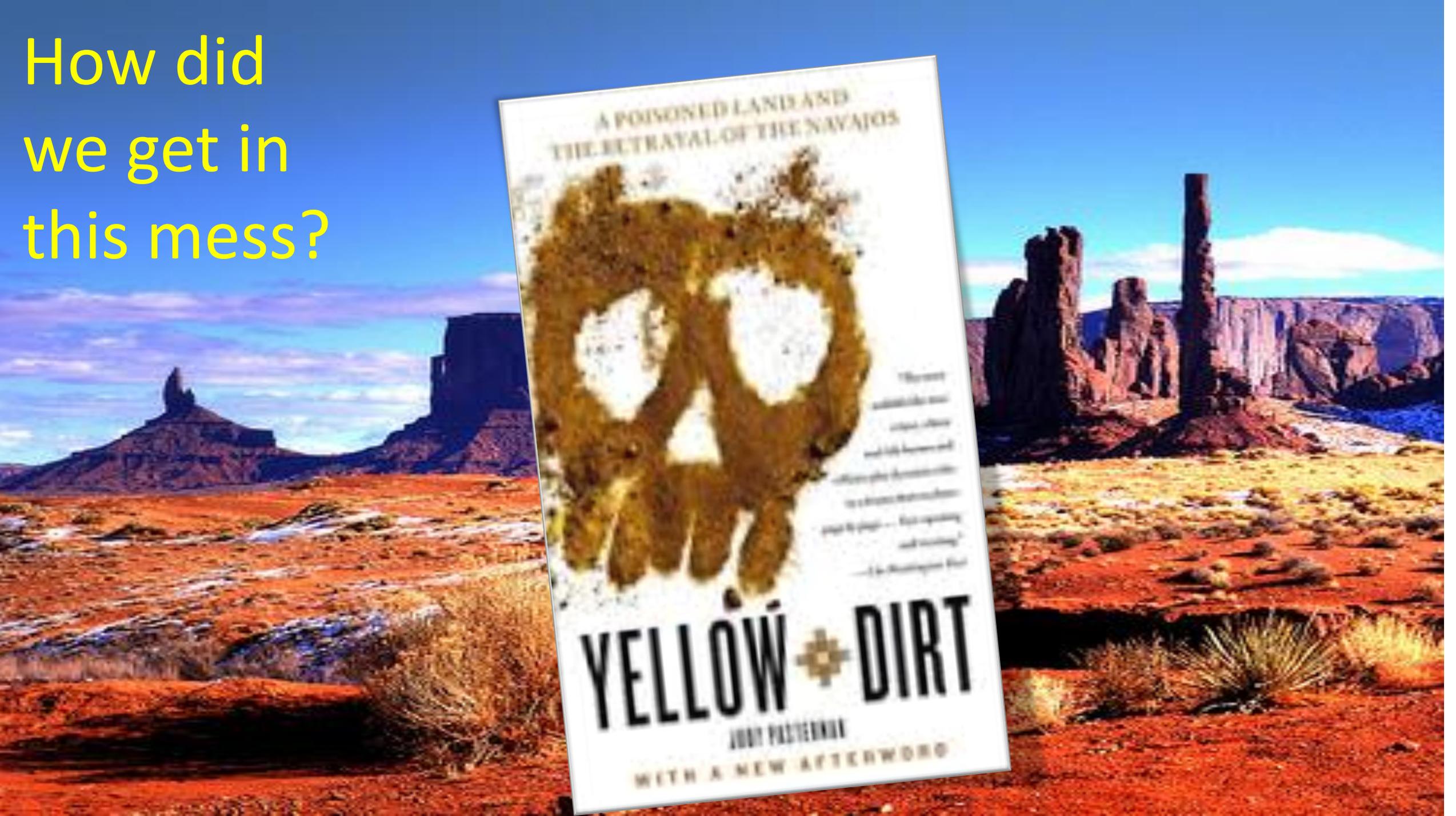
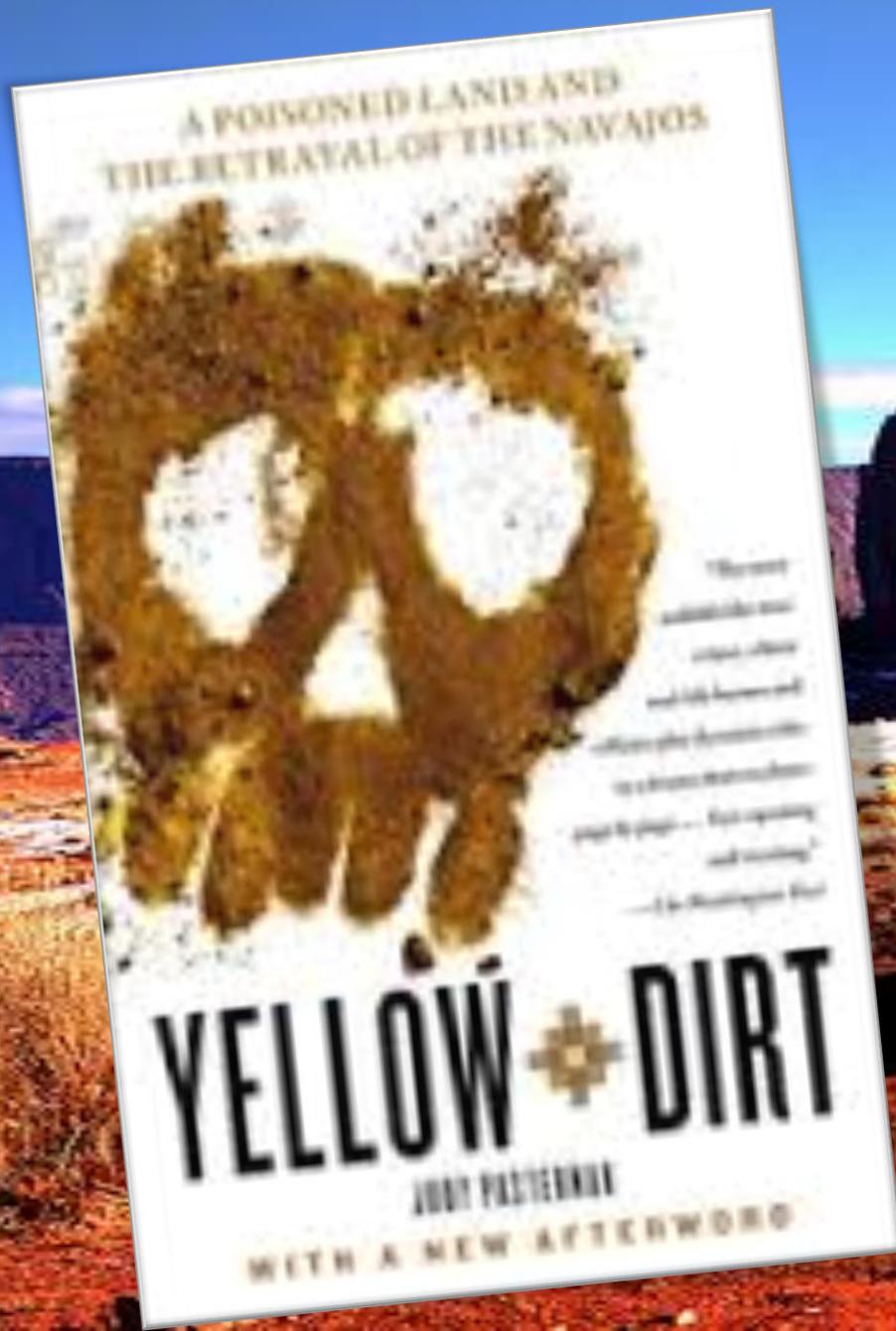
10T-573

10T-573



NNEPA estimates that up to 30% of the population must haul water because they are not served by piped water systems.(14,347 households)

How did we get in this mess?



# Inappropriate Technologies for the Navajo

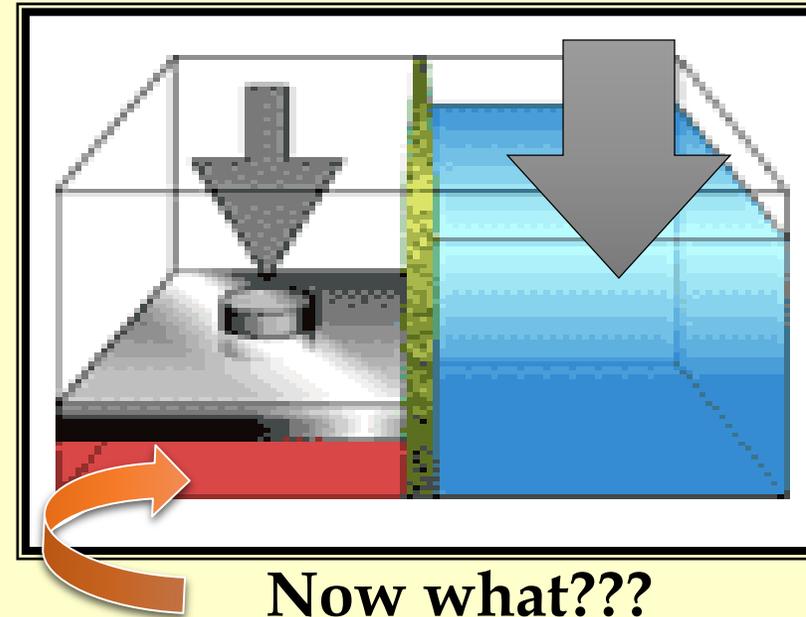
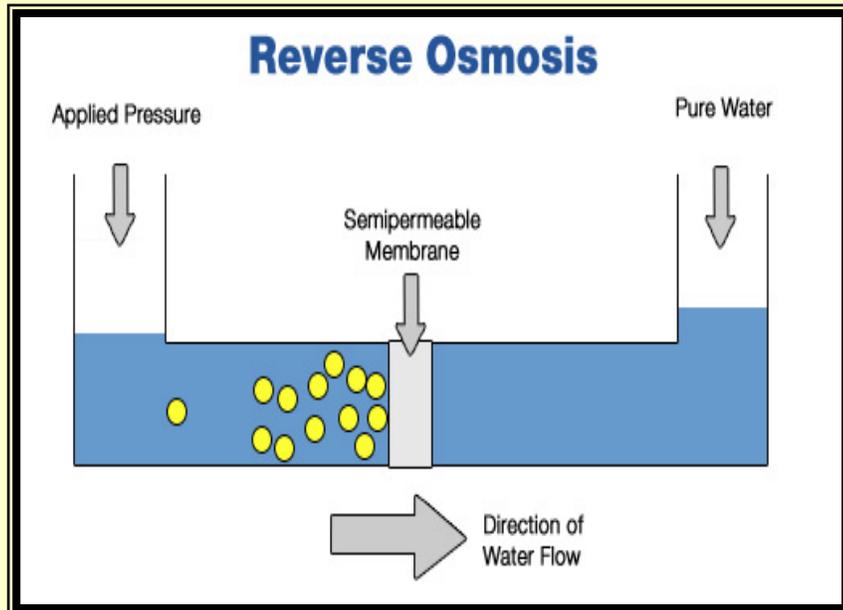
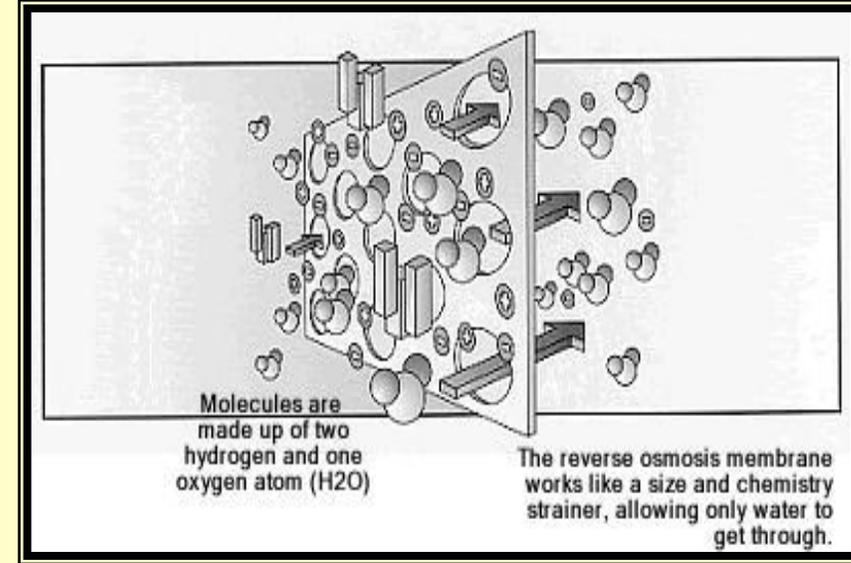
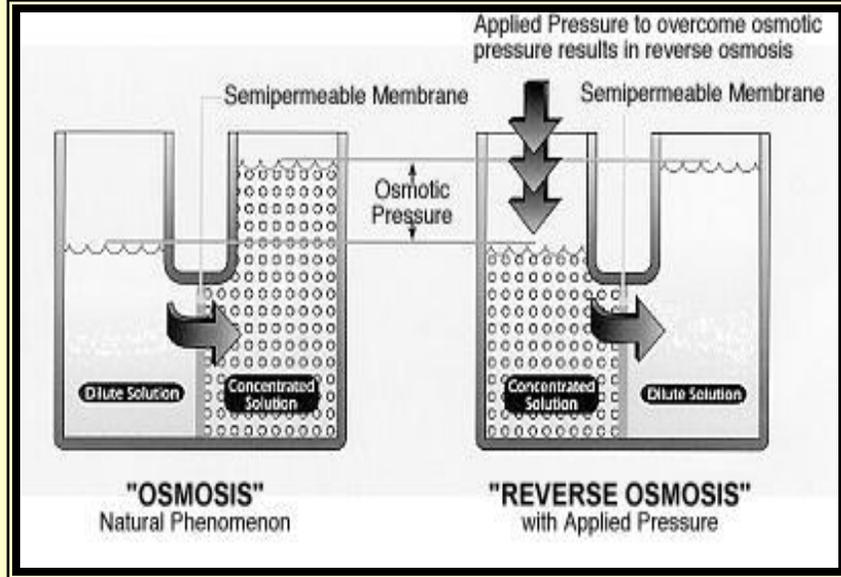
Expensive

Complex

Energy Intensive

What to do with the water by-product that is MORE highly contaminated than the origin water?

# Reverse Osmosis

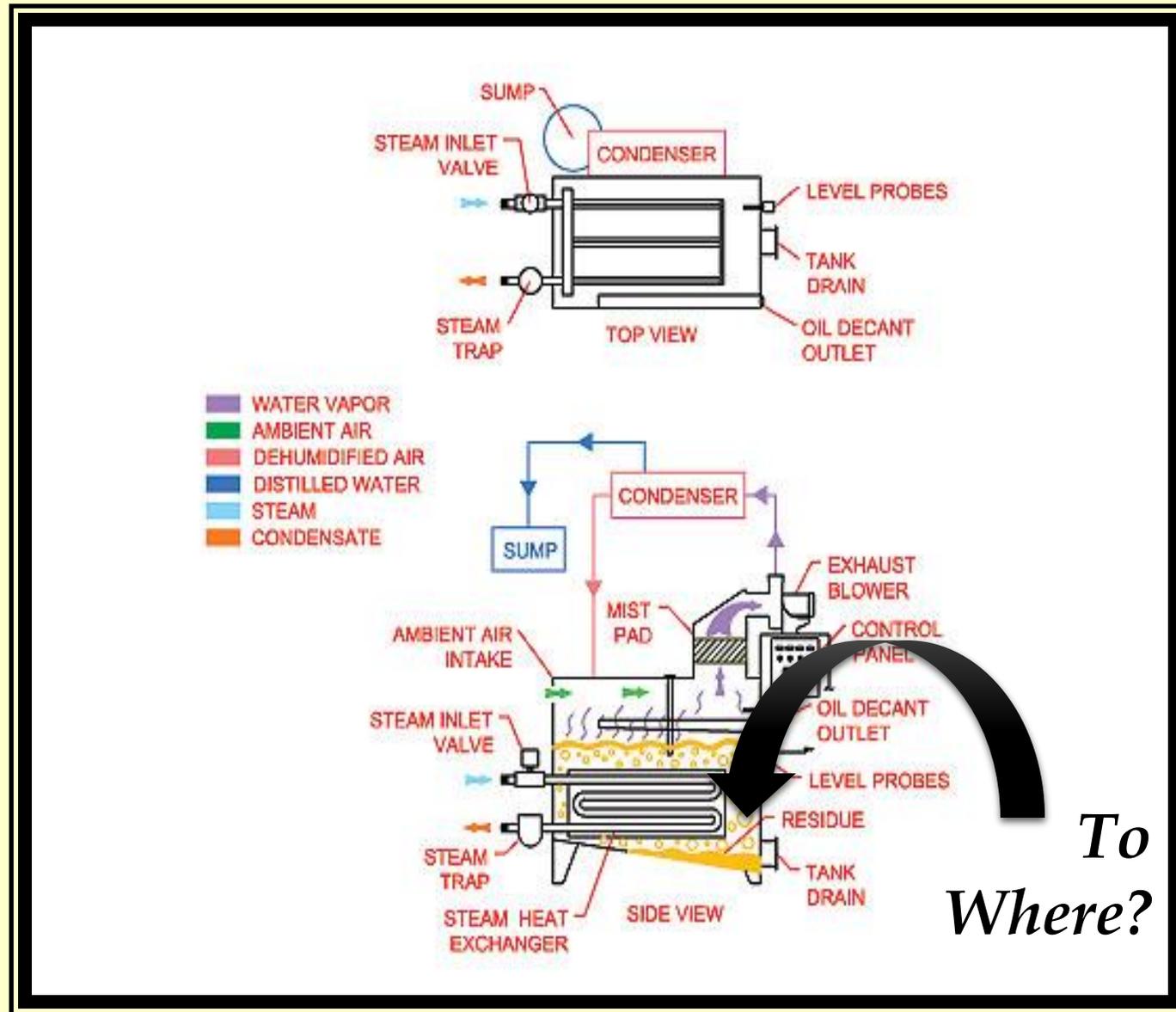


# Distillation

Price \$549.95



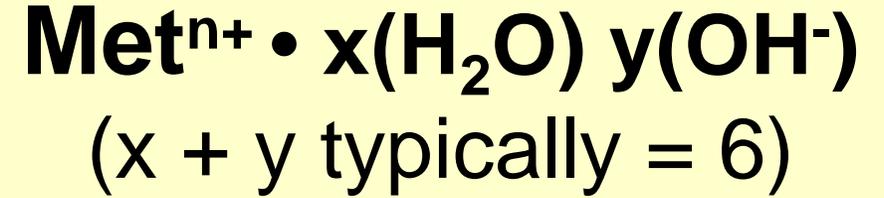
Price \$129



# Whole House Kinetic Degradation Fluxion (KDF)



BUY NOW IN USA!  
US \$359.95  
+ \$19.95 shipping



Only if

n = 0 or n = y

**Insoluble**

**Solubility is very pH and pE dependent**

## *How does KDF Work?*

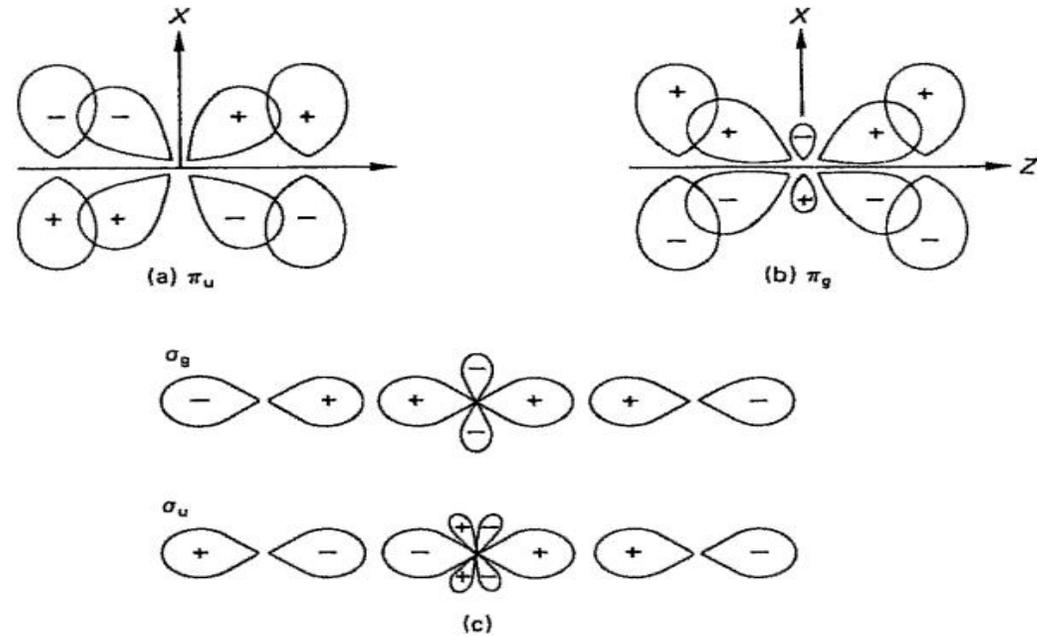
In short, the KDF redox process works by **exchanging electrons** with contaminants. This "give and take" of electrons converts many contaminants into harmless components. During this reaction, electrons are transferred between molecules, and **new elements are created**. Some harmful contaminants are changed into **harmless components**. Others are **electrochemically bound** to the KDF media.

# Solution

## Ion-Exchange

### Natural Resource - Clay

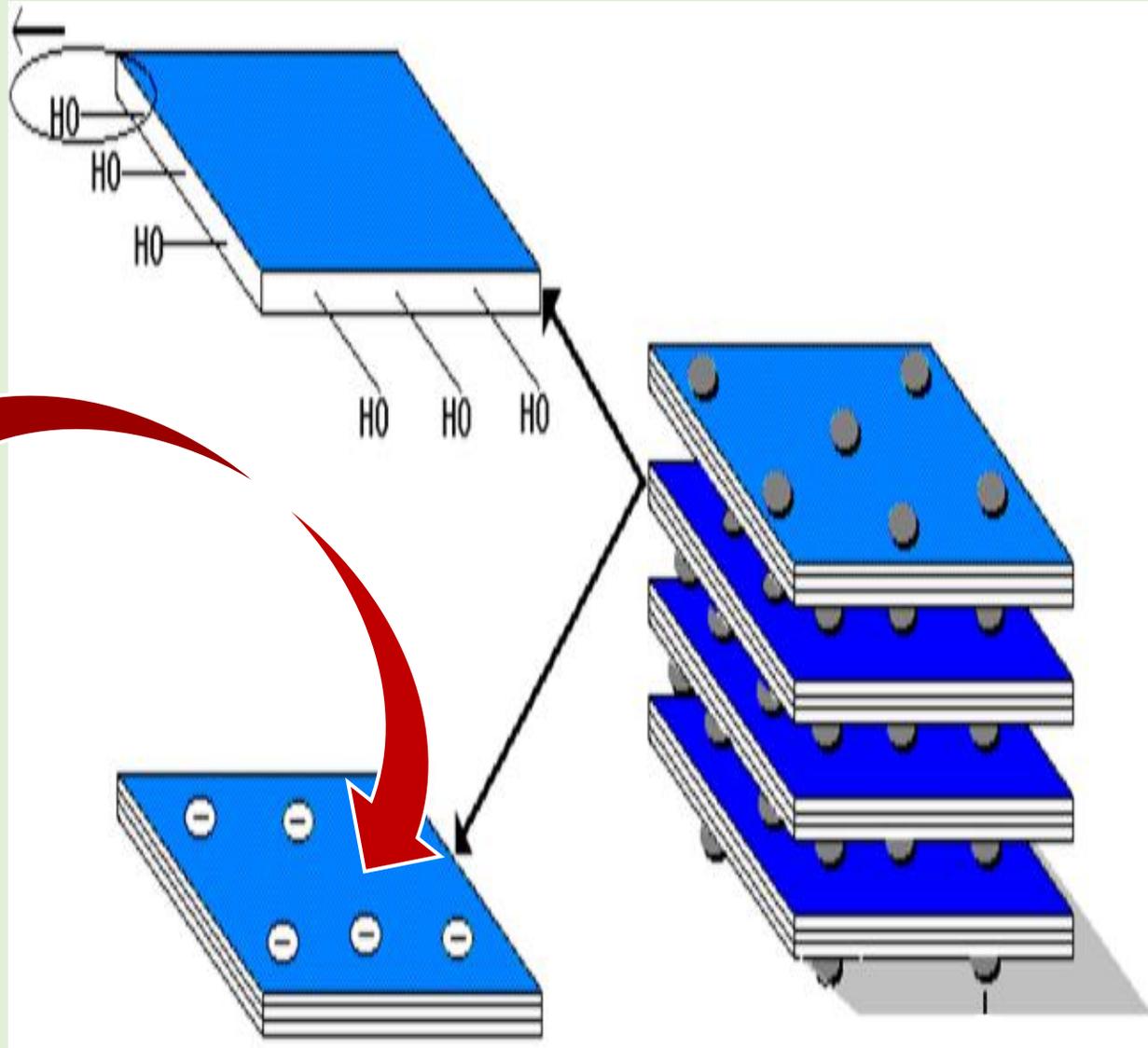
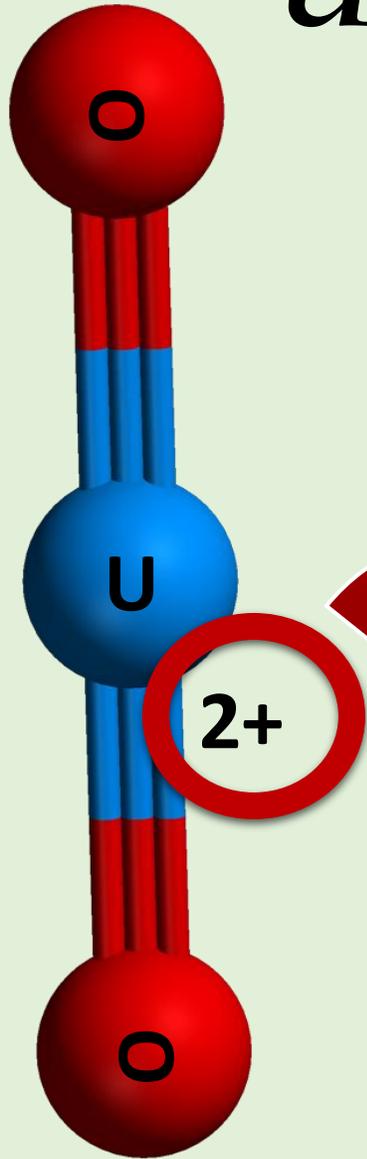
Uranyl ( $\text{UO}_2$ )<sup>2+</sup>



**Figure 11.1**

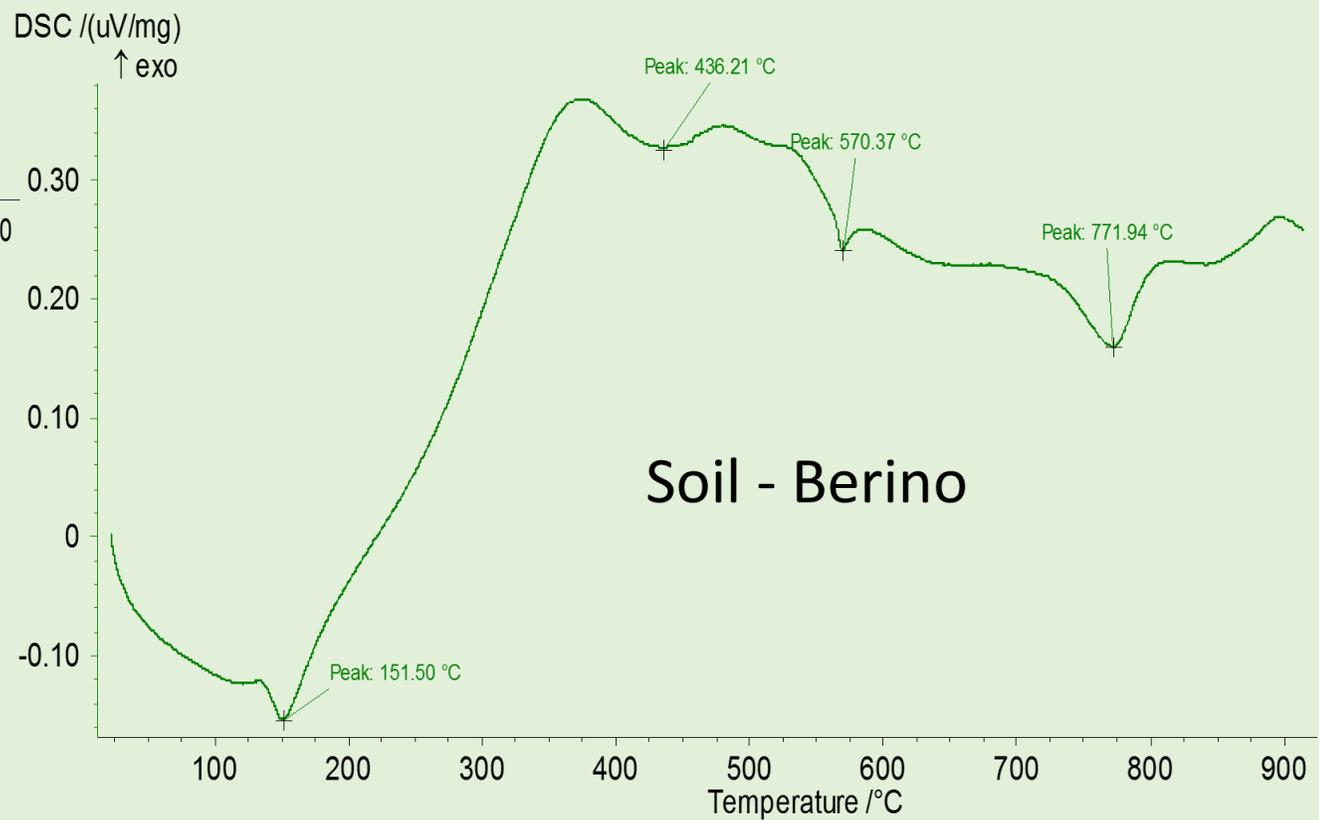
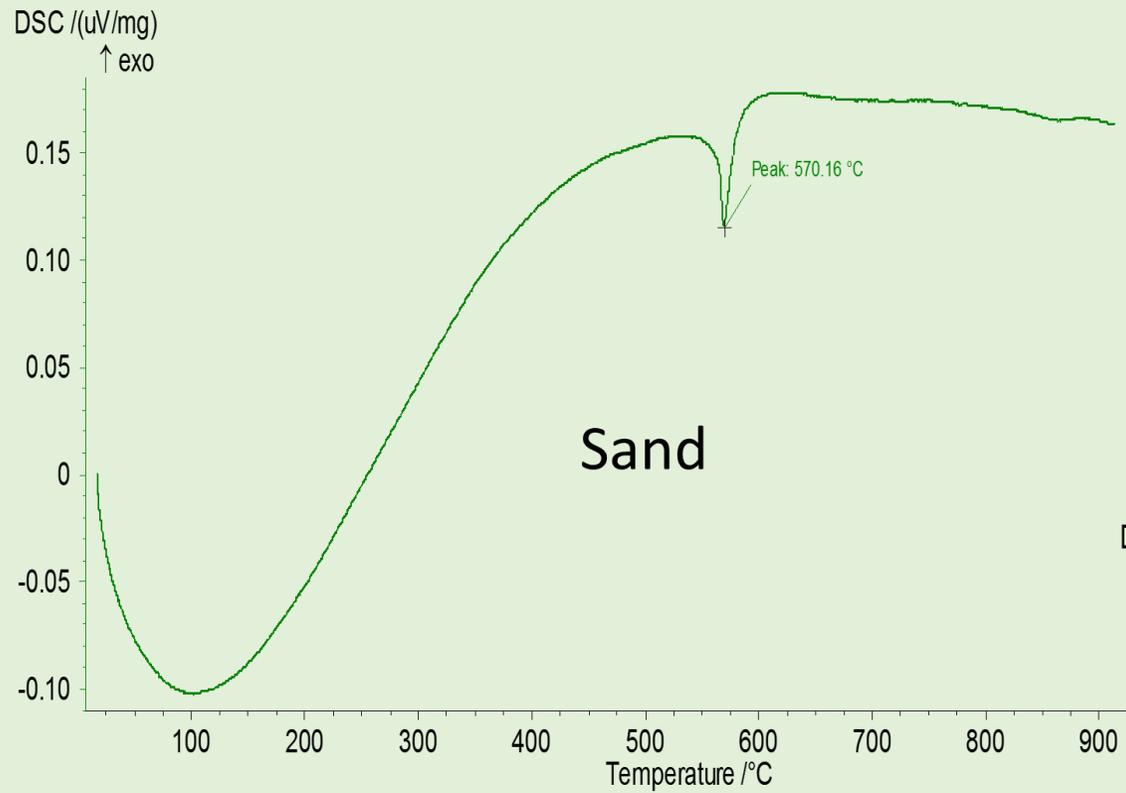
π-bonding in the uranyl,  $[\text{UO}_2]^{2+}$  ion: (a)  $d_{x^2-y^2}$ - $p_x$  overlap; (b)  $f_{x^2-y^2}$ - $p_x$  overlap; (c) σ-bonding in the uranyl ion (reproduced with permission from Figure 3.24 of S.A. Cotton, *Lanthanides and Actinides*, Macmillan, 1991).

# *Uranium Abatement*





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# WHY SOILS?



*Manageable*



*Will not leach*

*Inexpensive*



*Safe to transport*

*Ease of final disposal*

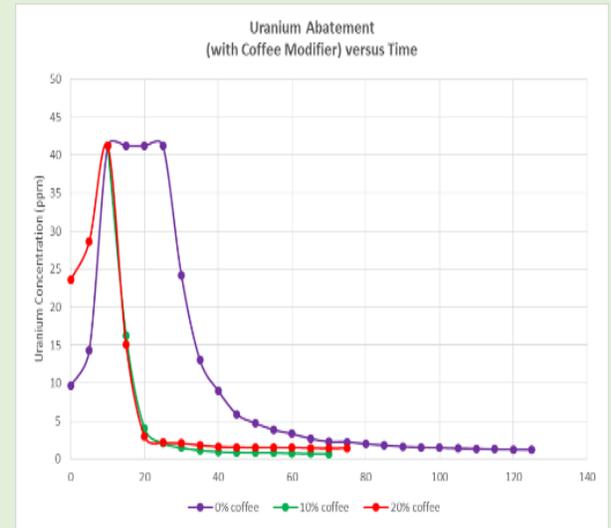
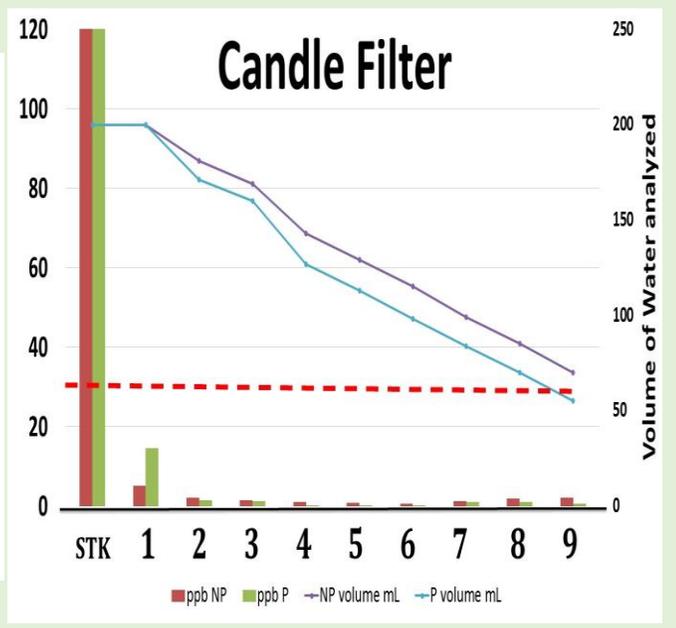
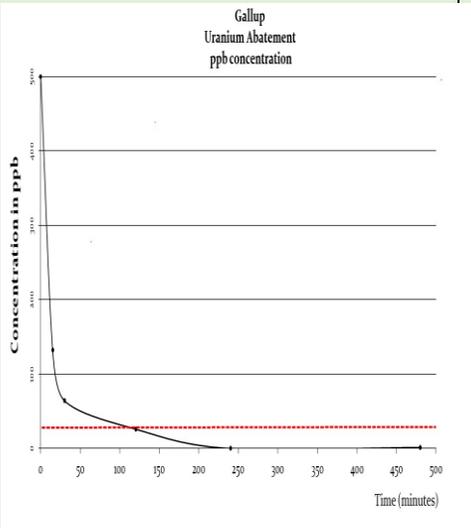
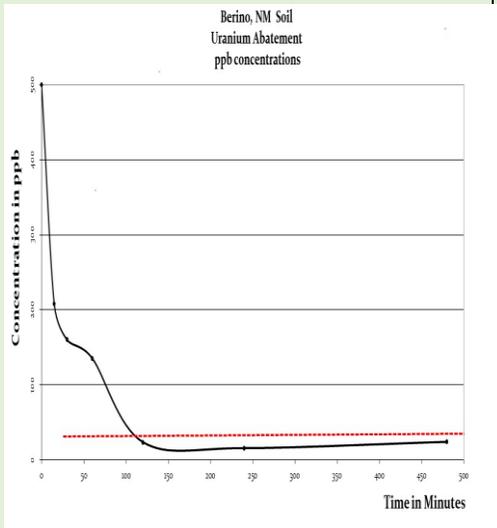
*Robust (Temperature,  
Redox, pH)*

*Vitrification for added safety*

# Uranium Abatement

ion-exchange onto Natural Materials

Each with unique properties

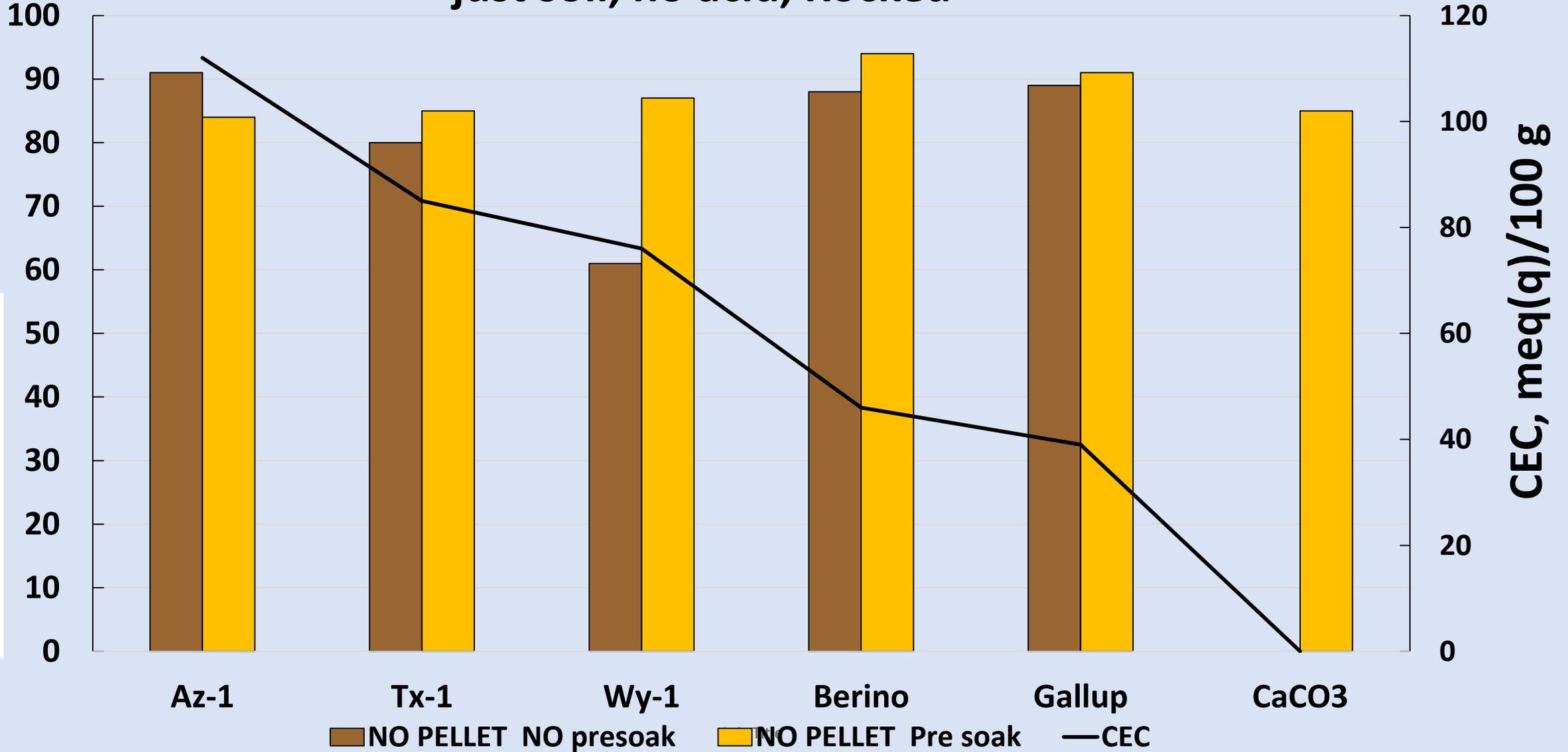


Clay	Berino Soil	Gallup Soil	Filter – soil from Ciudad Juárez, Mexico) and Berino Pellets	Berino Soil
Clay/Sand	60/40	60/40	60/40	100% Clay (Top Clay Fraction)
Presoak	Presoak	Presoak	Presoak	Presoak
Initial Uranium Concentration	500 ppb	500 ppb	124 ppb	15 ppm
Surface Area (Coffee)	No Coffee grounds	No Coffee grounds	No Coffee grounds	Coffee Gounds ~425 $\mu$ m Purple 0% Coffee grounds Green 10% Coffee grounds Red 20% Coffee grounds
Interaction conditions	Bulk Water-Pellet static	Bulk Water-Pellet static	Water moves past pellets Each trial was about 15 minutes	Bulk Water-Pellet static

# NO PELLETS

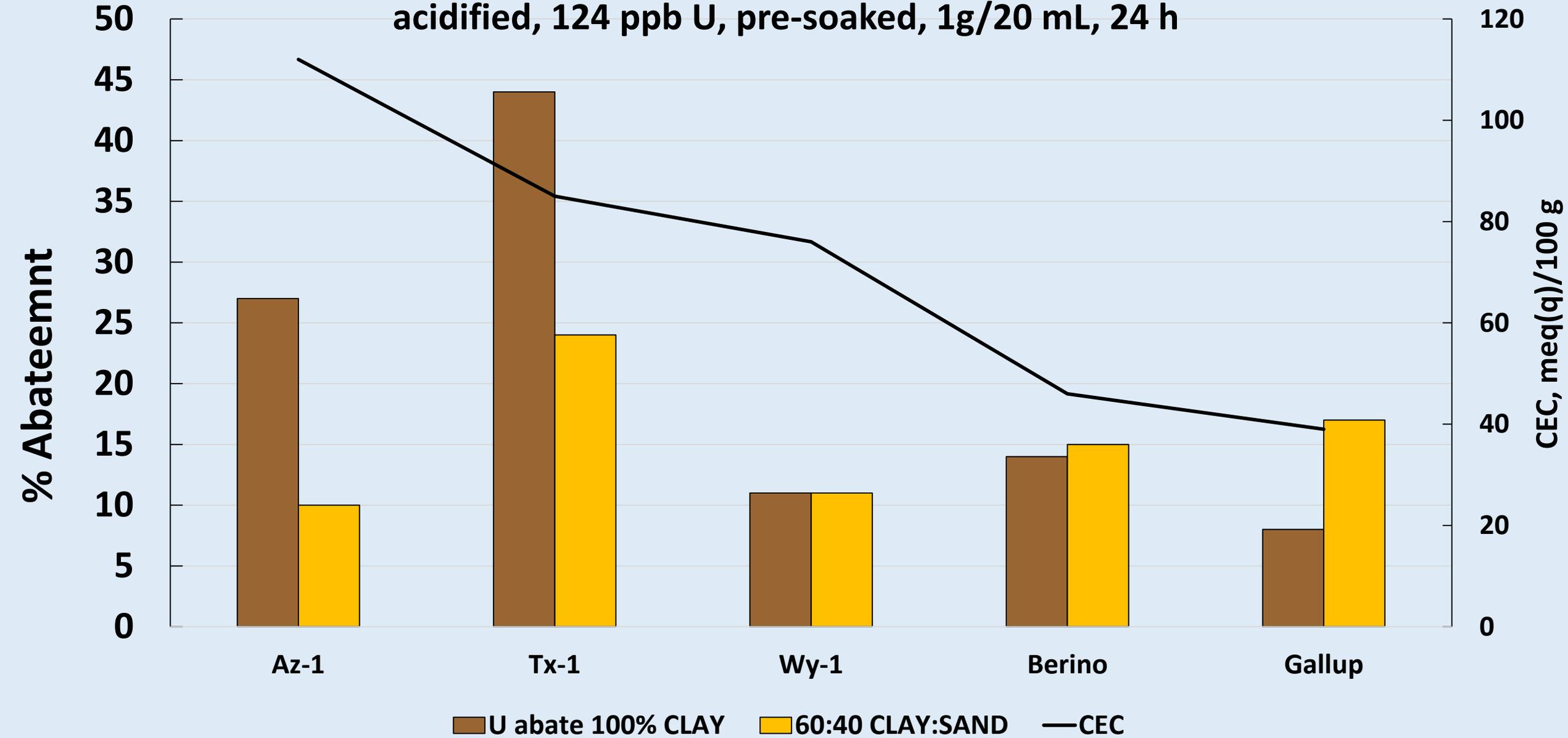
## % Uranium Abatement % - CEC (charge capacity)

### just soil, no acid, Rocked



# PELLETS

**% Uranium Abatement - CEC (charge capacity)  
acidified, 124 ppb U, pre-soaked, 1g/20 mL, 24 h**



## Characterization - Clay, Pellets, Sand

Clay (standard and "cleaned")

Formula - based on	Az-1	Tx-1	Wy-1	Berino	Gallup	SiO <sub>2</sub>
<b>Al</b> (moles) *2	<b>1.37</b>	<b>1.09</b>	<b>1.46</b>	<b>1.38</b>	<b>1.57</b>	<b>x</b>
<b>Ti</b> (moles)	<b>0.01</b>	<b>0.01</b>	<b>0.01</b>	<b>0.04</b>	<b>0.04</b>	<b>x</b>
<b>Fe</b> (III)	<b>0.07</b>	<b>0.04</b>	<b>0.17</b>	<b>0.33</b>	<b>0.33</b>	<b>x</b>
<b>Fe</b> (II)	<b>0.00</b>	<b>0.00</b>	<b>0.01</b>	<b>Need</b>	<b>Need</b>	<b>x</b>
<b>Mg</b> (moles)	<b>0.64</b>	<b>0.31</b>	<b>0.28</b>	<b>0.35</b>	<b>0.33</b>	<b>x</b>
<b>K</b> (moles)	<b>0.02</b>	<b>0.01</b>	<b>0.04</b>	<b>0.33</b>	<b>0.25</b>	<b>x</b>
<b>Ca</b> (moles)	<b>0.20</b>	<b>0.10</b>	<b>0.12</b>	<b>0.72</b>	<b>0.32</b>	<b>x</b>
<b>Na</b> (moles)	<b>0.01</b>	<b>0.03</b>	<b>0.19</b>	<b>0.10</b>	<b>0.04</b>	<b>x</b>
NEED XRF						
<b>CEC</b>	<b>112</b>	<b>85</b>	<b>76</b>	<b>46</b>	<b>39</b>	<b>0</b>

Technology Appropriate at Specific Site

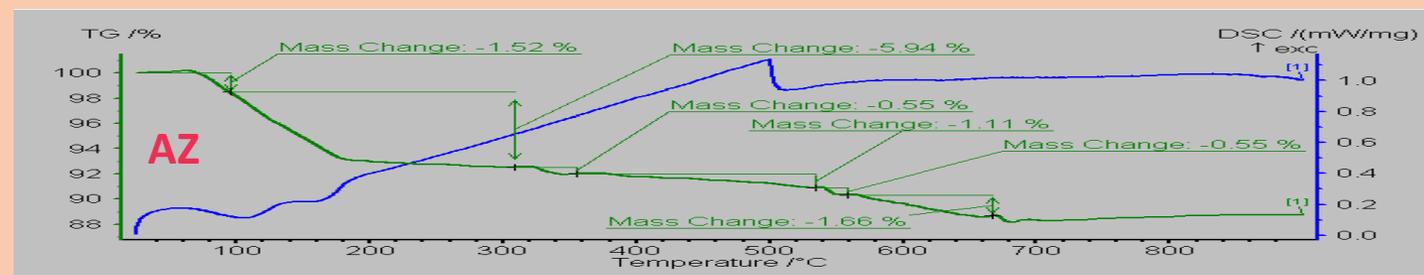
Navajo take Ownership

Entrepreneur Potential

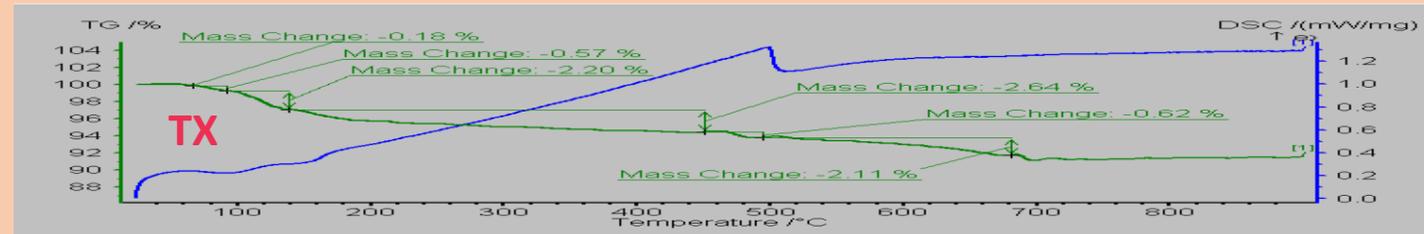
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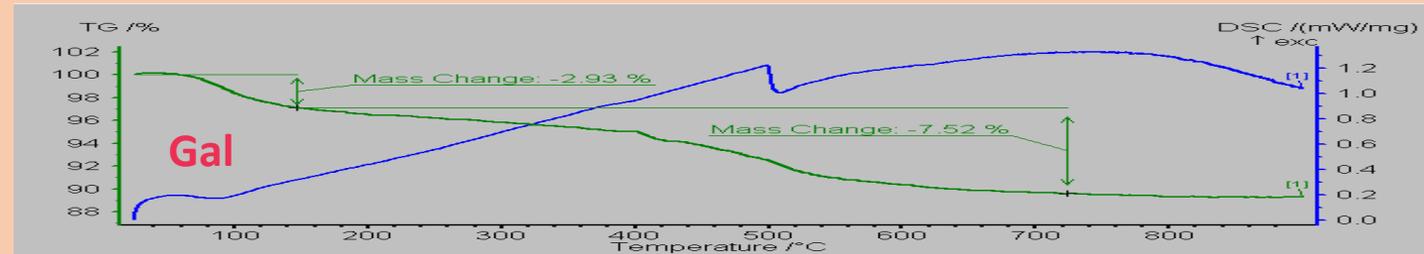
Entrepreneur  
Potential



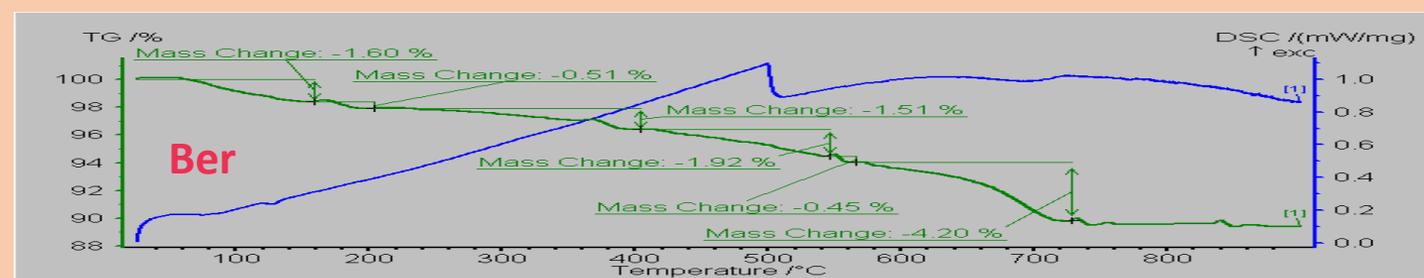
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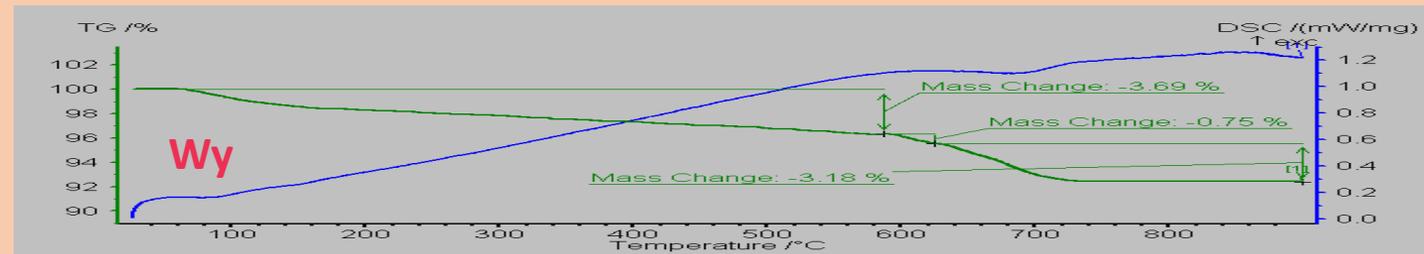
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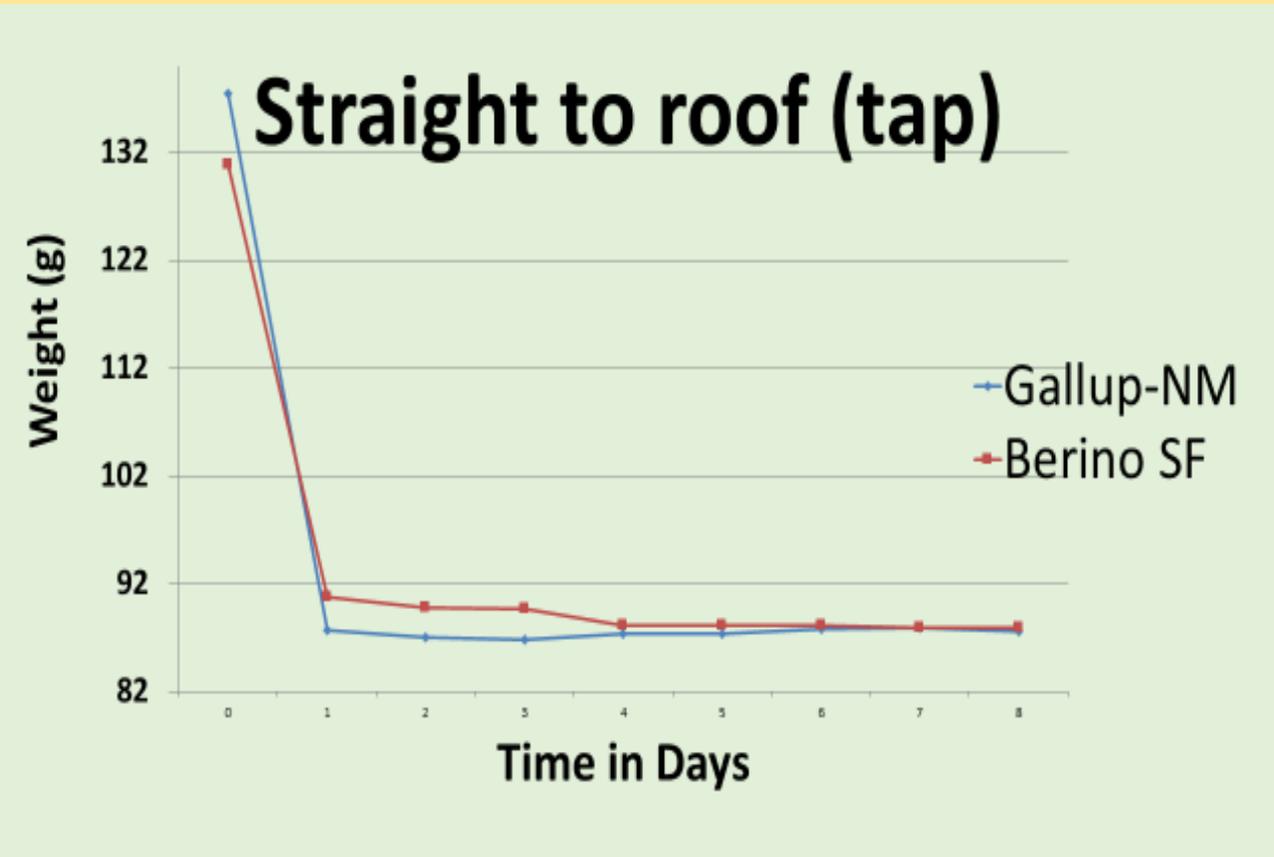
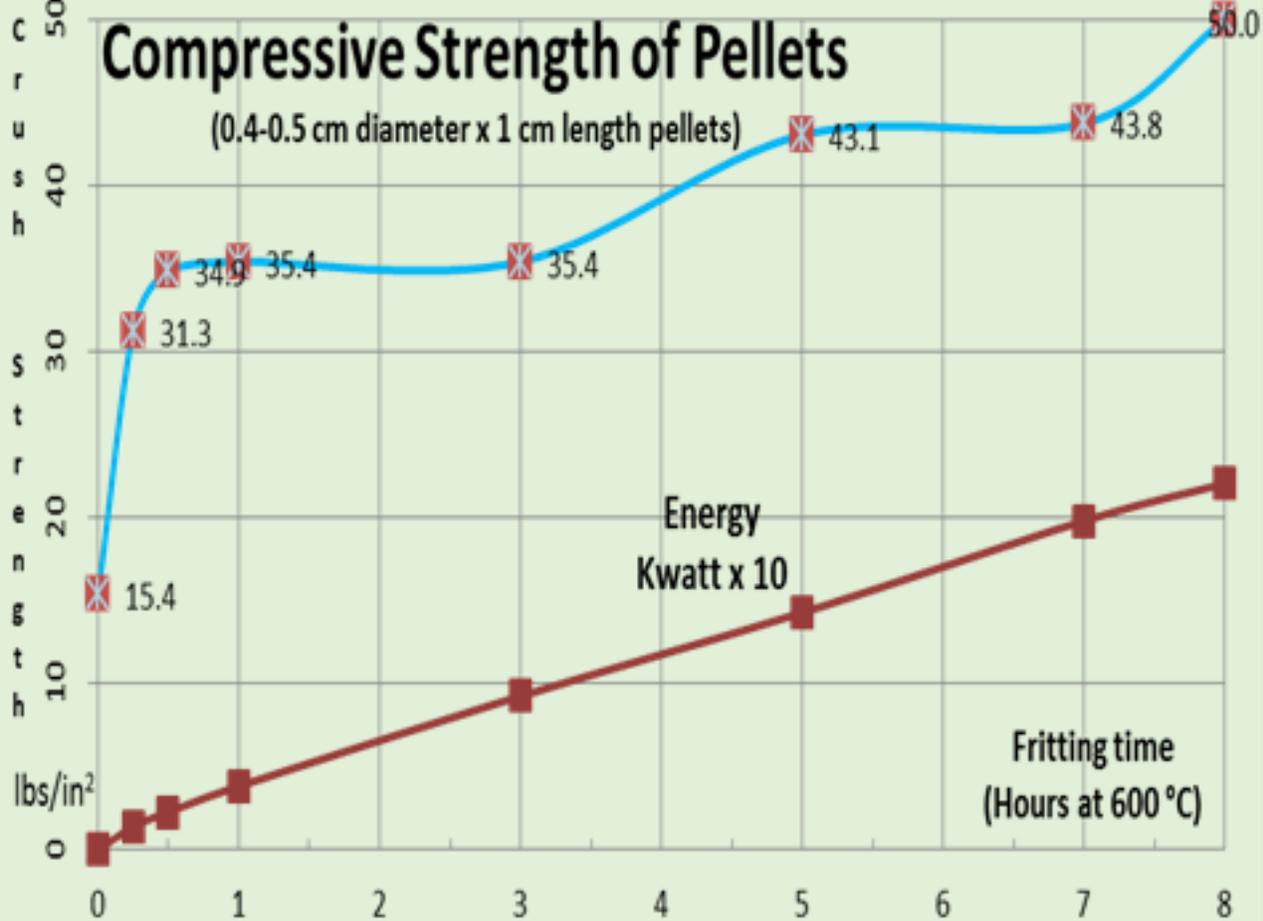
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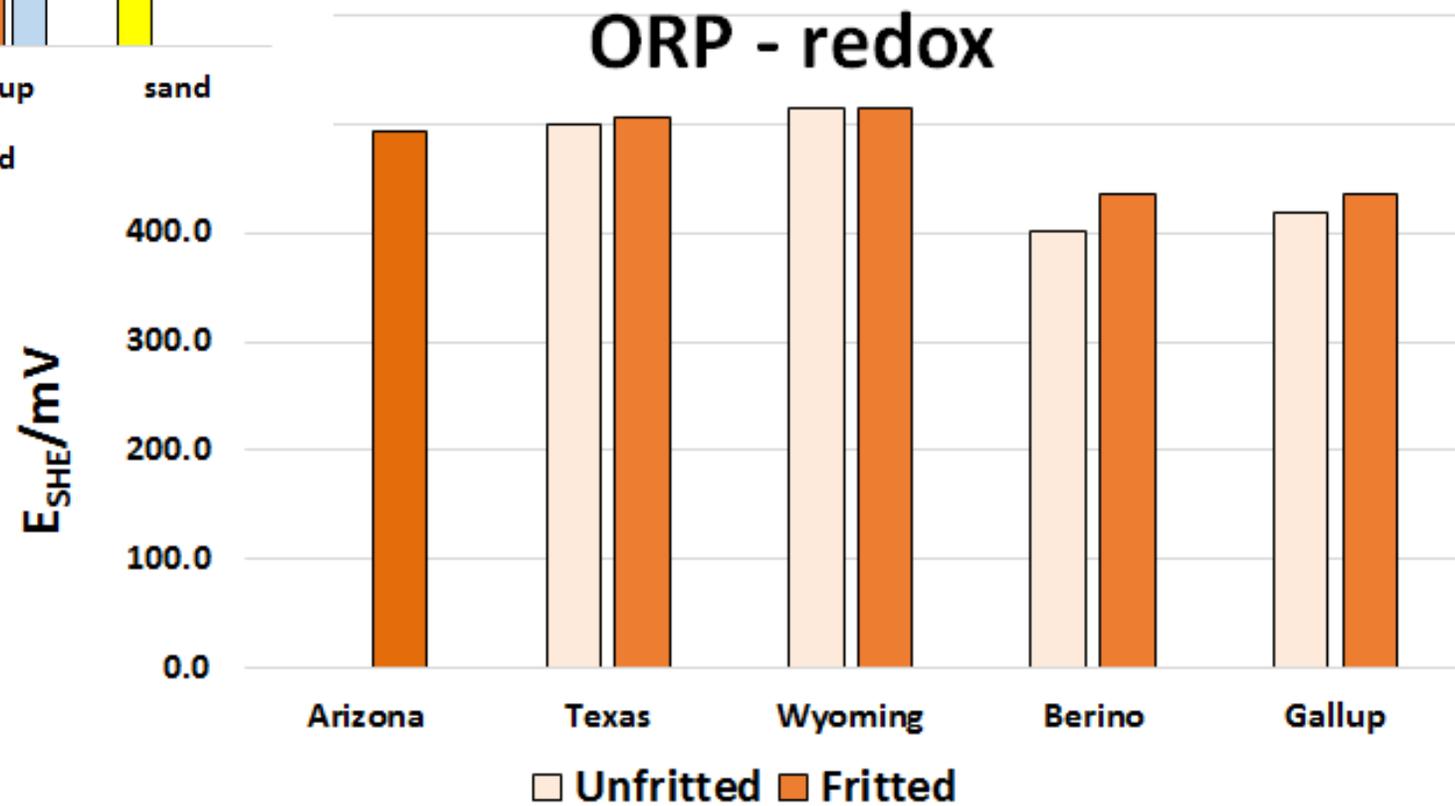
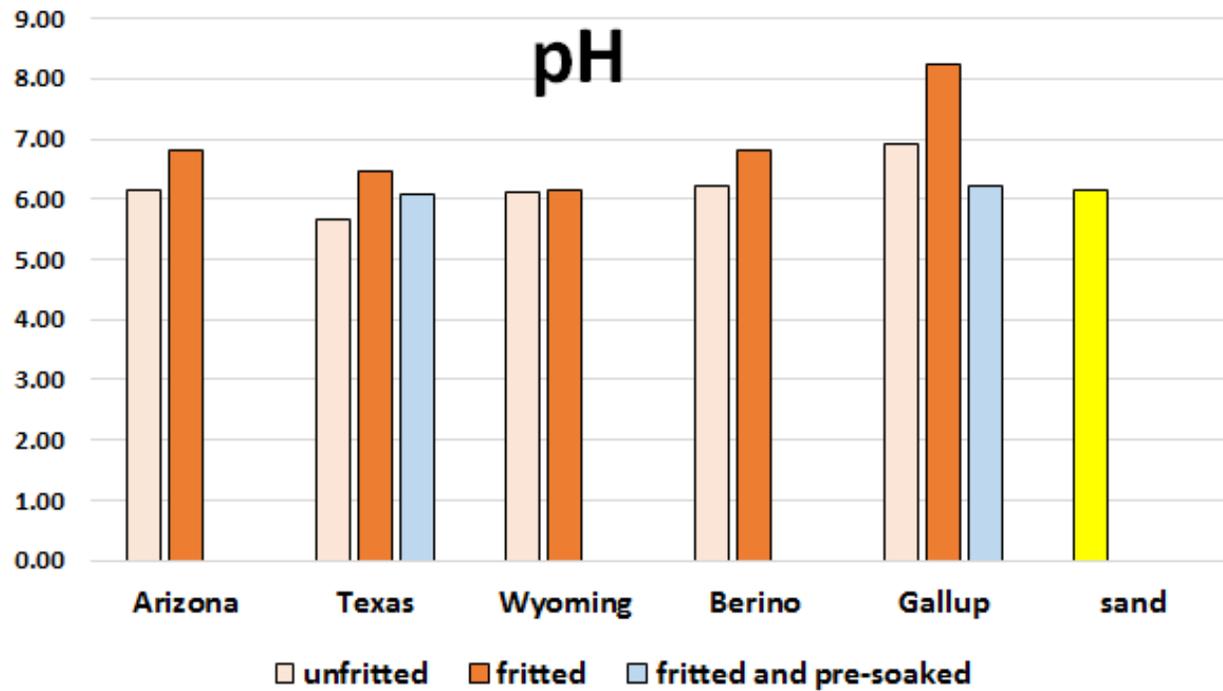
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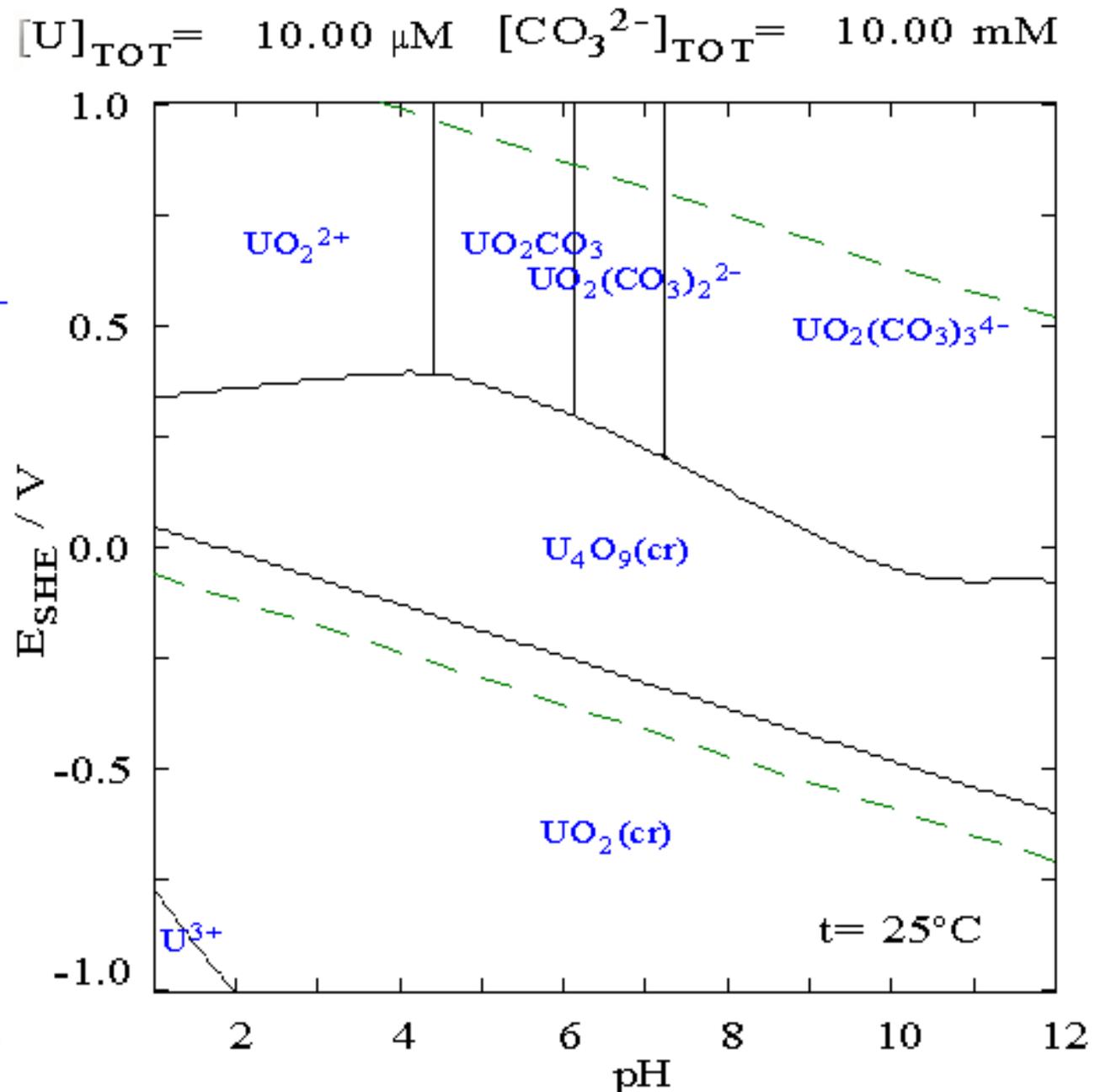
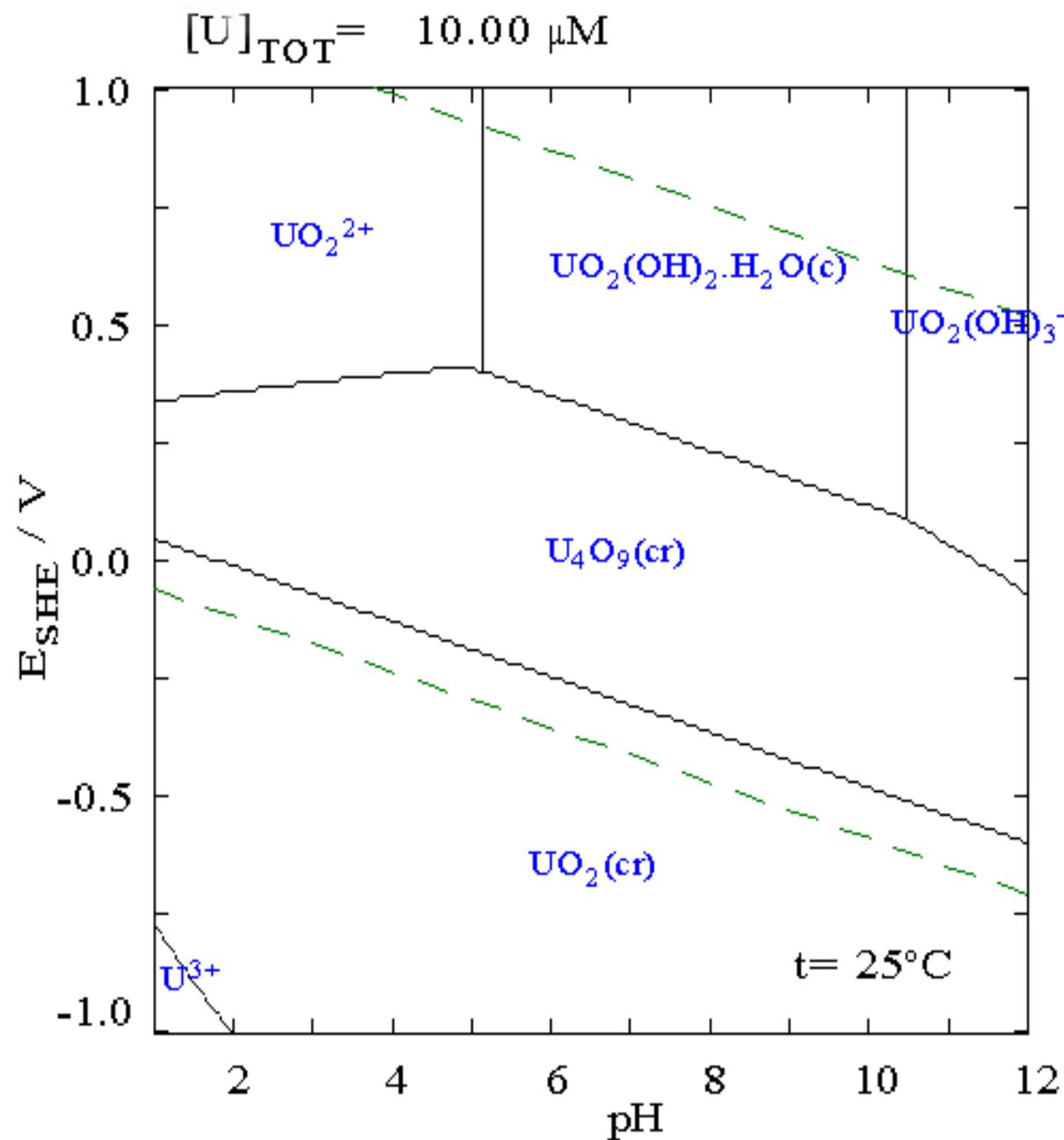


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What about the Water Itself?





Pourbaix diagrams for uranium in a non-complexing aqueous medium (left) and in carbonate solution (right).



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# Marquez Candle Filters

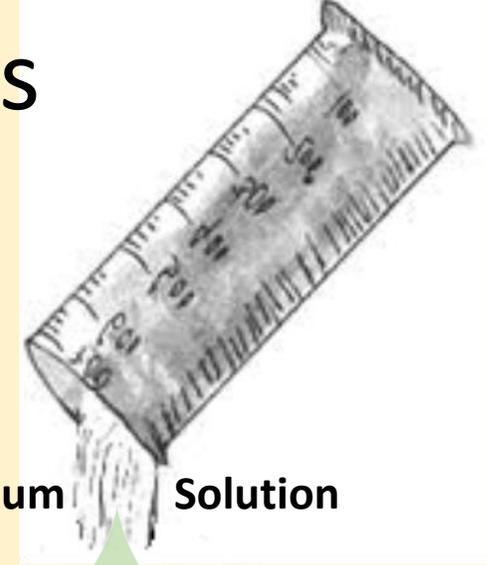
*Candle Filter*

*Versus*

*Candle Filter Packed with Berino Clay Pellets*



Uranium Solution



Uranium Solution

**Kinetics**

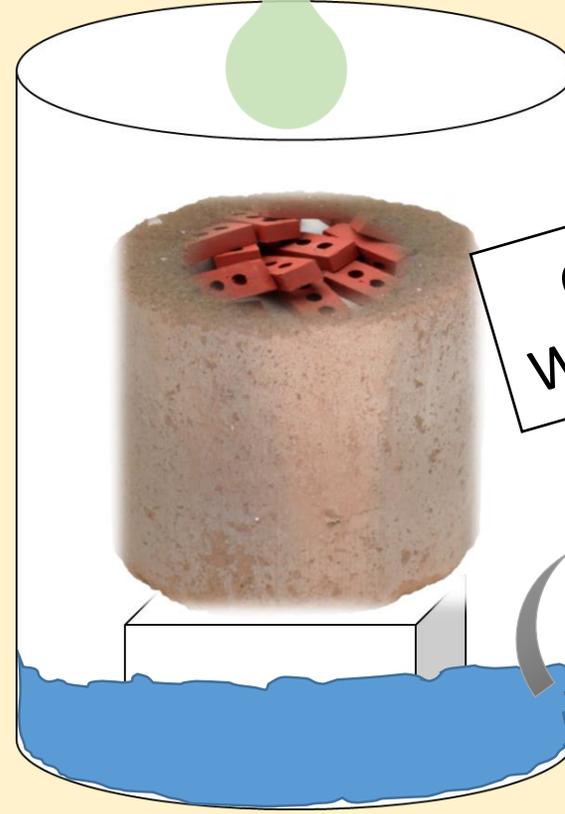
*Each filtration takes approximately 20 minutes*

**Candle Filter**



10 mL  
Filtered  
Samples  
For  
ICP-MS

**Candle Filter  
With Clay Pellets**



10 mL  
Filtered  
Samples  
For  
ICP-MS

# Any Pollutant



Pathogens

Particulates

# Thank You

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