



Arsenic Removal from Groundwater Wells by Means of Nanoparticles

US Patented NO: 7235179
(KJ Reddy, University of Wyoming)

HANNAH KING
APRIL 21, 2012
EPSCOR
DEPARTMENT OF RENEWABLE RESOURCES
UNIVERSITY OF WYOMING
LARAMIE, WY

Background of Arsenic



- Trace element that is odorless, tasteless, naturally occurring
- Low abundance in the Earth's crust
- Enters groundwater through geologic deposits (volcanic eruptions, erosion)
- Also through energy activities (burning of fossil fuels)
- Found as As(III) and As(V), As(III) more toxic to humans than As (V)

Effects of Arsenic



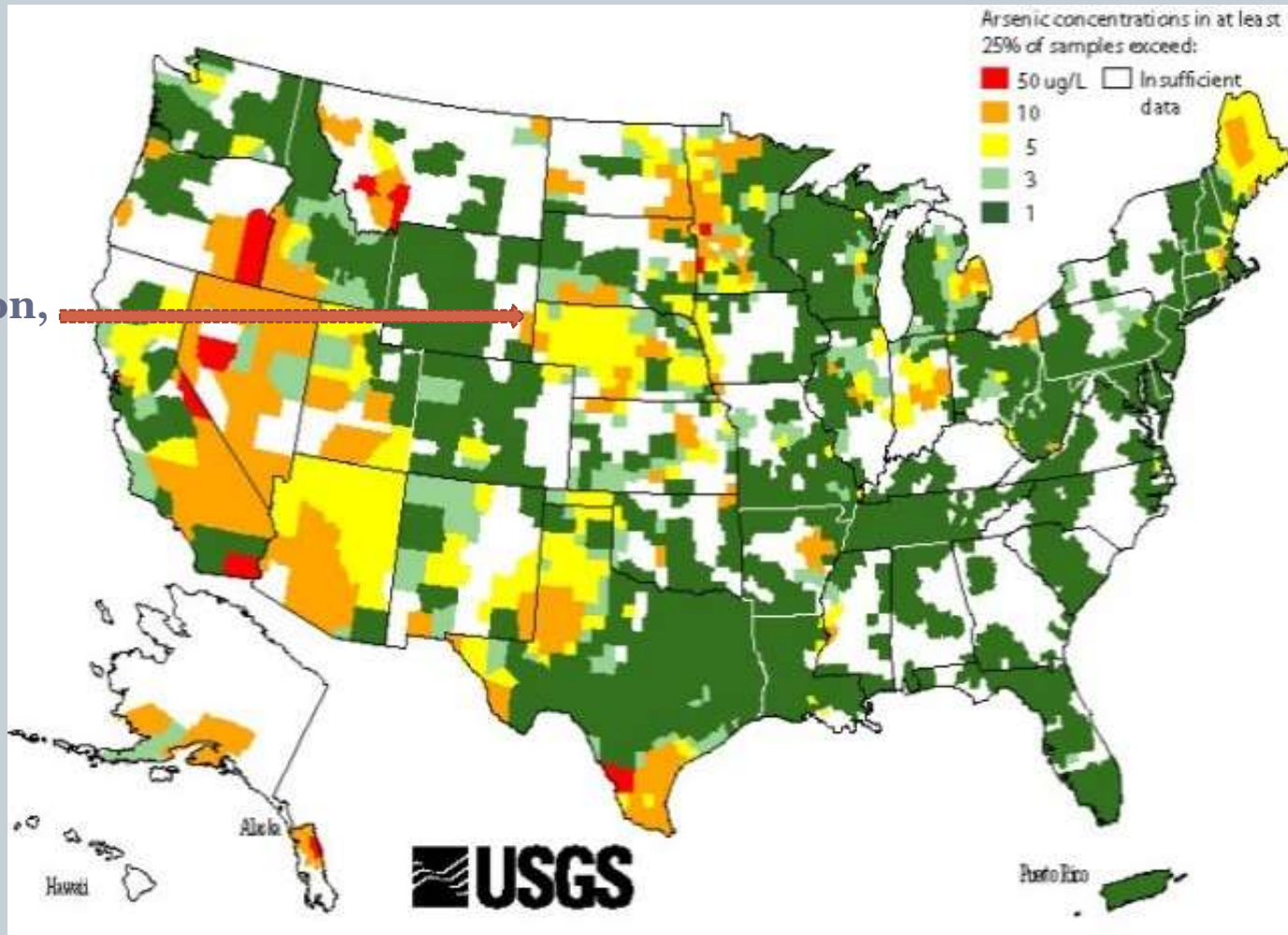
- Long terms risks if exposed including skin, lung, bladder and kidney cancer, even death
- Bangladesh and India
- EPA human drinking water limit 10 ppb



Levels throughout U.S.



Torrington,
WY



Wyoming



Duties of internship



- Correctly take water samples from 21 groundwater wells throughout Goshen County
- Analyze ground water samples and send to state lab to identify arsenic levels
- Create Cupric Oxide nanoparticles using detailed instructions (Martison&Reddy,2009)
- CuO Nanoparticles used to absorb/remove arsenic using flow-through system
- Report back to landowners results of wells

Field Work



- Two trips to Torrington (May 24-25, July 25-26 2011)
- Groundwater wells owned by city of Torrington, landowners and UW
- Collect samples using WDEQ sample collection protocol:
 - perge well
 - measure pH until stable
 - collect samples once stable
 - retrieved 5 liters of water
 - placed in cooler until lab



May Sampling



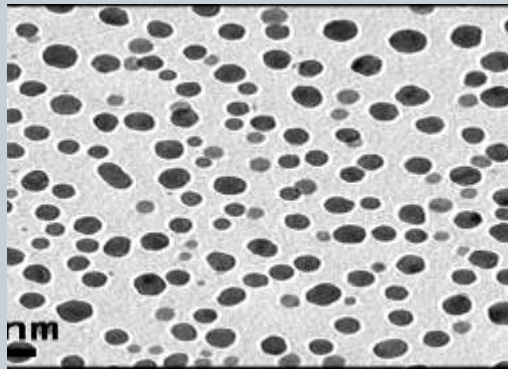
May 2011 Goshen County, WY Groundwater Arsenic Data

Well ID	Sample date	Arsenic conc. (ppb)
FG 71	24-May-11	3
TM 1	25-May-11	4
RR 69	25-May-11	7
WSH 20	25-May-11	15
DBH 1	25-May-11	4
CJ 66	25-May-11	6
DVWR 1	25-May-11	9
TSF 27	25-May-11	6
DV 20A	25-May-11	2
DBW 19	25-May-11	2
FG 72	24-May-11	10
LM 42	24-May-11	4
GCE 62	24-May-11	<1
NR 49	24-May-11	5
HAR 27	24-May-11	9
SP 39	24-May-11	3
PP 61	24-May-11	<1
LE 43	24-May-11	7
GC 64	24-May-11	<1
UW 70	24-May-11	12
BM 1	25-May-11	3

Lab Work



- Auto Titrator- Measure alkalinity as soon as possible (how basic water is)
- Create CuO Nanoparticles
 - Made 4 grams
 - Filtered, collected, dried in oven
- Used dry nanoparticles for flow-through system >10 ppb arsenic



Surface area = 85 m²/g ; Size = 12-18 nm



Advantages of CuO Nanoparticles

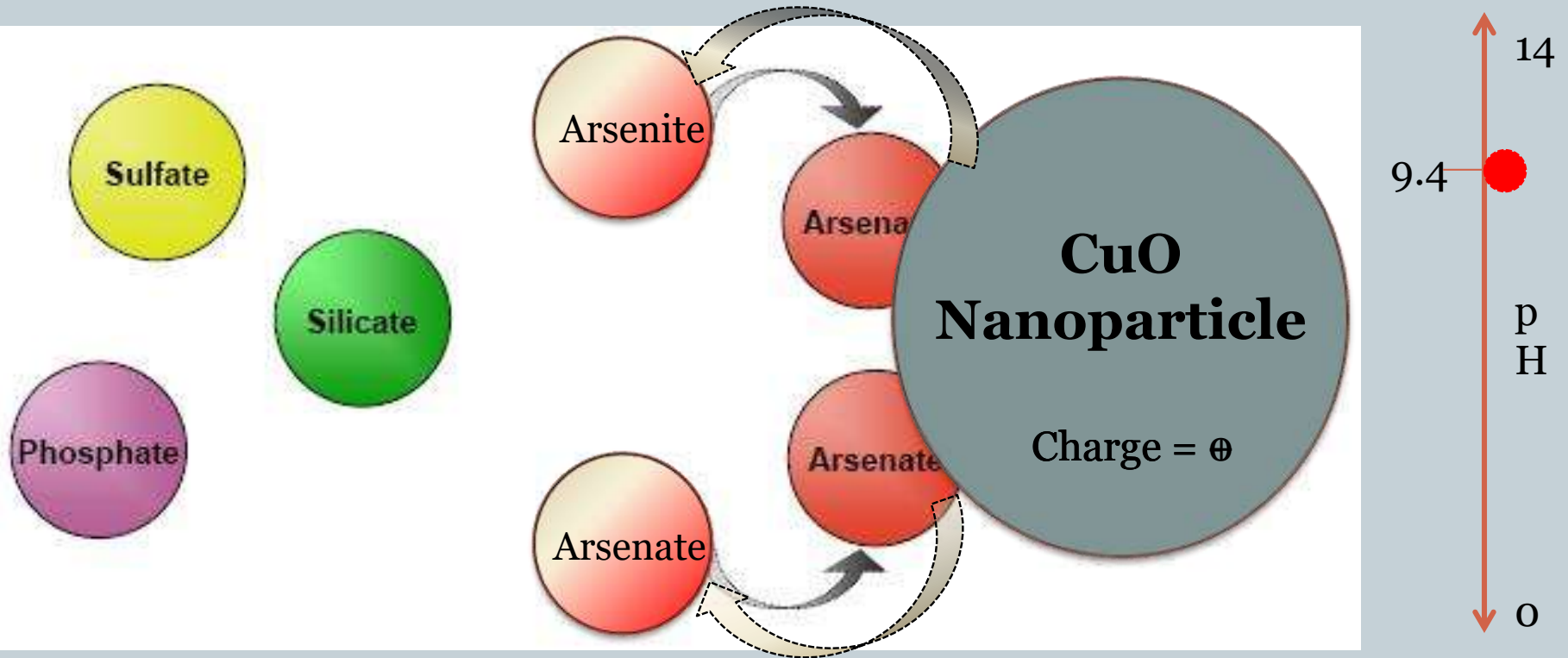


- One step removal- No pre or post treatment
- No pH adjustments
- Not effected by competing ions (sulfate, phosphate, silica)
- Can regenerate and re-use
- Nano have higher surface area/higher absorption capacity

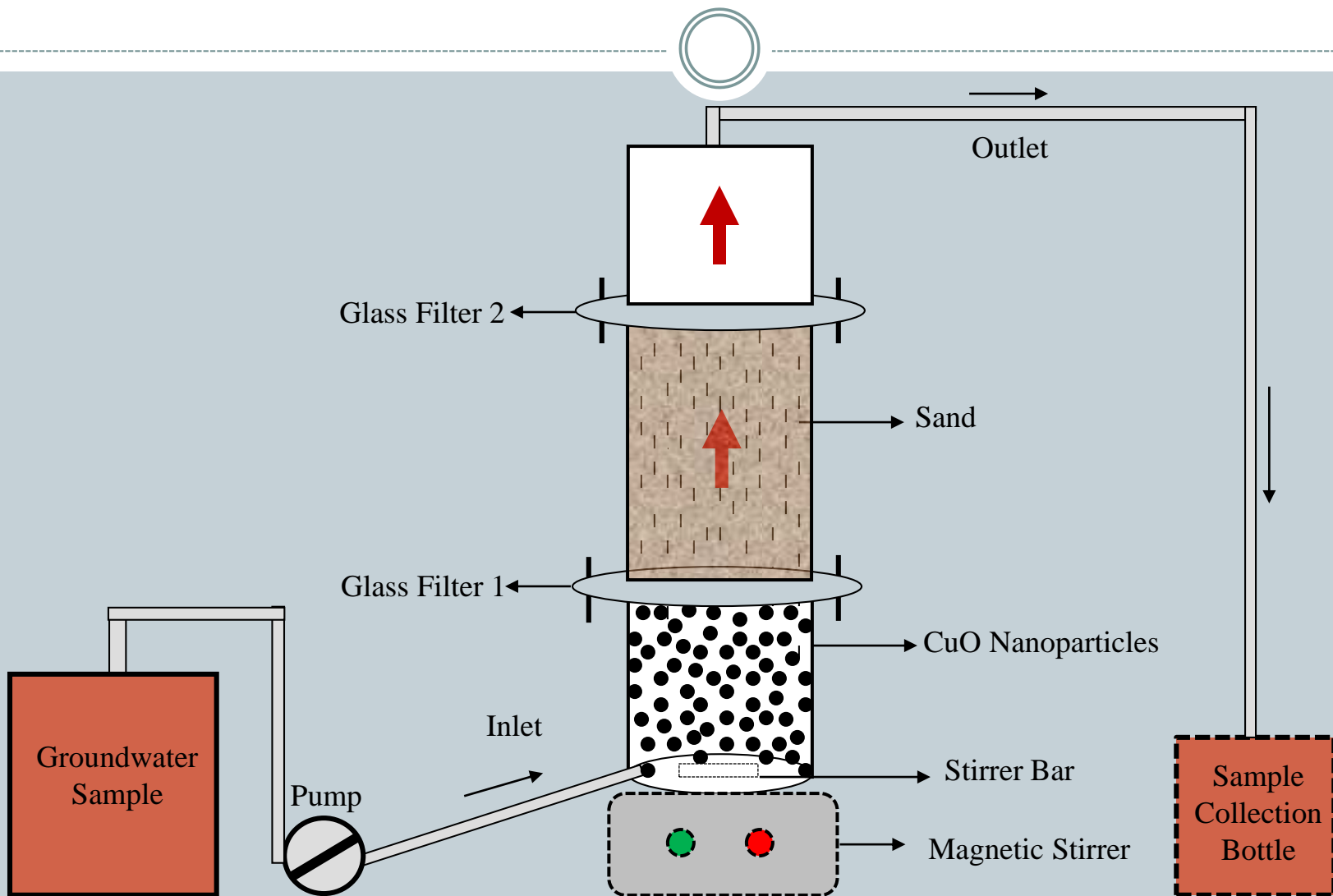
CuO Regeneration

Zero Point of Charge (ZPC)

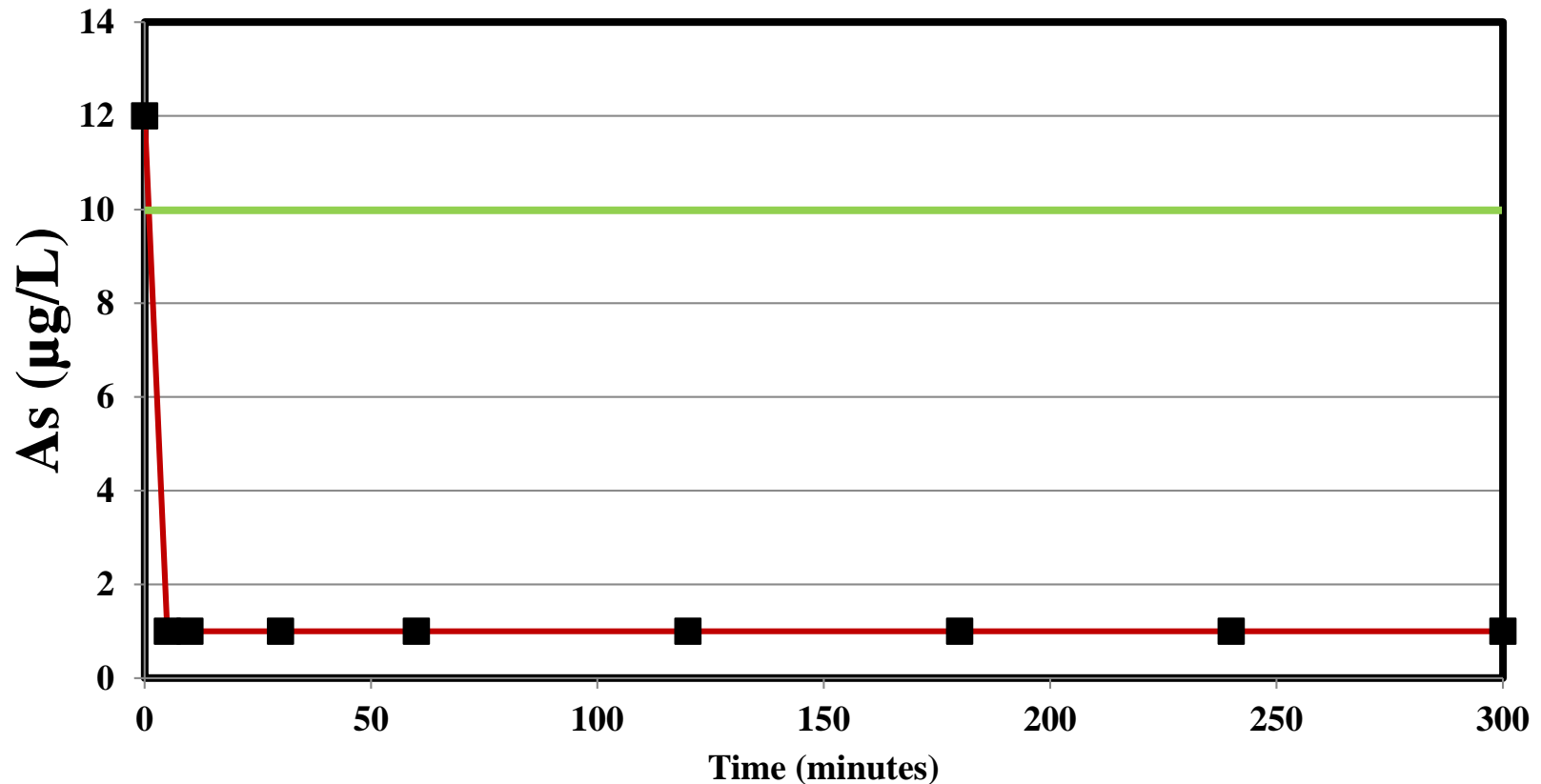
- pH of a solution at which the surface charge of a solid is zero
 - ZPC for CuO $\sim 9.4 \pm 0.4$



CuO Flow Through System

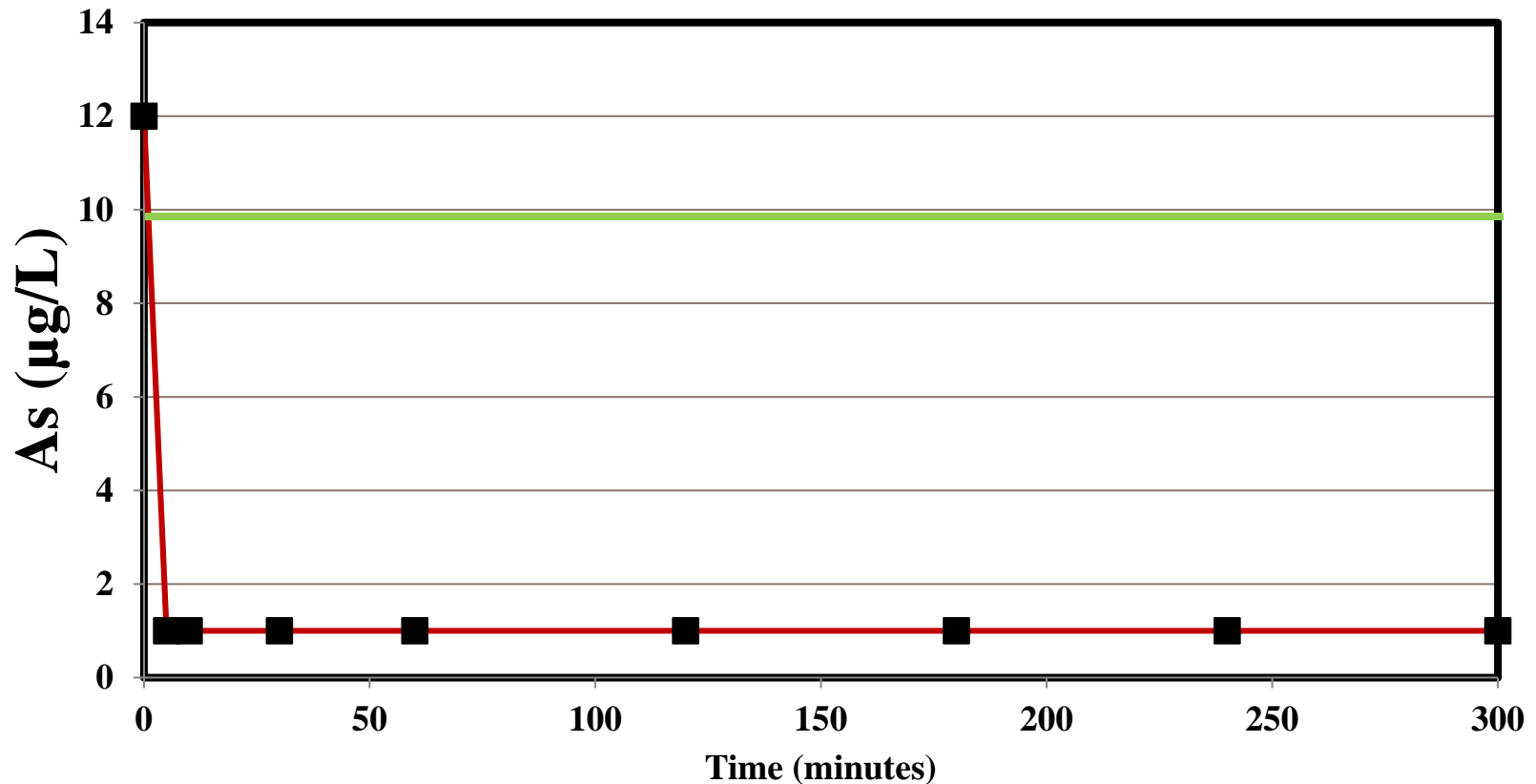


CuO Flow Through Reactor – Goshen County



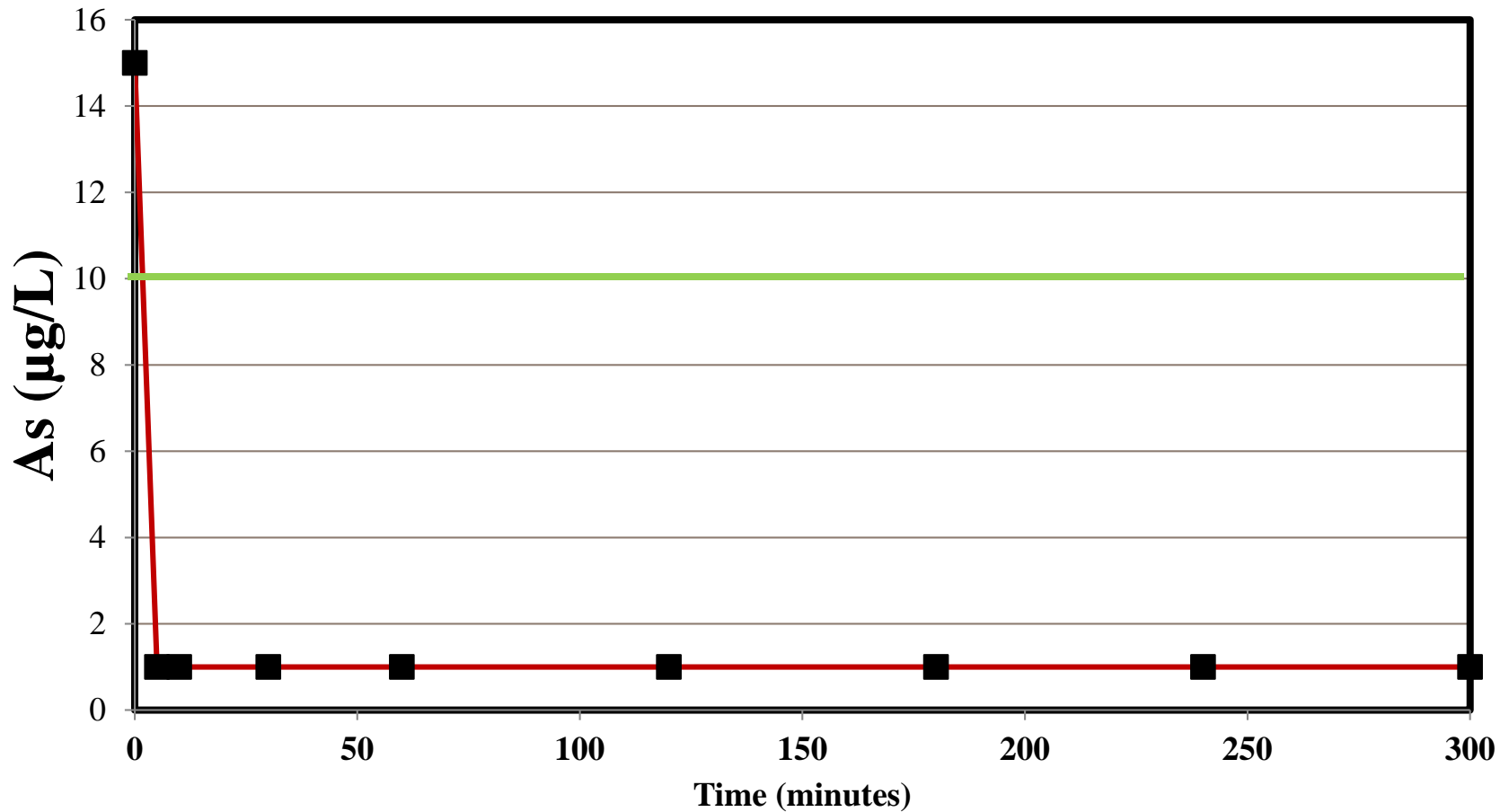
Arsenic content as a function of time in a 5 L flow-through experiment with CuO (1.2 grams) nanoparticles – Well #1 (Torrington, WY) July, 2011

CuO Flow Through Reactor – Goshen County



Arsenic content as a function of time in a 5 L flow-through experiment with CuO (1.2 grams) nanoparticles – Well #2 (Torrington, WY) July, 2011

CuO Flow Through Reactor – Goshen County



Arsenic content as a function of time in a 5 L flow-through experiment with CuO (1.2 grams) nanoparticles – Well #3 (Torrington, WY) July, 2011 WSH 20

Results



- 3 groundwater samples from Goshen County were above EPA human limit
 - Fairgrounds (FG 72)
 - Private landowner's home (WSH 20)
 - University of Wyoming Property (UW 70)
- After 5 hours flow-through system (1 liter per hour), samples had undetectable amounts of arsenic (<1 ppb)
- Discussed further plans with private landowner

Summary



- 3 wells above EPA human limit >10 ppb
- Prepare CuO nanoparticles and test in flow-through system to remove arsenic
- Very effective, non detectable levels of arsenic
- Other water quality components remained the same
- Communication between landowners and researchers
- Future studies to create field filtering system

Acknowledgements



- Dr. KJ Reddy
- Dr. Ajay
- Kyle McDonald
- Brandon Reynolds
- Alex Wann
- Wyoming EPSCoR