NJGSS 2003

Team 6 – Project in Chemistry

Water Analysis

Dr. James Y. Fukunaga, advisor
Matthew Singer, teaching assistant

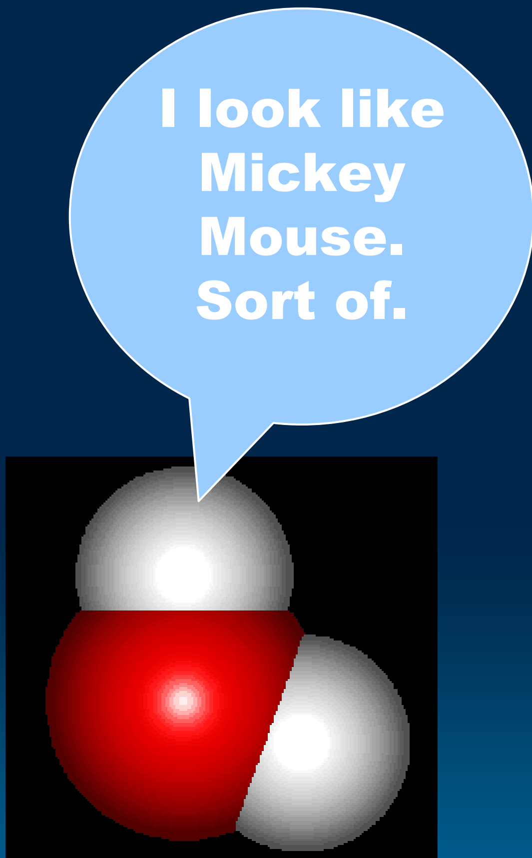
Harry An
Sara Delhauer
Stanislaw Gabryszewski
Zain Husain
Hannah Kim
Julia Pustizzi
Stuart Schussel
Vivien Sun
Mazell Tetruashvily
Monica Yu

WATER

TASTE

CHALLENGE

The Basics



- Simple structure (H_2O)
- Polar molecule, universal solvent
- Essential to life
- Comprises about 70% of body
- Regulates body temperature, transports nutrients and wastes, maintains homeostasis

Drink it up.

- The Earth's surface is about 70% water, but only about 1% is drinkable.
- Water must be treated before consumption to remove impurities.
- Purification methods include screening, sedimentation, filtration, chlorination, and irradiation.

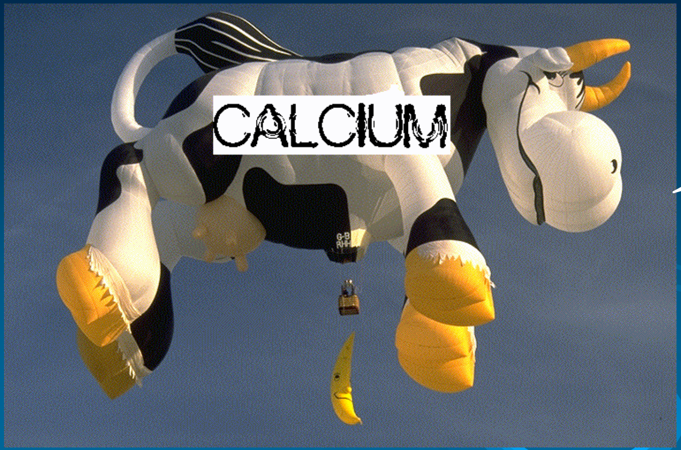
Chloride Ions

- Often come from NaCl (salt) and some $CaCl_2$.
- NaCl is spread on roads to melt ice; this washes away and ends up in reservoirs—contributes to Cl- in water.
- Chlorine is often used to treat and disinfect water (greatest contributor to high Cl^- content in water).
- Key component of bile and necessary in forming HCl (used in the digestive system)

I live in salty water.

Calcium Ions

- **Primary cause of water hardness**
- **Found in the soil in the form of $CaCO_3$ (limestone)**
- **Rainwater can dissolve and carry calcium into bodies of water and increase Ca^{++} concentration in drinking water.**
- **The heart, nerves, bones, and muscles all require calcium to function properly.**
- **Important in blood coagulation and maintaining bone density (deficiency can lead to Osteoporosis)**



Got water?

“Hard” Water

- refers to high concentrations of Ca^{2+} and Mg^{2+} (predominant components)
- not necessarily toxic
- difficult to make lather in soap
- contributes to buildup of minerals (i.e. soap scum)
- many techniques to soften water: boiling, treating with sodium carbonate and lime, filtration…

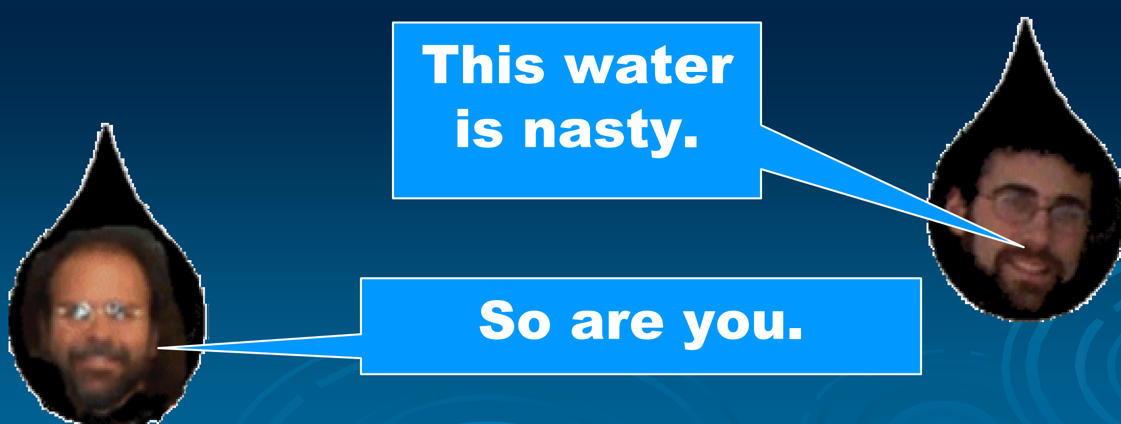
Scrub harder.

Too much calcium…

Madison's Water

- Madison's tap water comes from Buried Valley Aquifer, located beneath the Great Swamp

- Loantaka Brook and Black Brook both flow into the Great Swamp



Loantaka 2
Loantaka 1
Black Brook
MADISON
CHATHAM
HARDING
GREAT SWAMP
NATIONAL WILDLIFE REFUGE
meters 0 500 1000 1500 2000
miles 0 0.5 1.0

The Map…

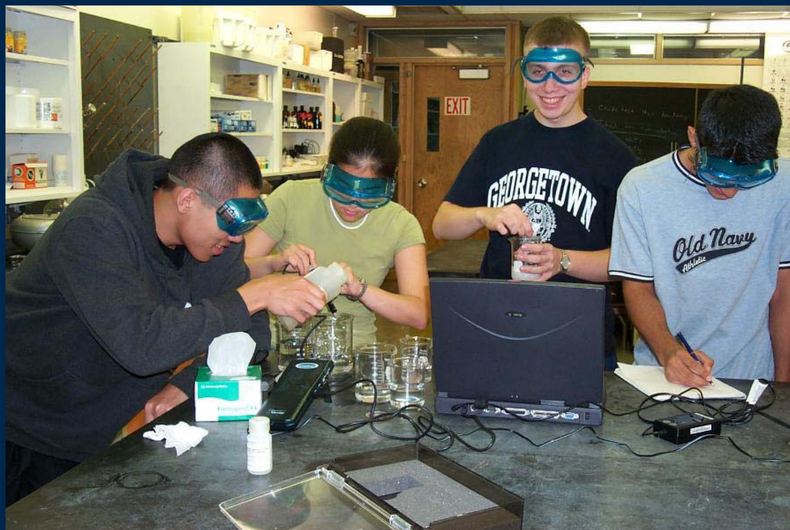
Madison's Water

Loantaka Brook

Madison's Water

Black Brook

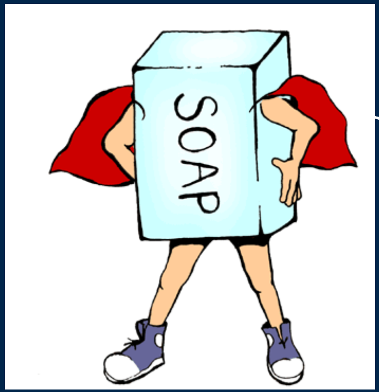
Our findings…



Water Hardness Revisited

$2CH_3(CH_2)16COO^{-}Na^{+} + Ca^{2+} \rightarrow [CH_3(CH_2)16COO^{-}]2Ca^{2+} + 2\ Na^{+}$

Water-soluble soap **Water-insoluble curd**



You're dirty.

- **In the presence of hard water, soaps and detergents replace ions at the head of the soap molecule and form insoluble carboxylate salts.**
- **We titrated different 50 mL water samples with 1 mL increments of soap solution**
- **Madison water – 27.00 mL titration**
  Spring water – 49.33 mL titration
- **Other ions (such as Mg^{++}) contribute to hardness as well**

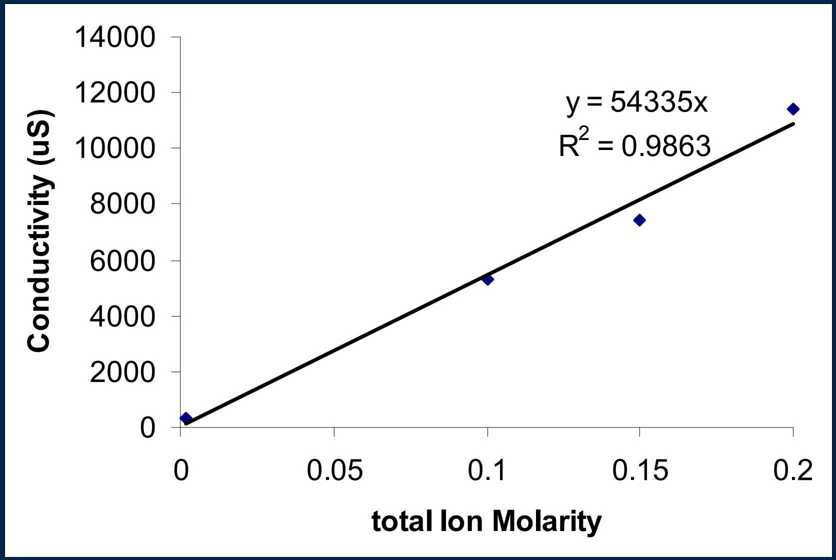
pH

Water Type	Mean	Stdev
De-ionized	7.68	0.71
Spring	6.22	0.13
Madison	6.11	0.08
Pond 1	6.08	0.09
Pond 2	5.94	0.11
Rain	7.03	0.88
Black Brook	6.19	0.04
Round Pond	6.40	0.16

- **We used Logger Pro to gather raw data.**
- **The pH of the water samples gives an indication of how readily $CaCO_3$ dissociates in water.**
- **The more acidic the solution, the more readily the $CaCO_3$ will dissociate into Ca^{++}.**

H_2O (l) + CO_2 (aq) $\leftarrow\rightarrow$ H_2CO_3 (aq)
H_2CO_3 (aq) $\leftarrow\rightarrow$ H+ (aq) $^+$ HCO_3^- (aq)
$HCO3^-$ (aq) $\leftarrow \rightarrow$ H^+ (aq) + CO_3^{-2} (aq)
$CaCO_3$ (s) + H_2O (l) + CO_2 (aq) $\leftarrow \rightarrow$ Ca^{2+} (aq) + 2 HCO_3^- (aq) Kc= 4.24×10^{-5}
$CaCO_3$ (s) + H^+ (aq) $\leftarrow\rightarrow$ Ca^{2+} (aq) + HCO_3^- (aq) Kc= 2.08×10^{10}

Total Ion Concentration



	Conductivity (µS)	*Molarity*
.05M NaCl	5337.5	0.098233
.05M $CaCl_2$	7457.5	0.13725
.05M CH_3COOH	357.5	0.00658
.05M $Al(NO_3)_3$	11432	0.210398
Madison	603.5	0.011107
Spring	655.5	0.012064
Heated Madison	630	0.011595
Heated Spring	426	0.00784
Pond 1 (7/18)	874	0.016085
Pond 2 (7/18)	2185.5	0.040223
Pond 1 (8/5)	666.5	0.012266
Pond 2 (8/5)	1529	0.02814
Black Brook	458.5	0.008438
Rain	0	0
Round Pond	138	0.00254

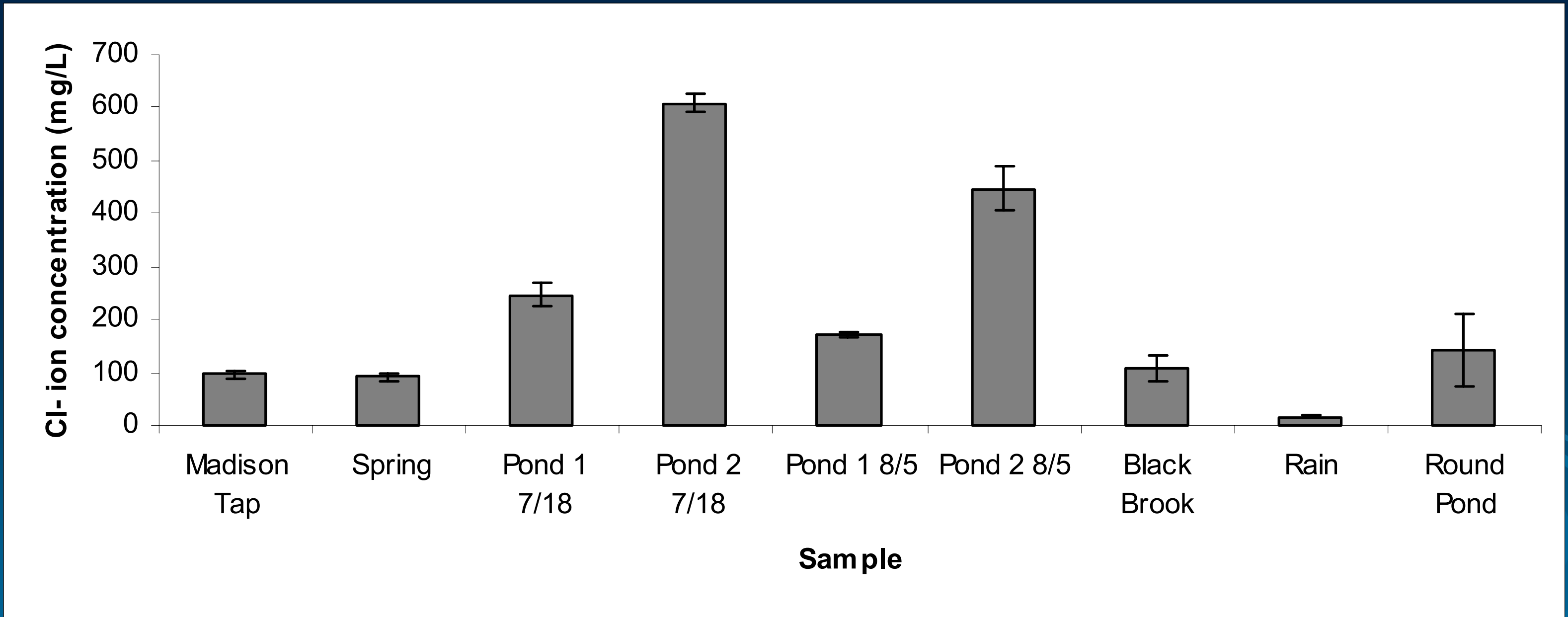
- **Conductivity = total ion concentration**
- **The higher the conductivity of ions in the water samples, the higher the concentration of Ca^{++} and Cl^-.**

Chloride Ion Concentration

$$Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$$

$$Ag^+_{(aq)} + CrO_4^-{}_{(aq)} \rightarrow Ag_2CrO_{4\,(aq)}$$

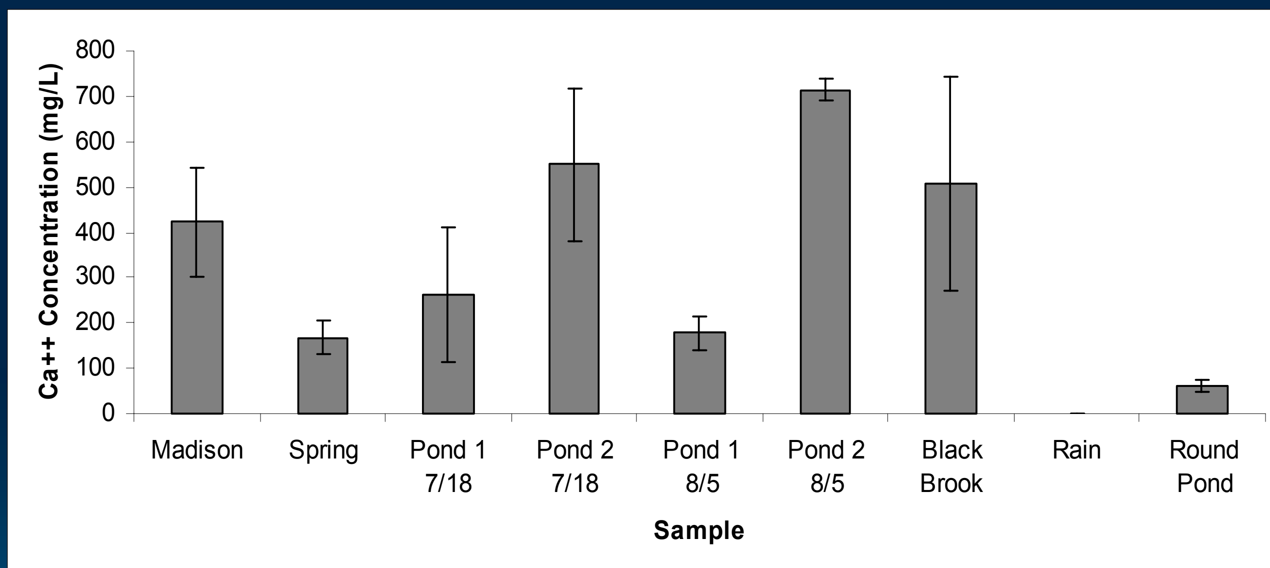
- **We titrated $AgNO_3$ solution to determine the concentration of Cl^- ions in different water samples.**



Calcium Ion Concentration

$EDTA^{2-} + Ca^{2+} \rightarrow Ca(EDTA)$

- **We titrated EDTA to test the abundance of the Ca^{++} ion in the water samples.**



Titrate this.

Putting it all together

- A probable source of Ca^{2+} is $CaCO_3$ (limestone).
- Probable sources of Cl^- are NaCl (road salt) and $CaCl_2$.
- The lower the pH of the water sample, the higher the Ca^{2+} concentration because $CaCO_3$ is more soluble in the presence H^+ ions.
- Spring water is found to be harder than Madison tap water, which was unusual, but can be associated with high concentrations of various ions including Mg^{2+} and Fe^{2+}.

WATER TASTE CHALLENGE

So…
what are you drinking in your water ?

NJGSS 2003

Team 6 – Project in Chemistry

Water Analysis