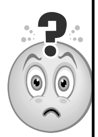
Dazed & Confused

Part I

Common Areas of Confusion from a Laboratory Perspective

Or

Stuff that confuses folks about sampling, testing, and reporting



Presented by
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TTL, Inc.

What's in a name?

- **Scientific names for chemicals/analytes can often be very confusing; even small variations in names can mean big differences (or not)**
  - The name flip-flop, TTHMs (Done just for fun?)
    - Dichlorobromomethane or Bromodichloromethane=$CHCl_2Br$
    - Dibromochloromethane or Chlorodibromomethane=$CHBr_2Cl$
  - Old school vs. new school
    - Carbon tetrachloride = tetrachloromethane
    - Ethyl Alcohol = Ethanol = drinking alcohol
    - Methylene chloride = dichloromethane
    - Lime = Calcium oxide

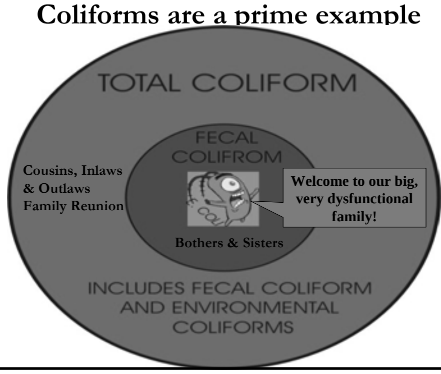
NAMES

What's in a name?

- Old school vs. new school
  - Caustic = Sodium hydroxide
  - Muriatic Acid = Hydrochloric Acid
  - Specific Conductance = Conductivity
- Close but no cigar (actually a different cigar)
  - Chromium vs. Hexavalent Chromium
  - Total vs. Free Chlorine
  - Nitrate vs. Nitrite
  - Dissolved vs. Recoverable Metals
- Just plain confused
  - Coliform (bacteria) vs. Chloroform (TTHM)
  - Total Coliform vs. Fecal Coliform vs. *E. Coli*

NAMES
NAMES

Confusion over names has often resulted in the wrong analysis; Coliforms are a prime example



What's in a unit?

- Most Common Units for Results
  - mg/L = milligrams per liter
  - µg/L = micrograms per liter

These two represent a weight to volume measurement; the weight of analyte in one liter of water. For example, if the total chlorine in your drinking water is 2.5 mg/L, then each liter (liter = ~1.06 quarts) of water contains 2.5 mgs of total chlorine.

*One penny weighs about 2.5 grams (g).

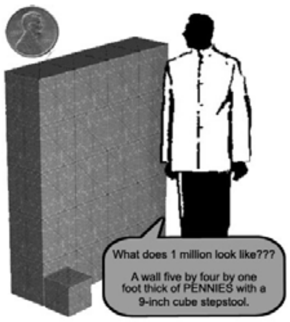
*One gram = 1,000 mg = 1,000,000 µg

*One liter of water weighs almost exactly 1,000 grams or 1,000,000 mg (which leads us to our next unit confusion)

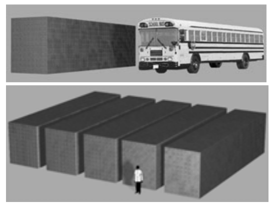
What's in a unit?

- If one liter of water weights 1,000,000 mg and we exchange 1 mg of the water for 1 mg of chlorine then we have 1 <u>part per million</u> (ppm) chlorine in one liter of water.
- In other words, if you were insane enough to divide your liter of water into one million equal parts, one part would be chlorine and the other 999,999 parts would be water.
- Therefore for measurements involving water:
  - ppm = parts per million = mg/L
  - ppb = parts per billion = µg/L

PPM and PPB



One million pennies



One billion pennies
Each of these blocks represents one 9x11x41 foot school bus.
It takes five to make 1 billion.

Source: www.kokogiak.com/megapenny/

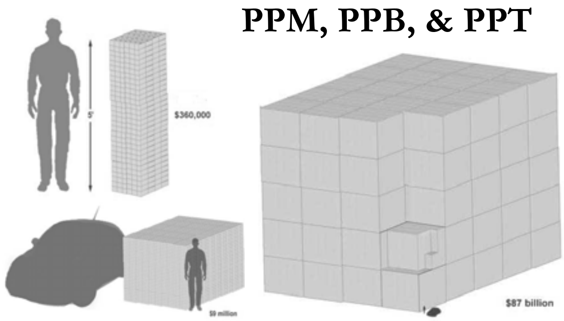
PPM, PPB, & PPT

One part per million (**ppm**): Denotes one part per 1,000,000 parts, This is equivalent to one drop of water diluted into 50 liters (13.2 gallons or roughly the fuel tank capacity of a compact car), or one second of time in approximately 11½ days.

One part per billion (**ppb**): Denotes one part per 1,000,000,000 parts, This is equivalent to 1 drop of water diluted into 250 chemical drums (50 m³), or one second of time in approximately 31.7 years.

One part per trillion (**ppt**): Denotes one part per 1,000,000,000,000 parts, This is equivalent to 1 drop of water diluted into 20, two-meter-deep Olympic-size swimming pools (50,000 m³), or one second of time in approximately 31,700 years.

PPM, PPB, & PPT



$87 Billion is a stack of $1 bills 100 feet tall, 250 feet long, and 125 feet wide. A stack of singles would be 28,998,000 feet, or over 5,492 miles, or a round-trip between Washington DC and Los Angeles, California. (2,650 miles, one-way).

What's in a unit?

- What about percent (%)? In our opinion, unless you talking about pay raises, percent should be banned from the lab.
- Percent is really only useful for talking about very high concentrations (like full strength acids).
- Percent is based on 100, in other words:
  1% = 1 part of 100 total parts and
  100% = 100 parts of 100 total parts
- Compare % to ppm where the base is one million, <u>1% is equal to 10,000 ppm</u> or <u>1% of one million (1%/100*1,000,000=10,000)</u>
- 1% = 10,000 PPM - Percent is much too cumbersome for small dilutions. Imagine reporting 1.5 ppm as 0.00015% or 1.5 ppb as 0.00000015%

%

What's in a unit?

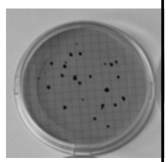
- **Units Dazed & Confused Hall of Fame**
  - **pH Units** – pH values are not actual amounts of anything. The pH scale is an inverse logarithmic representation of hydrogen proton concentration activity (yikes!) Each unit is a ten fold change in concentration of H^+ activity.
  - **μmhos/cm (specific conductance)** –
    A measure of how well water conducts an electrical current over a one centimeter gap. μmhos stands for micro-mhos. A mho is the inverse of ohm (resistance).
    Affected by salt concentration; pure water does not conduct electricity.

What's in a unit?

- Units Dazed & Confused Hall of Fame
  - **Units as equivalent** – For example, hardness and alkalinity are properties of water that result from a combination of analytes. Therefore, it is reported as an amount of a known chemical with the same properties. Hardness and alkalinity are reported as **mg/L as $CaCO_3$** or the equivalent amount of calcium carbonate that would produce the same results.

What's in a unit?

- Units Dazed & Confused Hall of Fame
  - **CFU/ml (fecal coliform)** – Colony Forming Units in each milliliter (not liter). A CFU can represent a single, strand or clump of bacteria that forms one colony on the membrane filter
  - MPN (raw drinking water coliform) Most Probable Number – Since colonies cannot be directly counted they must be estimated statistically



Calculated Confusion

- The terms mean and average are often used interchangeably for arithmetic mean (the most commonly used; the sum of all values divided by the number of values).
- Technically, average refers to a group of calculations that measure the central tendencies or middle of data
- Averages include arithmetic mean, geometric mean, median and mode

Calculated Confusion

- Weekly Mean – Arithmetic mean of all samples within one week from Sunday to Saturday.
- Monthly Average – Arithmetic Mean of all the results for samples within one month period.
- If a calendar week overlaps two months include the data with the month that contains the Saturday.
- Monthly average is not the mean of the weekly means (this would give the mean weekly mean).
- For monthly average loading, do not multiply the monthly mean concentration with the monthly average flow.

One Mean Calculation

- Not all “means” are created equal
  - Mean vs Geometric Mean – Some wastewater permits require that monthly fecal coliform results be calculated as geometric mean. This is a very different calculation than the arithmetic mean.
    - Arithmetic Mean (10+20+30+40)/4 = 25 CFU/mL Mean
    - Geometric Mean $\sqrt[4]{(10*20*30*40)}$ = 22.1 CFU/mL
      Multiple all the fecal values together then take the root of the number of samples or better yet, use the Excel function, GEOMEAN, i.e. =GEOMEAN(10,20,30,40)
  - Check your permit carefully, this is easy to overlook.
  - The good news is that geometric mean normally will produce lower monthly results

Calculated Confusion

- How do you calculate averages with results reported as less than or below the detection limit?
- Unless otherwise specified in the permit, the MQL, Minimum Quantification Level should be used in the calculation. This is usually the detection limit value.
- Report the average as “less than”
- Example: Four results for the month <3, 5, <3, 7
  Monthly Average: (3+5+3+7)/4 = 4.5
  Report on DMR as: <4.5

<

Calculated Confusion

- Another confusing issue is the “Too Numerous To Count” (TNTC) for fecal coliform results
- The lab should provide a “greater than” result which is the maximum counting range divided by the smallest dilution factor.
- This value is used to calculate the monthly average and the results reported as “greater than”
- Example monthly results: 200, 600, >60000, 100
  Calculation $\sqrt[4]{(200*600*60000*100)}$ = 921
  Report the monthly average as >921

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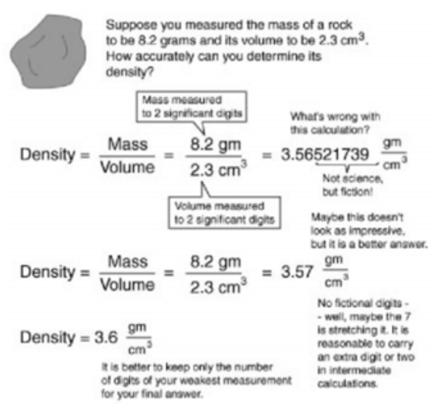
Significantly Dazed

- One of the most basic principals of chemistry is an understanding of significant digits.
- Unfortunately, it can also be one of the most mind numbing experiences known to man.
- Not even the experts in mathematics agree on how to best do it.
- The most simple definition = the number of digits which give a reasonable impression of the accuracy of the measurement.
- You normally should report the last digit you can be certain is accurate plus one uncertain digit.



Courtesy GA State University Hyperphysics Website

Significantly Dazed

- Using lots of decimal places may look impressive but they don't have any real value and they overstate the accuracy of the test.
- Each analysis should be carefully examined to determine the proper number of sig figs
- Once established, consistency is the key

My Head's Going Round(ing)

- Despite the importance of sig figs, some permits may require that results be rounded to a specific decimal point for compliance.
- EPA has a recommended method for rounding results.

My Head's Going Round(ing)

- For example, if your permit limit for a parameter is 1.0 mg/L and your results produce two decimal places:
  - **If the dropped decimal is 6, 7, 8, or 9, increase the preceding decimal by one, 1.06 becomes 1.1 and would be a permit violation**
  - **If the dropped decimal is 0, 1, 2, 3, or 4, do not change the preceding decimal, 1.04 becomes 1.0 and would not be a permit violation**
  - **If the dropped decimal is 5, round the preceding to the nearest even number, 1.05 becomes 1.0, 1.15 becomes 1.2, 1.25 becomes 1.2**

My Head's Going Round(ing)

- **Demo chart of possibilities when 5 is the digit to be dropped:**

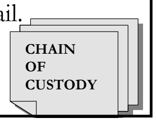
Result	Rounded	
1.05	1.0	Note that the underlined digit
1.15	1.2	will either stay even or
1.25	1.2	if it is odd it will be
1.35	1.4	raised to the next even
1.45	1.4	number. This assures
1.55	1.6	that in ½ the cases
1.65	1.6	the number will stay the
1.75	1.8	same and ½ will be
1.85	1.8	rounded up. It becomes
1.95	2.0	basically a coin flip.
2.05	2.0	

Confusion in a Bottle
Common Sampling Problem

- **Lab analysis no better than sample collected**
- **Failure to collect enough sample**
- **Overfilling the sample container**
- **Failure to properly ice samples**
- **Failure to use the proper type of bottle including proper preservatives**
- **Failure to deliver samples with enough holding time remaining**
- **Proper Chain-of-Custody – must clearly indicate date, time, and location**
- **No sample better than its Chain-of-Custody (COC)**

Paper Confusion

- That's right, no compliance sample is any better than its chain of custody.
- Once a sample is taken it is no better than its paper documentation to an ADEM or EPA auditor. That goes double for lawyers.
- The COC is usually the first thing lawyers will attack.
- The COC should be treated with the utmost care with close attention to every detail.
- The COC will remain long after the sample is gone.



Paper Confusion

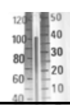
- COCs should contain the following information at a minimum.
  - **Permittee Name, Facility Name, Address, Phone Number**
  - **Outfall or Sample Location**
  - **Sample Description (Routine or Special, Grab or Composite, Weekly, Monthly, Annual)**
  - **Bottle type, number of bottles and preservative**
  - **Name of the sampler**
  - **For grab samples, the complete date and time the sample was collected, i.e. 7/29/2008, 08:00**

Paper Confusion

- For composite samples,
  1) complete date and time the sample started
  2) complete date and time the sample ended
  3) complete date and time the sample was collected or poured up
- Start and end for composites are usually the times the automatic sampler collected the first and last sample respectively. Collection is when the samples are poured up.
- When the collector relinquishes the sample, changes in sample custody should be documented with signatures, dates, and times with no break in custody.

Paper Confusion

- Sample temperature and any field parameters should be recorded on the COC
- If the samples are shipped, the shipping details should be recorded on the COC including shipper name and tracking number.
- If possible, it is best to use preprinted COC's Either provided by the lab or printed yourself. These should only require the sampler to fill out the sample dates/times and signature/date/time (and shipping details, if necessary).
  This provides consistency for auditors.



Three Step Program for Relieving Confusion

- **Communication** - If you have confusion over any issues concerning your permit requirements communicate with:
  - ADEM and/or EPA
  - Your laboratory
  - AWPCA, ARWA, AWWA, etc.
  - Experienced operators/Mentors
- **Education** – Stay up-to-date on regulation changes, review your permit frequently, update C.E.U.s

Three Step Program for Relieving Confusion

- **Consistency** – Confusion often results when we don't do the same job the correct way every time. Whether its analysis, sampling, rounding, or documenting, getting lazy and taking shortcuts is a snake that comes back to bite us.

Final Thoughts

- Our Age of Anxiety is, in great part, the result of trying to do today's jobs with yesterday's tools. – Marshall McLuhan
- We are drowning in information but starved for knowledge. – John Naisbitt
- One who asks a question is a fool for five minutes; one who does not ask a question remains a fool forever. – Chinese Proverb
- If you're not confused, you're not paying attention. – Tom Peters

Other Info

- We will post this presentation and other documents on TTL's Website:

  http://www.ttlusa.com/analytical.htm

- Questions/Comments