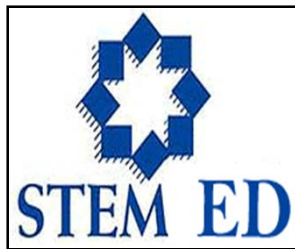




Water Treatment Experiments

Friday AM



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University of Massachusetts

Introduction

- The water industry spends a lot of money and effort on removal of natural organic matter (NOM) from drinking waters
- Problems with NOM (the more NOM the bigger problem)
 - NOM interferes with the ability of water treatment systems to remove substances that cause disease
 - Pathogenic organisms
 - Toxic chemicals
 - NOM reacts with chlorine-based disinfectants forming carcinogenic organic byproducts

Intro (cont.)

- Thinking about removal of NOM, many questions come to mind.
 - Which methods are most effective? Are home treatment systems as good as, better than or worse than community water treatment systems?
 - Will alum, the most common method of treatment in cities, really remove colored organic matter? If so, how much removal occurs?
 - How does alum compare to chlorine and GAC, the other major types of treatment
 - How does chlorine compare with the other disinfectants, iodine and chlorine dioxide?
 - How do the various home filtration products compare?
 - Does treatment effectiveness depend on the type of leaves in the watershed?

Materials

- Plant leachate
 - Yours or mine
- Containers for treatment & imaging
 - Plastic Culture Flasks (275 mL),
 - Corning #430720; \$3.70 each from Fisher, \$2 from Caroline Bio
- Treatment Chemicals & Equipment
 - Coagulation: alum
 - Activated Carbon Adsorption: Aquarium charcoal
 - Disinfection: household bleach, “field” disinfectants
 - Home Treatment Systems: Brita, etc.
 - Filtration apparatus
- Camera, computer & ADI software

What to Do for the Treatment Tests?

- Decide on plant leachate to treat
- Conduct Treatments
 - Bottle 1: Alum coagulation (do this first)
 - Bottle 2: GAC adsorption (two options)
 - Bottle 3: Disinfection/Oxidation (do one or more)
 - Bottle 4: Home Treatment (do one or more)
- Some may require paper filtration
 - If treated waters look cloudy
- Record Images and analyze
 - Collect at least one photographic image of the treated bottles next to a blank (tap water) and an untreated control (leachate)

Alum Coagulation

1. Add about 15-20 drops of the 4% sodium bicarbonate (NaHCO_3) solution you'll want to reach a pH of about 7-7.5
2. to your 250 mL sample, add about 1-2 drops of the 6% sodium hydroxide solution (NaOH). Check pH
3. Add a sufficient amount of the 10% alum solution (about 15-20 drops) to initiate floc formation. You will need to gently shake the bottle (slowly invert about 20 times over 60 seconds) and wait for the slow formation of visible and settleable floc. This step is called flocculation.
4. Check pH, add more NaOH if it is below 7, you may need to add 4-8 additional drops. Do this 2 drops at a time, checking pH. Remember your target is pH 7-7.5.
5. Allow the floc to settle for about a half-hour.

Granular Activated Carbon (GAC)

- There are at least two different methods of GAC treatment used in water treatment plants.
 - Both can be simulated in the laboratory, although the first may be easiest. You're welcome to select either one:
- 1. Filter Bed method: simultaneous contact/filtration
 - Gently pour half of the 250 mL sample into the filter funnel containing a layer of pre-washed GAC¹. Slowly turn on the vacuum until the level just starts to drop. Once the first half has been received into the filter flask, repeat with the second half. Don't discard the GAC; it can be used again. Transfer the filtrate back to your culture bottle for image analysis

or

- 2. Slurry method : contact then filtration
 - Add a spoonful of GAC directly to the 250 mL bottle, shake and allow it to settle. You may need to filter the sample after it settles

¹GAC was gently introduced over a sandwich of 2 Whatman #1 filter circles (90mm)

Disinfection & Oxidation

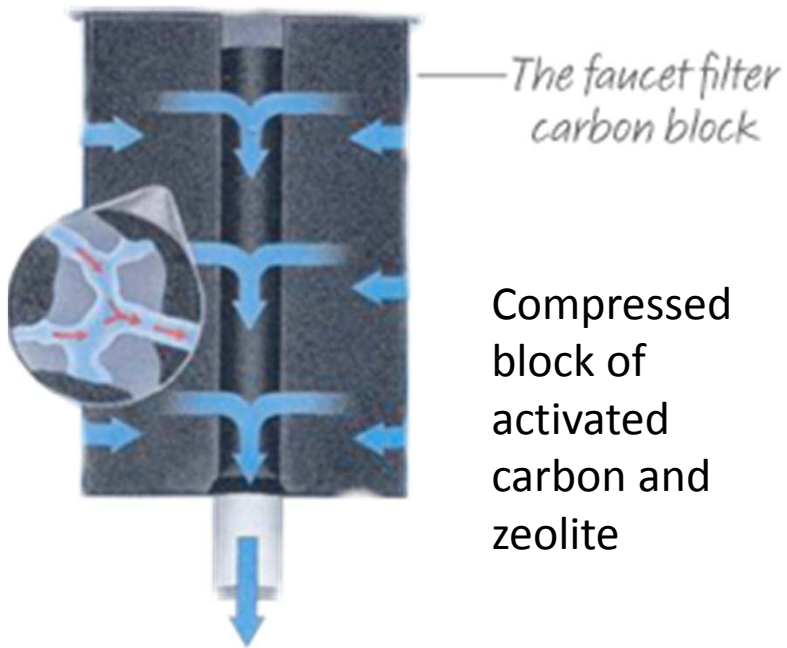
1. Add one of the following:
 - Chlorine or Household Bleach: 10 drops of the 5% chlorine solution (each group has a bottle).
 - Iodine or Potable Aqua: add 1 tablet to the 250 mL sample (only one set of tablet for the class)
 - Chlorine Dioxide or Aquamira: add $\frac{1}{2}$ to 1 tablet to the 250 mL sample (only one set of tablets for the class)
2. Shake and wait about 10 minutes for reactions to occur
3. Collect images and analyze

Home or Point of Use Treatment

1. Select one or more treatment products
 - Brita Bottle
 - Brita Pitcher
 - ZeroWater Pitcher
2. Pour 250 mL sample into reservoir.
3. Allow water to percolate through or squeeze it out (Brita bottle)
4. You may need to filter if the treated water looks cloudy
5. Return it to the culture bottle, image and analyze

Brita: Water Bottle

- GAC/ion exchange
- Replace cartridge every 75L





*The amazing
Brita® pitcher filter*

Brita: Pitcher

- Same
 - Activated Carbon and Ion Exchange resin
- 160 L per cartridge



ZeroWater

- 5-stage dual Ion Exchange
- Replace cartridge when TDS meter reads 6 ppm
- Capacity depends on TDS of water to be treated



Data Analysis

- Using line or rectangle tool, determine color intensity of red, green & blue
- Tabulate these values and compare with calibration curve
 - This will show the amount of colored organic matter remaining after treatment
 - Comparison with a calibration helps to assign a quantitative “% remaining” or “% removal”

Calibration Curve & Beer's Law

- From a single leachate sample
 - Prepare serial dilutions with each successive sample diluted to half its initial concentration
 - 100%, 50%, 25%, 12.5%, 6.25% etc.
 - Image bottles with a blank (pure dilution water)
 - Prepare plot of color intensity vs % of initial concentration

Spatial tools measure the color and size of features in digital images.

Select Version of Image to View and Analyze

Original Enhanced Masked

Line Tool

Click and drag to create a line. Use the blue and red arrows below to move the corresponding end one pixel, or click and drag either end.

Select Color of Tool



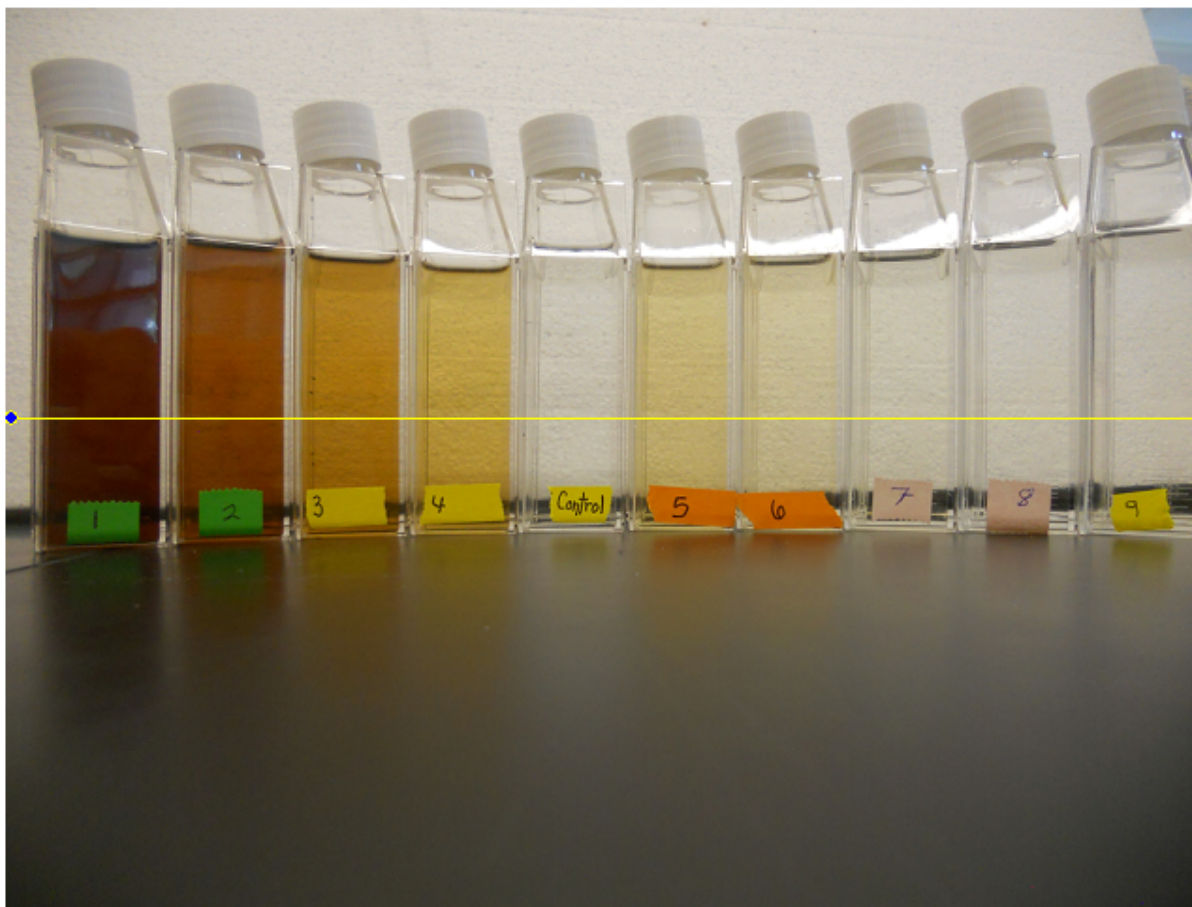
Hide Tool

Erase Tool

	Pixel Position	Adjust
	X Y	
Start Point	6 350	
Stop Point	1022 350	
Number of Pixels	1,017	

Color	Intensity [%]
Average Red	64.28
Average Green	55.52
Average Blue	40.25
Average Color	53.35

Intensities of colors range from 0%, meaning none of the color is present, to 100%, when maximum color is present.



Trimmed DSCN4416.JPG is 1024 by 768 pixels

Zoom In (drag slider or type '+') Magnification: 0.6250 x Zoom Out (drag slider or type '-')

When zoomed in, pan around the image by using the arrow keys or holding the SHIFT key and clicking and dragging the image.

Spatial feature

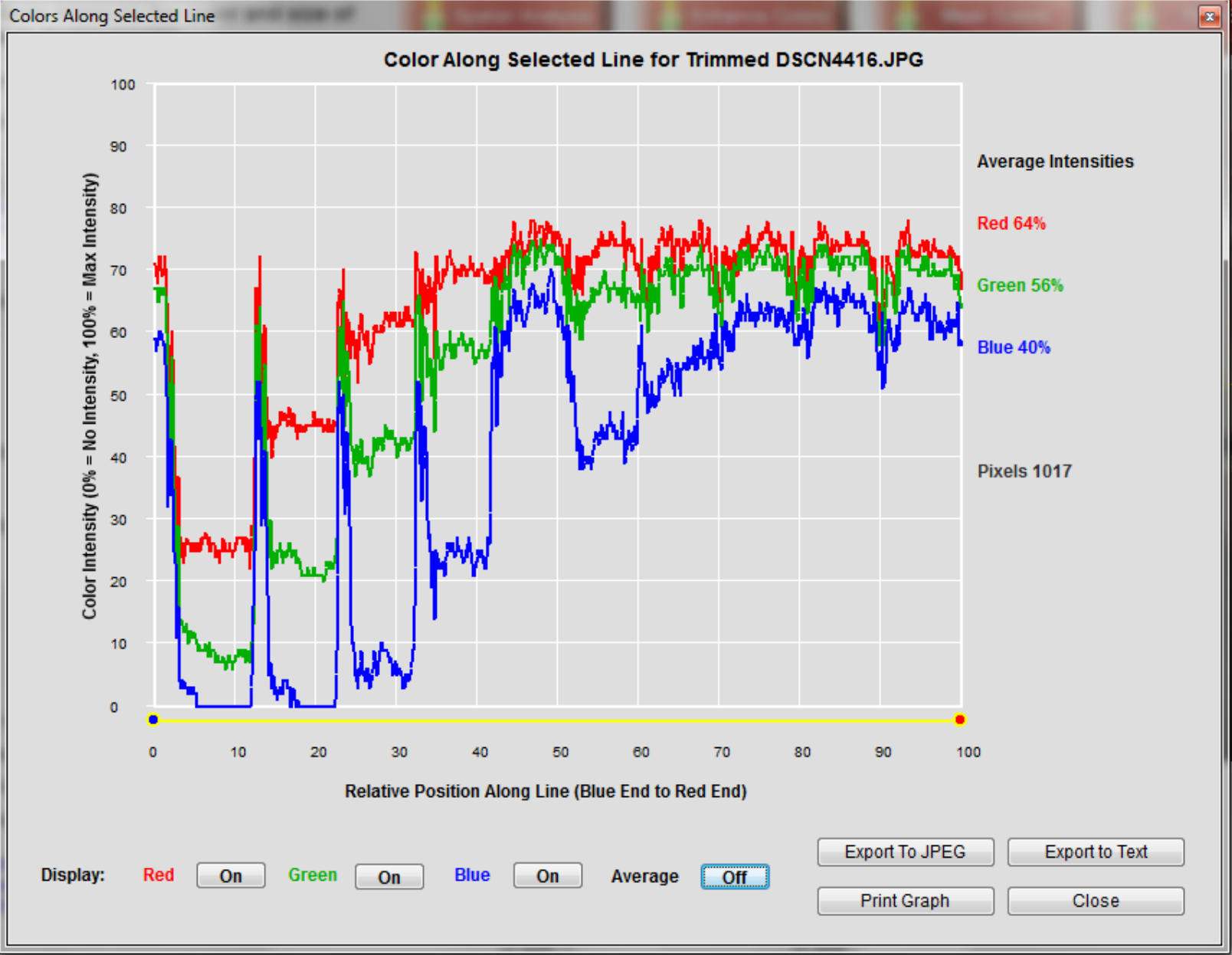
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Spatial feature

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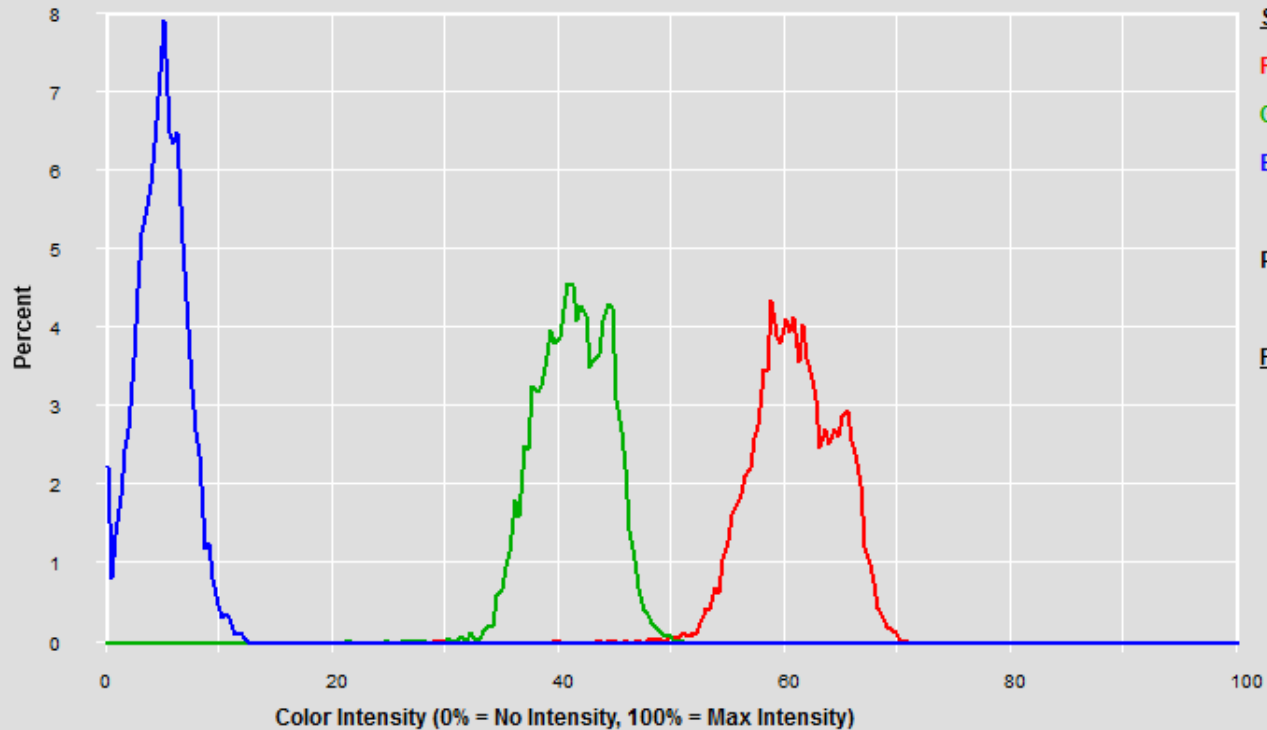
Rectangl

Click and red arrow pixel, or cl

Select Co of Too

Color Histogram of Displayed Image

Color Distribution in RGB Image: Trimmed DSCN4416.JPG



Selected Area

Red: 61%

Green: 41%

Blue: 5%

Pixels: 6650

Full Image

Color histogram of currently displayed image, and, if an area is selected, the color histogram drawn in a brighter color.

If a masked image is being displayed, the color distribution of the image being masked is drawn.

Selected Area: Red On Green On Blue On Average Off

Full Image: Red Off Green Off Blue Off Average Off

Export To JPEG

Export to Text

Print Graph

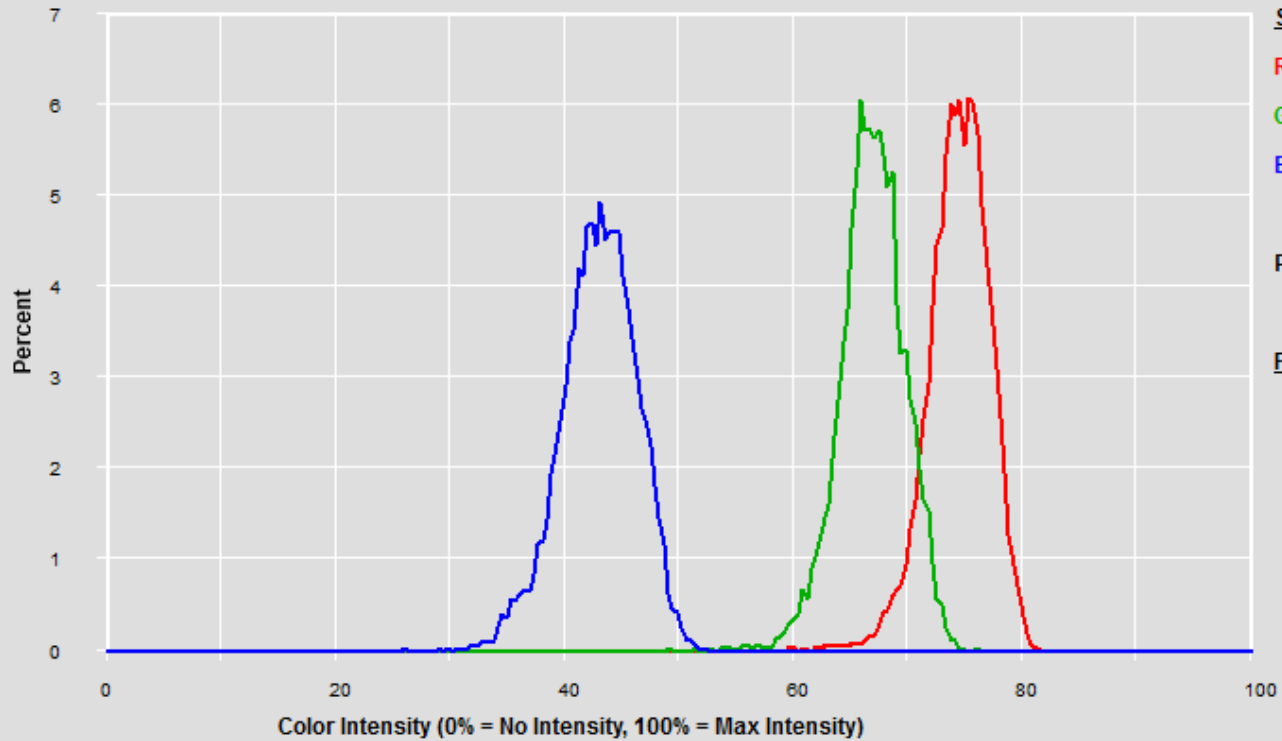
Close

Int
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10

#5

Color Histogram of Displayed Image

Color Distribution in RGB Image: Trimmed DSCN4416.JPG



Selected Area

Red: 74%

Green: 67%

Blue: 43%

Pixels: 8625

Full Image

Color histogram of currently displayed image, and, if an area is selected, the color histogram drawn in a brighter color.

If a masked image is being displayed, the color distribution of the image being masked is drawn.

Selected Area: **Red** **Green** **Blue** Average

Full Image: **Red** **Green** **Blue** Average

Export To JPEG

Export to Text

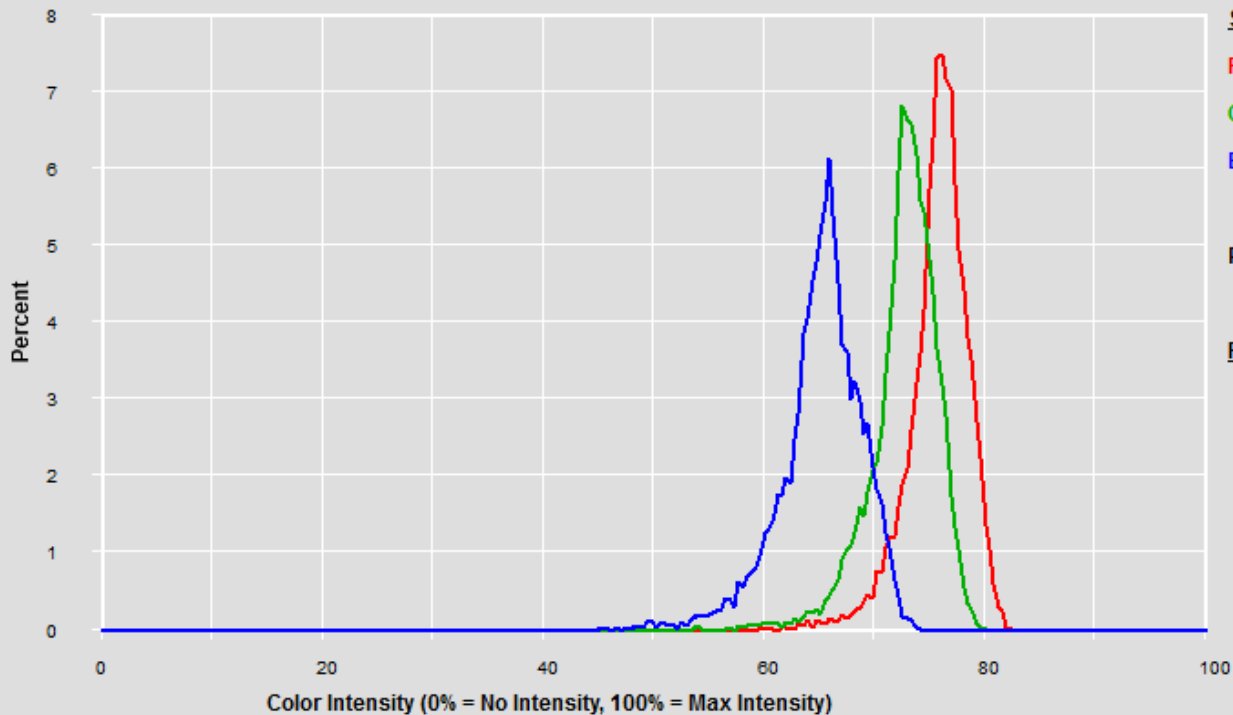
Print Graph

Close

Control

Color Histogram of Displayed Image

Color Distribution in RGB Image: Trimmed DSCN4416.JPG



Selected Area

Red: 76%
Green: 73%
Blue: 65%

Pixels: 8375

Full Image

Color histogram of currently displayed image, and, if an area is selected, the color histogram drawn in a brighter color.

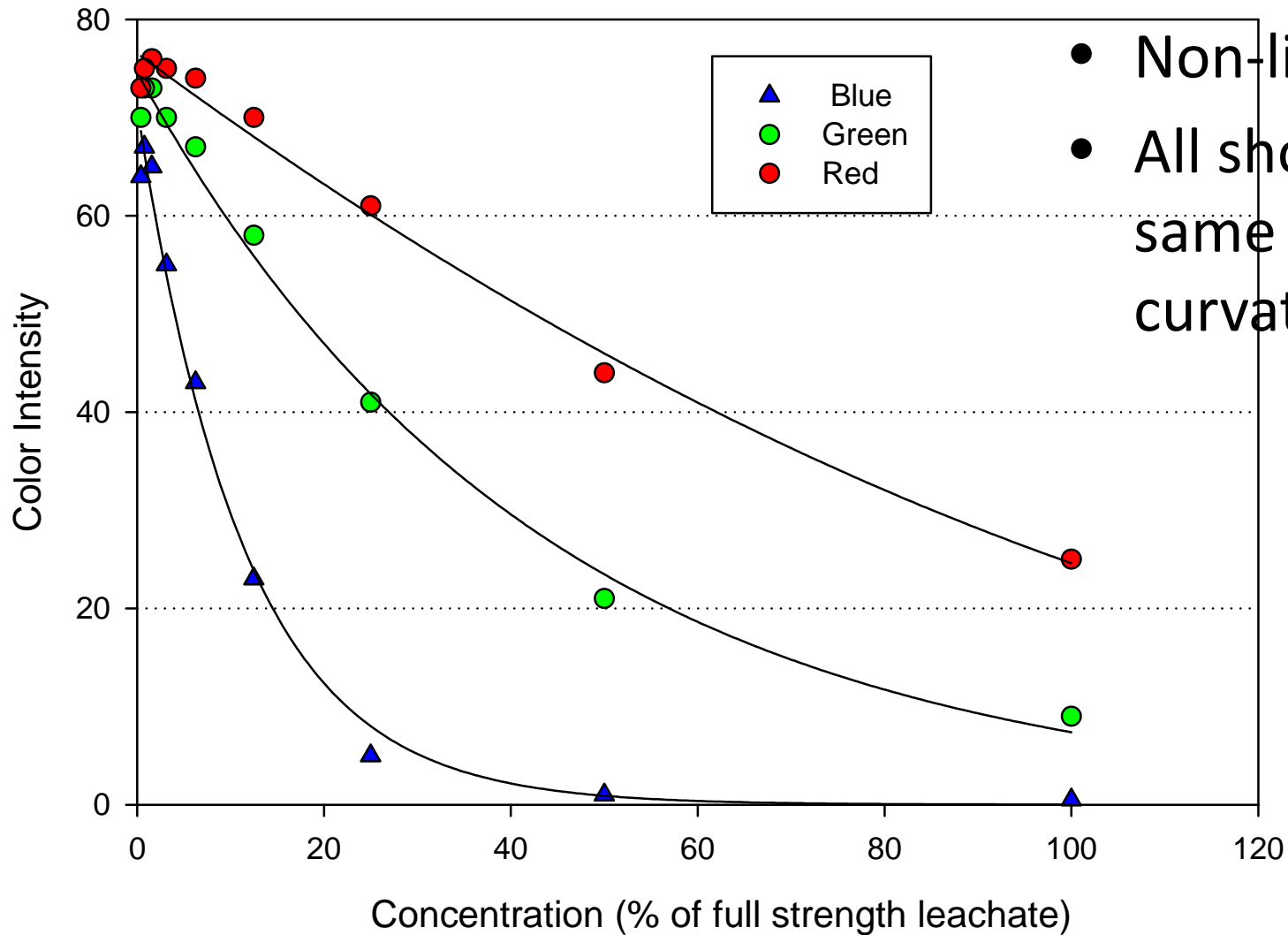
If a masked image is being displayed, the color distribution of the image being masked is drawn.

Selected Area: Red On Green On Blue On Average Off

Full Image: Red Off Green Off Blue Off Average Off

- Export To JPEG
- Export to Text
- Print Graph
- Close

Direct Calibration



Beer's Law: making it linear

- Concentration of a solution of an absorbing compound or a mixture of compounds with fixed proportions is directly proportional to the logarithm of the light intensity for experimental (I) divided by the light intensity for the blank (I_0)
 - This is the “Absorbance”

$$\text{Absorbance} = -\text{Log}\left(\frac{I}{I_0}\right)$$



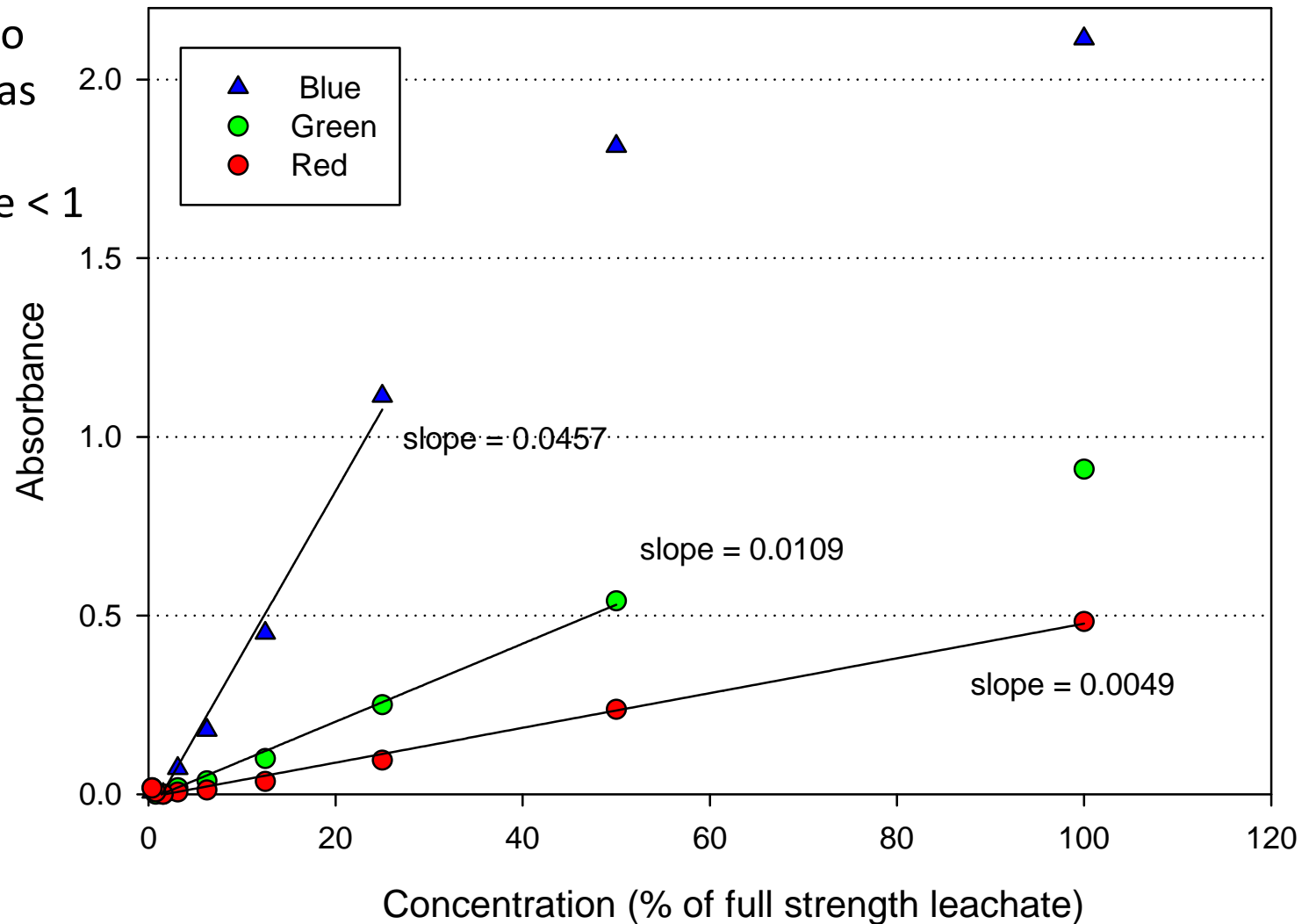
$$\text{Absorbance} = \underbrace{\text{concentration} \times \text{pathlength}}_{\text{What you're trying to determine}} \times \underbrace{\text{absorptivity}}_{\substack{\text{Fixed value} \\ \text{determined by} \\ \text{analyzing a} \\ \text{“standard”}}}$$

What you're trying
to determine

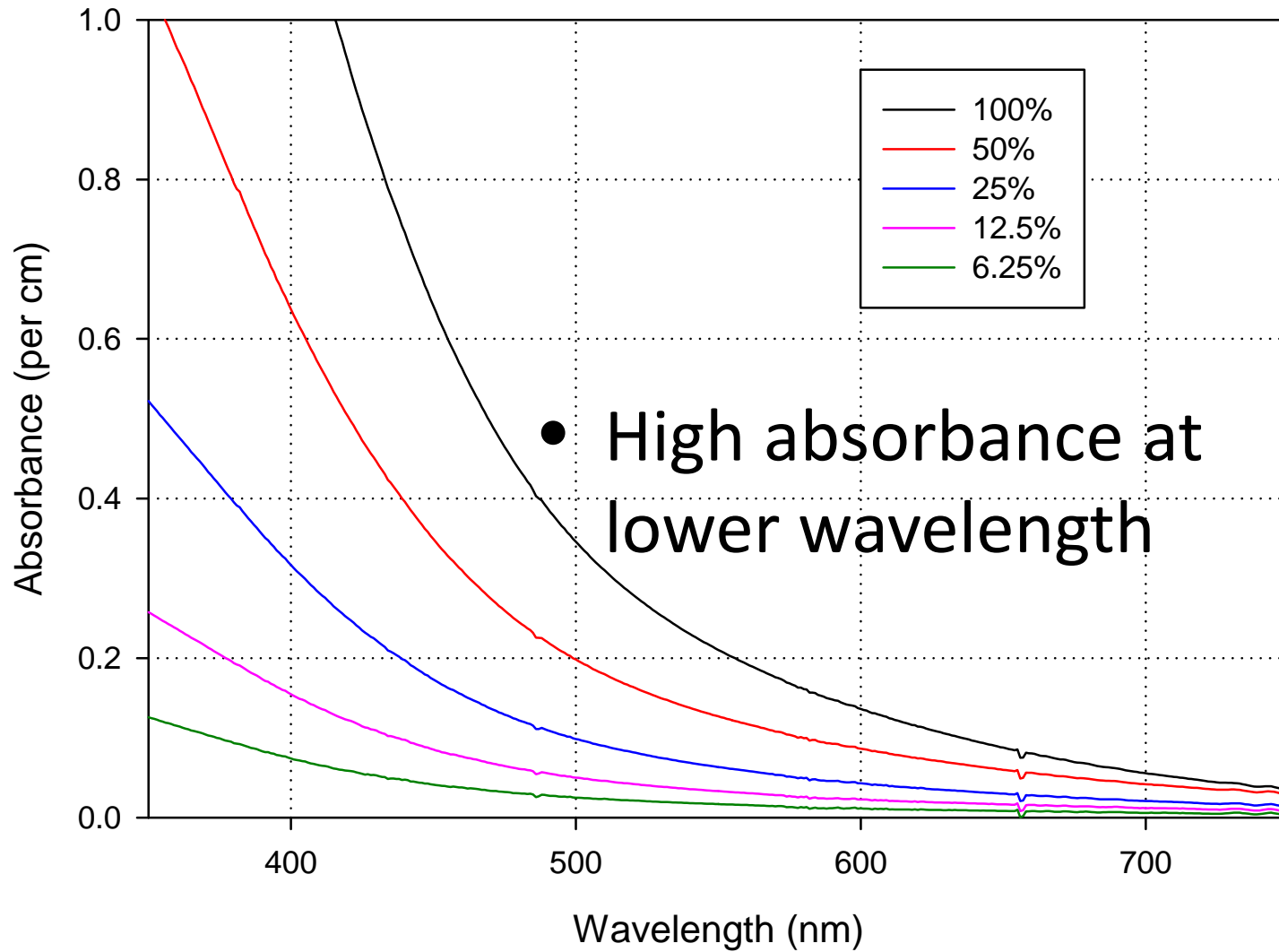
Culture Bottles: “Absorbance”

- Linear

- Conforms to Beer’s law as long as Absorbance < 1



Spectrophotometer: High Resolution Absorbance Spectra



Camera vs Spectrophotometer

- Can give equivalent answers

