

Research Study: Accuracy of Texas CCS Water Quality Monitoring Data (Texas Stream Team)

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What is Community Citizen Science (CCS)?

a.k.a. Participatory Science, Volunteer Monitoring, Crowdsourcing, and many more...



The participation of students, amateurs, or volunteers (any non-professional scientist) in the process of scientific research.



Recent Growth

Technological advancements (smartphones)
Enhanced data collection,
Educational and societal impacts



Groups and Resources

Citizen Science Association, SciStarter, iNaturalist,
Master Volunteers, Texas Stream Team

Image Source: <https://fritsahlefeldt.net/>

Benefits of CCS



Data Collection

- Eyes on the ground
- Data gaps
- Accessibility (off limits)
- Machine learning (AI)



Education and Outreach

- Broaden engagement
- Project-based Learning
- Virtual options
- Curricular materials



Impacts

- Community input & support
- Learning gains
- Funding opportunities
- Sustainability goals

Photo credit: From Texas Stream Team website (<https://www.meadowscenter.txstate.edu/Service/TexasStreamTeam.html>) and from: www.WFAA.com

Volunteer Water Quality Monitoring

- Volunteers from all over the US have been collecting data for decades with citizen science (CS) programs
- Water monitoring one of the most prevalent types of CS program worldwide



Question: What is volunteer CCS data used for?

- Uses of TST data limited, largely unknown at time of publication
- Still no “official” management or regulatory uses
- Few citations in peer-reviewed articles

Texas Stream Team: Data Uses



Common issue throughout CCS water monitoring

Volunteer datasets **not fully utilized** by professionals and scientists

Top concerns about **accuracy and applicability** of data

Top reason not used in publications: **researcher's perceptions of volunteer data quality**

Comprehensive Literature Review: 26 WQ Comparison Studies

- General “Good” agreement between volunteer and professional
- Pros and cons of comparison studies

A little sus?
Or not?

Research: Volunteer Water Quality Monitoring Data Accuracy



Texas Stream Team Opportunity:

- *Long-term continuous data collection over large area*
- *with QAPP*
- *at sites that correspond to professional samples.*

Assess relative accuracy of TST water quality data (*DO, pH, conductivity*) by comparing to professional data & analyzing variations across scales

- First comparison study to
 - Utilize TST data
 - Combine large and small-scale analysis
 - Analyze existing and experimental datasets

RESEARCH QUESTION 1

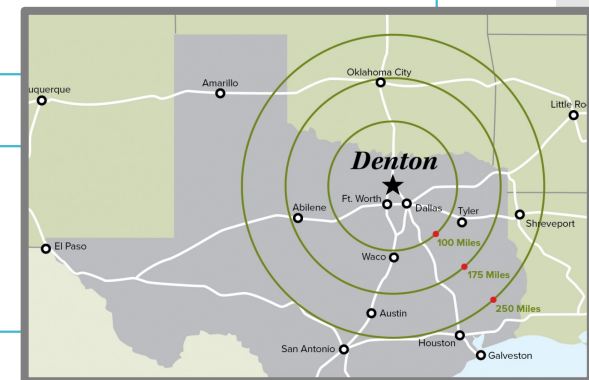
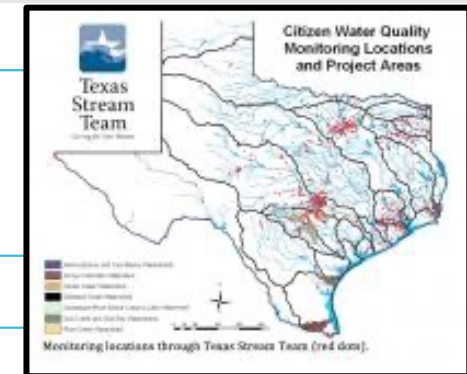
- Existing, Statewide, 1992-2016 (long-term, large-scale)

RESEARCH QUESTION 2

- Existing, City of Denton, 2009-2017 (long-term, local scale)

RESEARCH QUESTION 3

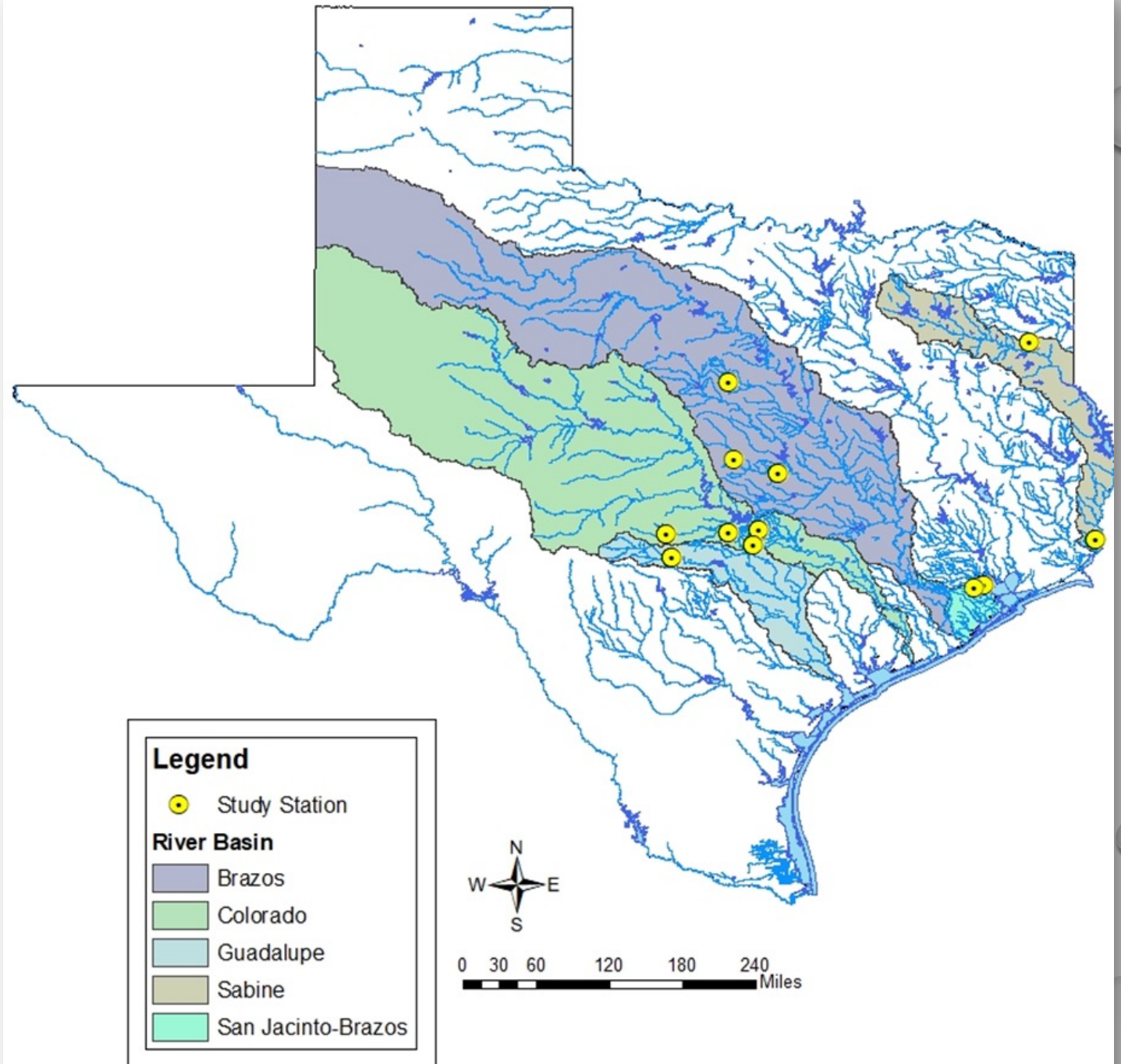
- Experimental, City of Denton, 2017-2018 (short-term, local)



RQ 1: Statewide

Figure 1. Map of Study Stations. Existing Statewide Water Monitoring Station Locations, with River Basins

(12 stations, 5 river basins)



Research Question 1:

Existing, Statewide,
1992-2016 (long-term,
large scale)

Results - RQ 1: Existing, statewide

- **234 professional, 350 volunteer samples, 12 stations, 38 station years**
 - Samples analyzed by year/station for each of the parameters (DO, pH, conductivity)
- **Result: 82 station/year ANOVAs**

Answered the question: Is there a significant difference between volunteers and professionals at that station for that year, for that parameter? (DO, pH or conductivity)

Table 2. Statewide ANOVA Metadata. Percent agreement between TST volunteer and TCEQ professional data based on ANOVA results (*Table 1*) for all statewide models run and for each parameter.

Data Category	# ANOVAs	# Statistically Significant	Total Percent Agreement
Total Statewide	82	16	80.49%
DO	30	7	76.67%
pH	24	5	79.17%
Conductivity	28	4	85.71%

Results - RQ 2: Existing city of Denton

Research Question 2:

Existing, City of
Denton, 2009-2017
(long-term, local
scale)

- **159 vol/pro paired samples, 6 stations, 24 sampling years**
 - (Same as RQ 1) Samples analyzed by year/station for each parameter (DO, pH, conductivity)
- Result: **70 total analyses**
 - (ANOVAs for DO and conductivity, and KST for pH)
- More controls = less variation in datasets → **Group Analysis** of entire dataset
 - Provide more detailed information about parameters over time
 - Found pattern in DO and pH data

DO – Systematic bias

- Group Analysis of City of Denton volunteer and professional sampling data =
- **Found: consistent pattern for DO** across all sites for all years
 - Reproducibility for all samples = systematic bias or error
 - *Reproducible, consistent magnitude = not a reflection of actual variation in dataset (Taylor 1997)*
 - Calibration confirmed:
 - **Add 2 mg/L to all volunteer DO samples to remove bias = no significant difference (Figure 5).**
 - Note: Adding 2 mg/L to the volunteer data only one option
- Applied to all City of Denton results (RQ 2 and 3)

DO – Systematic bias adjustment

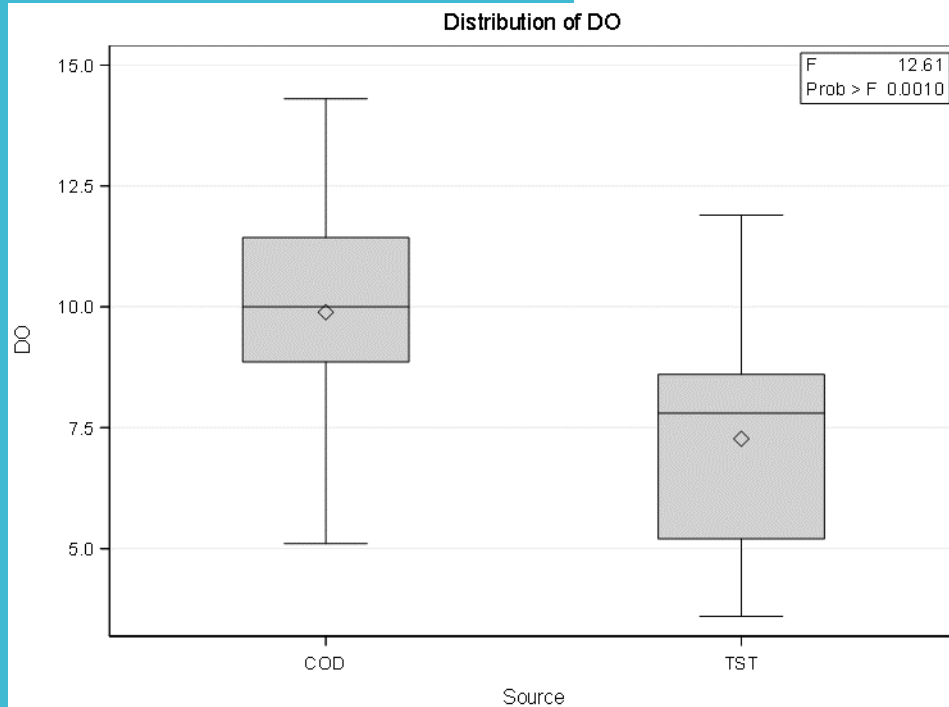


Figure 4. Boxplot of City of Denton DO data – Bias Uncorrected. All professional (COD) DO samples compared to all volunteer (TST) DO samples showing systematic bias across all years and stations.

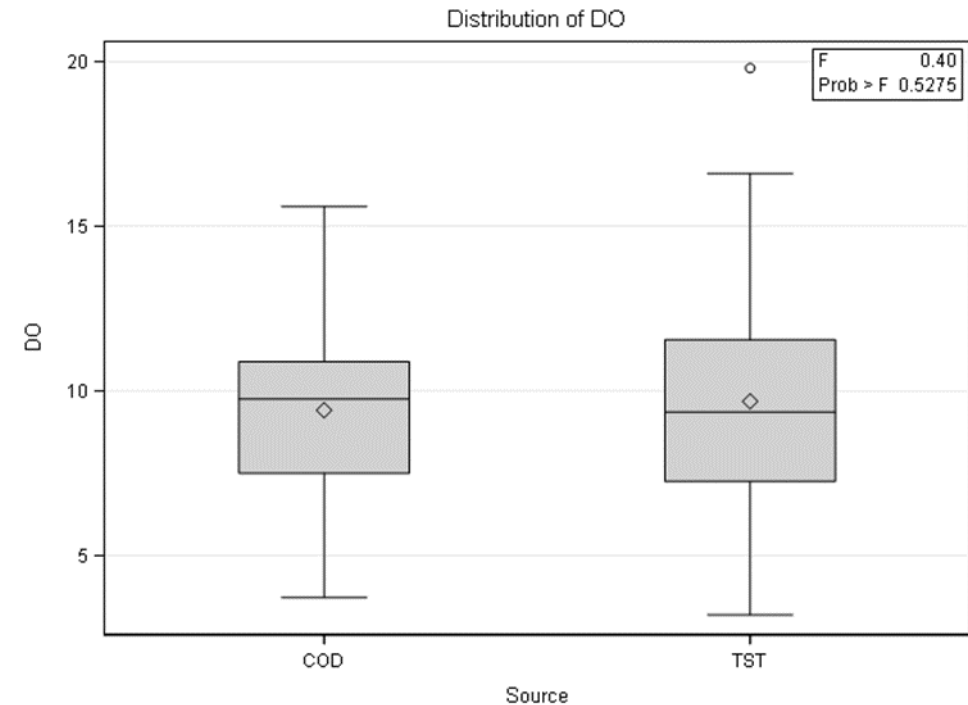


Figure 5. Boxplot of City of Denton DO data – Bias Corrected. All professional (COD) DO samples compared to all volunteer (TST) DO samples when systematic bias corrected by adding 2 mg/L to all volunteer samples.

Table 7. City of Denton ANOVA Metadata. Percent agreement between TST volunteer and City of Denton professional data based on ANOVA/KST results (*Table 6*) for all models run and for each parameter

Data Category	# Analyses	# Statistically Significant Analyses	Total Percent Agreement
Total Denton	70	6	91.43%
DO	23	2	91.30%
pH	24	4	83.33%
Conductivity	23	0	100%

Results – RQ 2 – Group Analyses (DO, Cond.)

- Paired samples, more localized dataset = group analysis between vol and pro across all stations and years
- **No significant difference between volunteer and professionals for DO and Conductivity**

Table 8. Group ANOVAs for Historic City of Denton Data.

The statistical variation (Pr>F) between volunteer and professional data across all stations and years (2009-2017) for both DO and conductivity.

Parameter	# Samples	DF	Type III SS	Coeff Var	F Value	Pr>F
DO	184	1	3.4060	30.546	0.40	0.5275
Cond	184	1	0.0330	5.6719	0.24	0.6230

pH Group Analysis

Table 9. Group KST test for pH for Historic City of Denton Data. The non-parametric test showing the statistical variation ($Pr > KSa$) between volunteer and professional pH data across all stations and years (2009-2017).

Kolmogorov-Smirnov Two-Sample Test

(Asymptotic)

KS	0.332368	D	0.664776
KSa	4.508464	Pr > KSa	<.0001

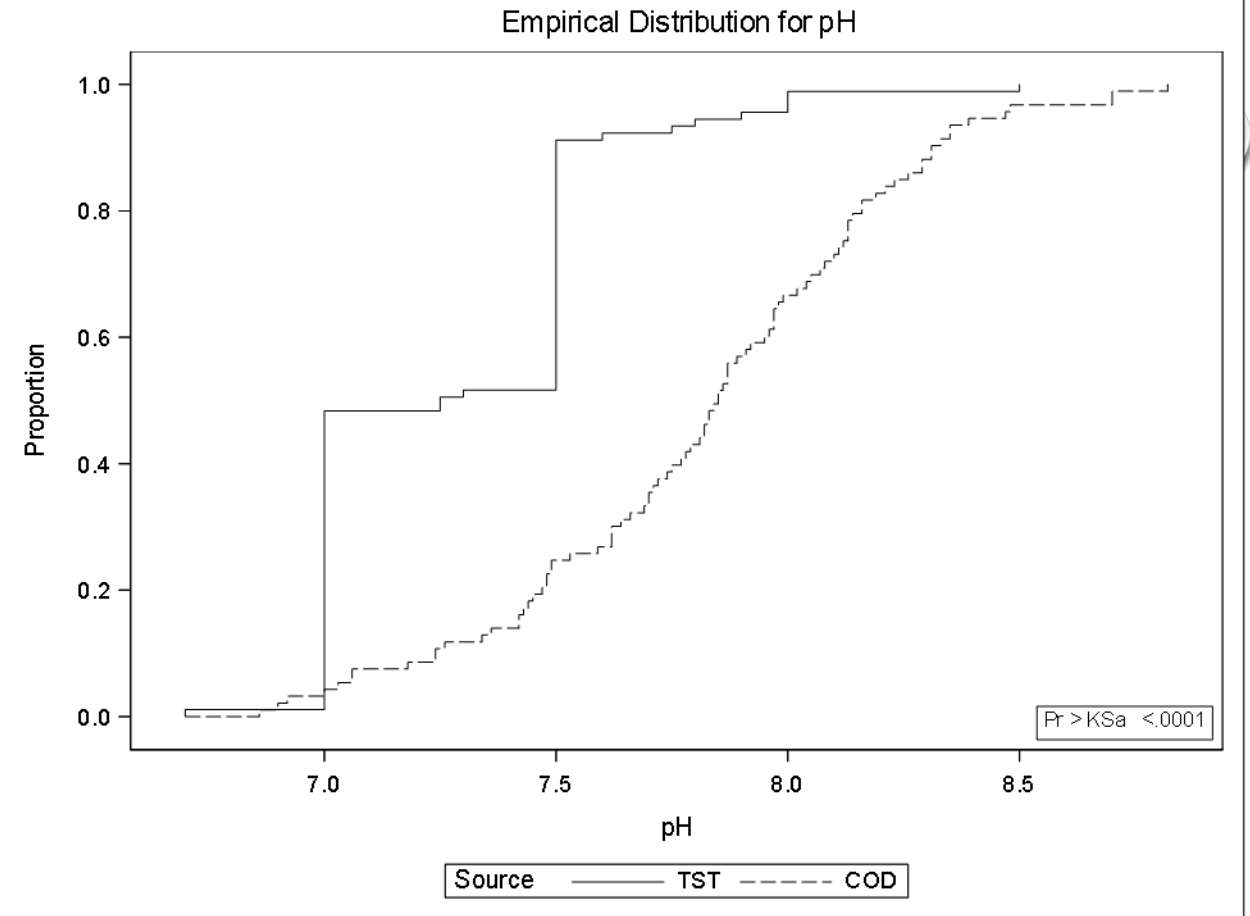


Figure 6. Distribution of pH for Historic City of Denton Data. The distribution of the volunteer (TST) and professional (COD) data at all stations for all years (2009-2017), with the KST statistic showing a significant difference between the two datasets.

Raw data: 90% of volunteer pH data either a 7 or 7.5

Despite post-hoc constraints:

LARGE-SCALE	EXISTING	UNPAIRED
<ul style="list-style-type: none">Increased variability in time, space, and collecting agencies	<ul style="list-style-type: none">No experimental controls,No standardization of equipment or protocol	<ul style="list-style-type: none">Vol/Pro samples possibly months apartSites up to 60m apartNo seasonal controls



Existing TST citizen scientist data show 80% overall agreement with professional data for DO, pH and conductivity over program's entire duration, statewide

> **Local analysis with paired samples even higher (91%)**

- Inform increased utilization of large-scale TST datasets that already exist
 - CS WQ programs worldwide with similar program structure

Current Research & Teacher Workshops



ACCESS Water Program

- Educator workshops to promote CCS water quality data collection
 - Texas Stream Team
 - New Research (Tamplimg)
- Curricular resources, materials and supplies, hands on training, ArcGIS tools

TEXAS STATE
Soil & Water
CONSERVATION BOARD

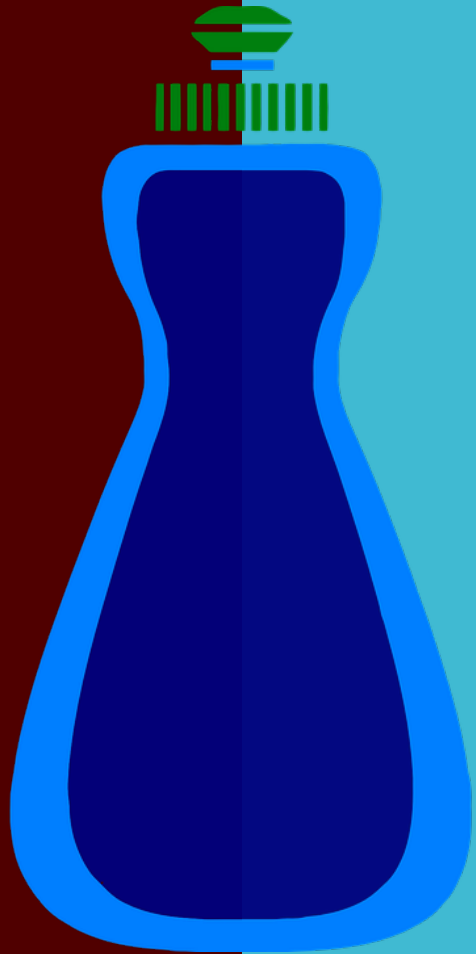

Texas Water
Resources Institute
make every drop count

TEXAS A&M
AGRILIFE
EXTENSION

TEES
Texas A&M Engineering
Experiment Station



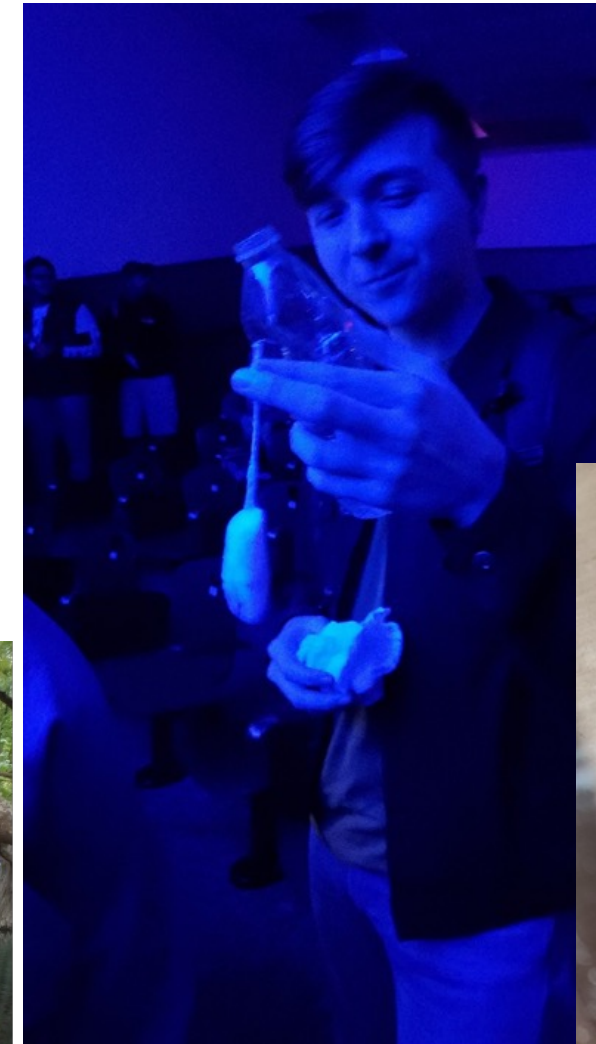
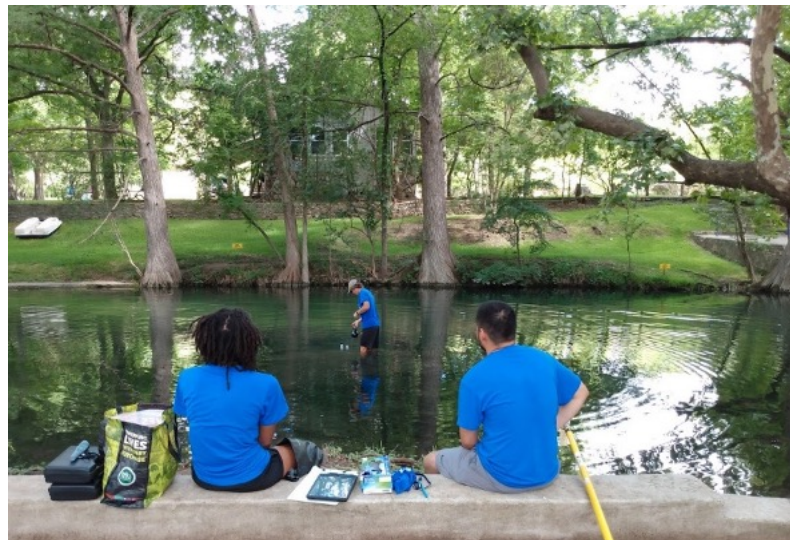
Optical Brighteners (OBs)



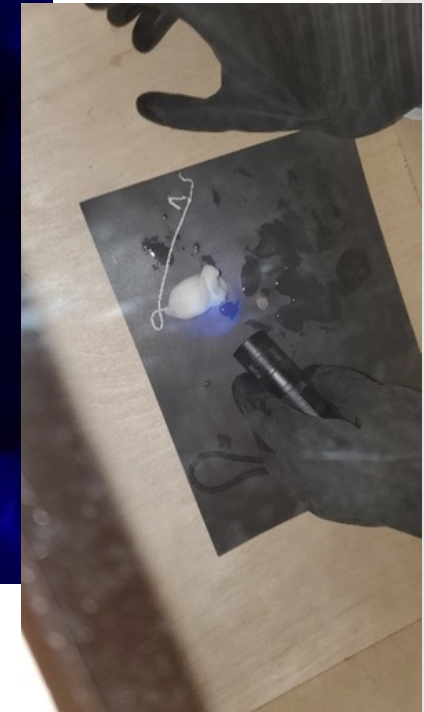
- Found in detergents and soaps, don't break down quickly
- Should be removed in treatment process
- Presence of OB's in waterways can alert to the presence of **human sewage contamination** as a proxy to bacterial sampling
- Fluoresce under a black light – glow blue
- Adsorb to **COTTON** (*on a string...*)

- Presence/Absence Data
- “Red Flag” events

"Tampling"



→
Student
proudly
displaying his
Tample





"After attending the ACCESS workshop..."

"I can do a better job giving my students hope for the future, and they will feel like they can actually make a difference in the world"



"I will be able to seamlessly integrate into my courses without much effort."



"My students will become more familiar with their local water bodies and have a deeper understanding about the issues."

Project Reach (as of December 2022)



[ACCESS Workshops Website](#)

Project Reach (as of December 2022)

- 42 Teachers Trained
- 6000+ Students reached
- 105 GIS products (maps, Storymaps) created by teachers and students

familiar with their local water bodies and have a deeper understanding about the issues."

Social Media Engagement



TikTok:

- 93 videos
- 8,815 views

Instagram:

- 7121 views

Facebook:

- 5811 views



"It was the most enjoyable PD I have gone to!"

7th/8th grade Science Teacher

The ACCESS Water Team:

Texas Water Resources Institute (TWRI)

Texas A&M AgriLife Extension

Texas A&M Engineering Experiment Station (TEES) and SPARK!

Sponsored by: Texas State Soil and Water Conservation Board

TEXAS A&M AGRILIFE

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→ **CCS Fact Sheet (*Albus, Bowling 2022*)**

AgriLife Learn - free download here:



<https://agrilifelearn.tamu.edu/s/product/citizen-and-community-science-inclusive-research-for-a-sustainable-future/01t4x000007U3TqAAK>