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Prerequisite:
Background Research

Testing Water Quality

- allows us to get a good picture of the flora and fauna inhabiting the water body
- tells us if we are managing our waste (trash, chemicals, etc.) properly
  - pollutants harm ecosystems
  - pollutants can cause havoc in food webs
- can also include a chemical test (more common than with macroinvertebrates)
- tests can be for pH, ammonia, dissolved oxygen, nitrates, nitrites, temperature, fecal coliform, turbidity, etc.

Common Aquatic Macroinvertebrates of California

- Mayflies (order Ephemoptera)
  - small mayflies Bactidae
  - cotton mouth minnow mayflies Ameletidae
  - small square gill mayflies Caenidae
- Dragon flies and Damselflies Odonata
  - darners Aeshnidae
  - clubtail dragonflies Gomphidae
  - spread-winged damselflies Lestidae
- Stone flies Plecoptera
  - small winter stoneflies Capniidae
  - perlodid stoneflies Perlodidae
- and a whole lot more
  - see California Macroinvertebrate Taxa for reference

What are Aquatic Macroinvertebrates?

- animals that live in water based environments (aquatic)
- that can be seen without a microscope (macro)
- and lack a backbone (invertebrate)

Using Aquatic Macroinvertebrates for testing water quality

- have been used to test water quality since the 1870s
- their growth, survival, and reproduction is dependant on water quality
- short term or long term pollution events

Why?

1. Spend at least part of their life cycle in aquatic environments
2. can be found in and around water bodies (rocks, logs, vegetation, etc.)
   - do not migrate (far)
   - sedentary
3. easy to collect and identify
4. can tolerate a range of pollution levels

Hilsenhoff's Biotic Index (HBI)

- a generalized scale of pollution tolerance for aquatic macroinvertebrates
  - 0 = extremely sensitive
  - 10 = extremely tolerant

Order	Family	Tolerance Value (a)
Plecoptera	Perlidae	1
Ephemeroptera	Baetidae	4
	Caenidae	7
	Heptageniidae	4
	Leptophyphidae	4
Odonata	Aeshnidae	3
	Calopterygidae	5
	Coenagrionidae	9
	Libelluidae	9
Trichoptera	Hydropsychidae	4
	Hydroptilidae	4
	Leptoceridae	4
Megaloptera	Corydalidae	0
Lepidoptera	Pyralidae	5
Coleoptera	Elmidae	4
Diptera	Ceratopogonidae	6
	Chironomini (blood-red)	8
	Chironomidae (other)	6
	Empididae	6
	Psychodidae	10
	Simuliidae	6
	Tabanidae	6
	Tipulidae	3
Amphipoda	Gammaridae	4
Isopoda	Asellidae	8

← The HBI (tolerance value) of various families

Table 2. Evaluation of water quality using the family-level biotic index.

Family Biotic Index	Water Quality	Degree of Organic Pollution
0.00-3.75	Excellent	Organic pollution unlikely
3.76-4.25	Very Good	Possible slight organic pollution
4.26-5.00	Good	Some organic pollution probable
5.01-5.75	Fair	Fairly substantial pollution likely
5.76-6.50	Fairly poor	Substantial pollution likely
6.51-7.25	Poor	Very substantial pollution likely
7.26-10.00	Very poor	Severe organic pollution likely

↑ Using the FBI (family biotic index) to determine water quality and the degree of pollution

Calculating the family biotic index (FBI)

$FBI = \frac{\text{total}(n \times a)}{\text{total}(n)}$ ← FBI formula

example

order	Specimen family	tally (n)	tolerance (a)	Product (n×a)
Odanata	Coenagrionidae	8	9	72
Diptera	Chironomidae	4	6	24
Amphipoda	Gammaridae	2	4	8
		14	≈6.3 avg.	104

FBI	water quality	degree of organic pollution
7.43	very poor	severe organic pollution likely

$FBI = \frac{n \cdot a}{n}$ so... $\frac{104}{14} \approx 7.43$

The family biotic index of this data set is 7.43.

The Los Angeles River
- a 51 mile long water way
  - starts at Canoga Park
  - drains into Pacific Ocean
  - enters ≈17 different cities
- paved with concrete in 1938
  - except for in 3 locations:
    Glendale Narrows
    Sepulveda Basin
    and Willow Street
  - this prevented large trees, fish, mammals, and other organisms from thriving here
- in some accessible areas, you can find macroinvertebrates
- almost guarenteed to spot birds
  - great blue herons
  - snowy egrets
  - black-necked stilts
  - belted Kingfishers
  - black-crowned night heron
- [1]is known for its unsanitary water (specifically in the downtown Los Angeles area)
  - Known pollutants include:
    pestdicide runoff
    fecal coliform
    trash
    fertilizer runoff
    motor oil runoff

[1]credit Paul Alva of L.A. county public works

Prerequisite:
Experiment Layout

Collection notes
- macroinvertebrates like to hide in sediment and vegetation
- also abundant in stagnant water

Materials

macroinvertebrate test
- white pan (16½ in. × 10½ in. × 3 in.)
- tall rainboots
- protective gloves
- field guide
- mobile identification app (iNaturalist)
- phone for photography and mobile app
- notebook
- pencil

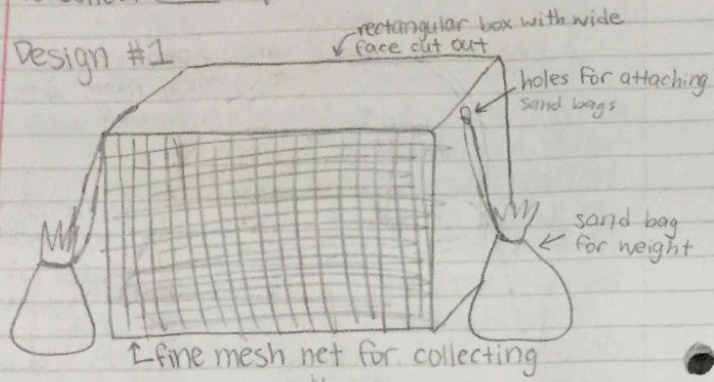
aquatic light trap
- small bucket with lid and handle (113.04 inches³)
- aluminum foil
- long lasting glow stick (12 hours)
- 2½ cement "rocks"
- sturdy twine (≤ 20 pounds)
- razor blade
- drill

chemical analysis
- 3 vials
- water quality testing kit (API Freshwater)
  - ammonia
  - nitrate
  - nitrite
  - pH

Prerequisite:
Additional Collection Design

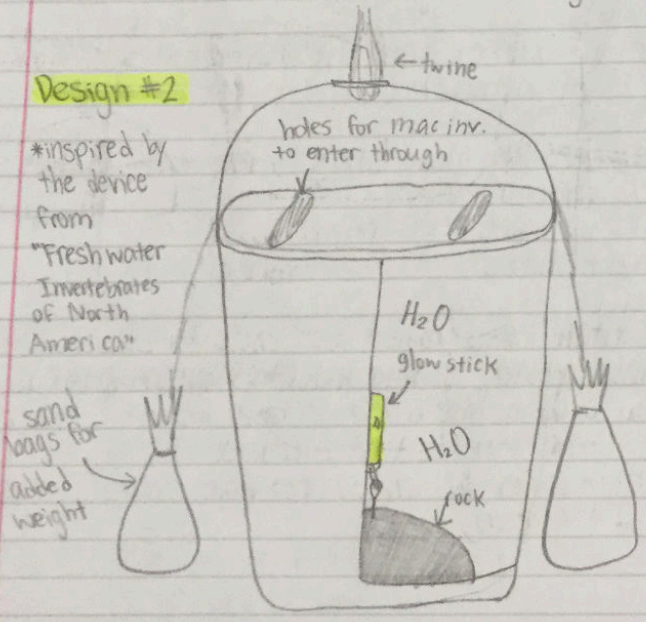
Goal:
To collect more aquatic macroinvertebrates

Design #1

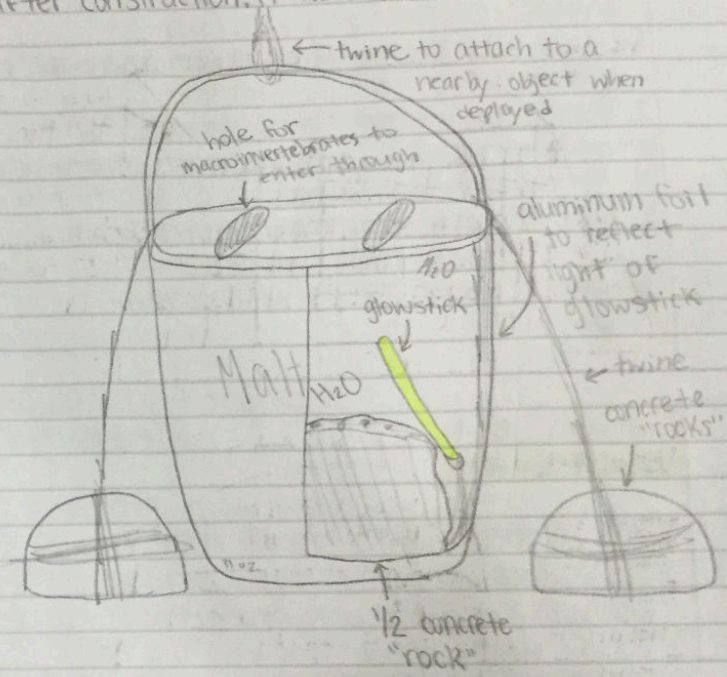


Design #2

*inspired by the device from "Freshwater Invertebrates of North America"



Revision of Design #2 after construction, it turned out like this:



*After two tests, and more time to elaborate on my project, I decided to build a device that would allow me to test longer. Greater length of time to test means I will get a better idea of the macroinvertebrates inhabiting the LA River.

Experimentation:

Procedure

Macroinvertebrat Test

tests #1 and #2

1. Lower white pan into water and collect sediment
2. Then allow sediment to settle to the bottom of the pan and macroinvertebrates to reveal themselves
3. Identify and tally macroinvertebrates to determine HBI and FBI
4. Repeat above steps until 1 hour is up

Chemical Test

tests #1 - #4

1. Fill 3 vials with 5 mL of river water
2. Add corresponding chemicals (ammonia, nitrate, [2]nitrite, and pH)
3. Follow instructions stated in the API Freshwater Mastery Kit handbook

ammonia → add 8 drops of solution #1
add 8 drops of solution #2
shake vigorously for 5 seconds
wait 5 minutes
read the results (ideally 0-0.25 ppm)

nitrate → add 10 drops of solution #1
cap and invert several times
vigorously shake solution #2
add 10 drops of solution #2
vigorously shake for 1 minute
wait 5 minutes
read results (ideally 0-10 ppm)

[2]nitrite → add 5 drops of solution
cap and shake for 5 seconds
wait 5 minutes
read results (ideally 0-0.25 ppm)

pH → add 5 drops of solution
cap and invert several times
immediately read results
(ideally 7)

[2] nitrites not taken consistently

Aquatic Light trap Test

tests #3-#4

1. Activate glow stick
2. Lower trap into a deeper area
3. Tie securely to a nearby sturdy object
4. Set timer for 3 hours
5. Check after 3 hours
6. Identify and Tally macroinvertebrates to find HBI and FBI

Experimentation:

Testing macroinvertebrates

Test 1/4

Test Date: Nov 10, 2019, 2 pm
Location: Marshy area
Weather: sunny clear skies

Specimen order	specimen family	tally (n)	tolerance (a)	product (n·a)
Odonata dragon flies + damselflies	Coenagrionidae damselflies	8	9	8·9=72
	Libellulidae dragon flies	1	9	1·9=9
Hemiptera true insects	Corixidae water boatman	7	5	7·5=35
Diptera true flies	Syrphidae hover flies	4	10	4·10=40
Neogastropoda sea snails	Nassariidae eastern mudsnails	2	7	2·7=14
Amphipods amphipods	Gammaridae scuds / gammarus shrimp	4	4	4·4=16
Diptera true flies	Chironomidae non-biting midge	2	6	2·6=12
Ephemoptera mayflies	Baetidae small mayflies	1	4	1·4=4
Total	8 families	total (n) 29	average HBI 6.75	202

HBI + FBI

$HBI = \frac{\text{total (n·a)}}{\text{total (n)}} \cdot \frac{202}{29}$

≈6.97	Poor	Very substantial organic pollution likely
FBI	water quality	degree of pollution

Test 2/4

Test Date: Nov 17, 2019, 2 pm
Location: near riffle, stagnant water, other side of overpass
Weather: hot, clear skies

Specimen order	Specimen family	tally (n)	tolerance (a)	product (n·a)
Ephemoptera mayflies	Baetidae small mayflies	4	4	4·4=16
Gastropoda gastropods	Physidae pouch snails	6	8	6·8=48
Diptera true flies	Chironomidae non-biting midges	2	6	2·6=12
Hemiptera true insects	Corixidae water boatman	5	5	5·5=25
Total	4 families	17 total (n)	average HBI 5.75	total (n·a) 101

HBI + FBI

$HBI = \frac{\text{total (n·a)}}{\text{total (n)}} \cdot \frac{101}{17}$

≈5.94	fairly Poor	substantial Pollution likely
FBI	water quality	degree of pollution

Final (1)

average FBI = 6.46
water quality = fairly poor
degree of pollution = substantial pollution likely
average tally = 23
average tolerance = 6.5/7
average product = 151.50
total tally: 46 individuals
total families: 10

Test 3/4

Test Date: Feb 23, 2020 2pm
Location: near overpass, marshy area
Weather: breezy, warm weather

Specimen Order	Specimen Family	tally (n)	tolerance (a)	Product (n·a)
Ephemoptera mayflies	Baetidae small mayflies	5	4	5·4=20
Lepidoptera butterflies+ moths	Pyralidae aquatic moths	1	5	1·5=5
Diptera true flies	Chironomidae non-biting midges	1	6	1·6=6
	Simuliidae black fly	3	6	3·6=18
Total	4 families	10 total (n)	5.25 average HBI	49 total (n·a)
HBI + FBI	$HBI = \frac{\text{total (n·a)}}{\text{total (n)}} \cdot \frac{49}{10}$	= 4.9 FBI	good water quality	Some organic pollution likely degree of pollution

Test 4/4

Test Date: March 8, 2020
Location: Marshy area
Weather: Sunny, breezy

Specimen order	Specimen family	tally (n)	tolerance (a)	Product (n·a)
Ephemoptera mayflies	Leptophlebiidae prong-gilled may flies	4	4	$4^2=16$
	Baetidae small mayflies	100	4	100·4=400
Gastropoda gastropods	Physidae pouch snail	4	8	4·8=32
Diptera true flies	Chironomidae non-biting midge	2	6	2·6=12
	Simuliidae black fly	60	6	60·6=360
Lumbriculida earthworms	Lumbriculidae aquatic earthworm	16	8	16·8=128
Total	6 families	186	average HBI 6	948
HBI + FBI	$HBI = \frac{\text{total (n·a)}}{\text{total (n)}} \cdot \frac{948}{186} \approx$	5.1 FBI	fair water quality	Fairly substantial pollution likely degree of pollution

Experimentation:

Testing chemical

Test	Ammonia	Nitrate	pH
1/3 Dec. 15, 2019	1 ppm	10 ppm	8.4
for tests 1/4 and 2/4	notes: previously rained, may have reduced ammonia levels		
2/3 Feb. 23, 2020	0 ppm	10 ppm	8.4
for test 3/4	notes: previously rained (again), reducing ammonia and nitrate, urban runoff		
3/3 Mar. 8, 2020	0.15 ppm	20 ppm	8.4
for test 4/4	notes: abundance of algae may be result of urban runoff during rain		

Observations:
Abundant growth of algae at test 2/3, may be caused due to urban runoff carying nitrate rich fertilizers.

Experimentation:

Totals and Averages

Macroinvertebrate Test

#	Specimen Family	Common Name	HBI	total tally
1.	Coenagrionidae	Damselfly	9	8
2.	Libellulidae	Dragon fly	9	1
3.	Syrphidae	Hover fly	10	4
4.	Gammaridae	Scud	4	4
5.	Nassariidae	Eastern mudsnail	7	2
6.	Pyralidae	Aquatic moth	5	1
7.	Corixidae	Water boatman	5	12
8.	Baetidae	Small mayfly	4	85
9.	Physidae	Pouch Snail	8	10
10.	Chironomidae	Non-biting midge	6	7
11.	Simuliidae	Black fly	6	63
12.	Leptophlebiidae	Prong-gilled mayfly	4	27
13.	Lumbriculidae	Aquatic earthworm	8	16
			average tolerance: 6.5	total: 240 individuals

Chemical Test

Ammonia: 0.83 ppm
Nitrate: 13.3 ppm
pH: 8.4

Family Biotic Index (FBI)

5.73
Fair water quality
Fairly substantial pollution likely