MOBILE WATER PURITY TESTER (MWPT)

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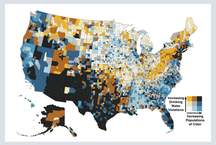
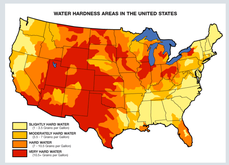
PROBLEM STATEMENT

Many people in the United States have been drinking contaminated waters unknowingly, which causes health problems. Our solution targets middle class homeowners, property owners, and communities with widespread water contamination.



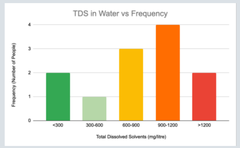


OBJECTIVE

- Reducing financial costs of frequent water testing, therefore increasing accessibility
- Helping the environment by creating a reusable prototype
- Creating a user friendly design that can easily be navigated by anyone with any level of experience with tech

RESEARCH

- Neighborhood Survey with Our Clients
- 6 out of the 12 homes we surveyed in Millcreek and Holladay said they have or had water with an unsafe TDS.
- 1/5 of the people in the United States have been exposed to contaminated waters
- Furthermore, the current market solutions to this product are either cheap and do not provide comprehensive information, or they are very expensive and inconvenient to use. Our goal is to create a device to compete with these two options, creating a more competitive option in the marketplace.



COMPONENTS & COSTS

Bill of Materials

Component	Price
Arduino Mega	$3.10
TDS Sensor	$2.80
Turbidity Probe	$2.20
Temperature Sensor	$1.20
pH probe	$4.20
TFT LCD (ILI9341)	$4.57
5V Buck Converter	$0.68
DS3231 RTC Module	$0.85
SD Card Module	$0.59
General Discrete Components	$0.10
Waterproof Case	$5.50
Battery	$8.95
Total:	$34.74


ARDUINO MEGA


TDS PROBE


SD CARD MODULE


PH PROBE

USER REQUIREMENTS

AFFORABLE
In the current market, high quality water purity testers are around $100 and often require you to send them to a lab. The other end of the spectrum comprises cheap single use kits that lack measurement characteristic and understandable data

REUSABLE
Most common water testers in the market are single use and can be unhealthy for the environment as they are made of plastic. Our clients want the ability to check their water purity regularly to ensure that the quality hasn't changed and their filters are working properly.

EASY TO USE
Complications of instructions could impact the outcome of the testing process and cause incorrect results. Another major concern for our clients was usability.They wanted a device that was easy to use and presents the data in a simple model.

PEACE OF MIND
Clients want to know for sure if there's anything wrong with their water and the confidence to drink it without concerns about safety.

OVERVIEW

The latest revision includes the following:
- The ability to log data onto an SD card for data processing.
- The ability to measure different characteristics of water, including pH, TDS, Turbidity, and Temperature.
- Wired direct connectivity to a desktop application to directly interface with the data collection.
- Easy to use touchscreen to allow for easy interface with the functionalities of the device.
- Portability in a waterproof and sturdy container for ease of use in almost any location.
- Rechargeable batteries to reduce the amount of E-waste produced from single use batteries.
- Easily replaced low cost sensor probes to allow for an extended working lifetime.

PROTOTYPES AND DESIGN ITERATIONS

First Design

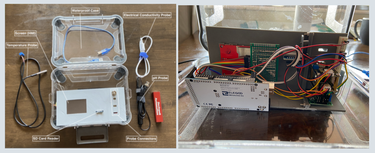
1. Added a 16x2 LCD screen display for an interface and implemented sensors that detected pH levels, TDS levels, Turbidity levels, and temperature.

Second Design

2. The first design was used for multitudes of different water tests from numerous sources of water. Data was written down digitally or written by hand.
3. We evaluated the limitations of the prototype and based on client feedback and other challenges we faced during development, we implemented the solutions to these problems in the second prototype
   a) Challenge #1: The device was terribly fragile, had difficulties in transportation, and was very vulnerable to damages
      i. Solution: To combat this problem we added a waterproof case and had parts soldered together onto PCBs
   b) Challenge #2: Prototype could not operate if unattached to an outlet.
      ii. Solution: Further iterations were built to be powered by a mobile power source
   c) Challenge #3: No data storage
      iii. Solution: Integration of an SD card module to allow for easy data logging of the sensors' readings
4. Tested the second prototype similarly to the first prototype(repeating steps 2 & 3)

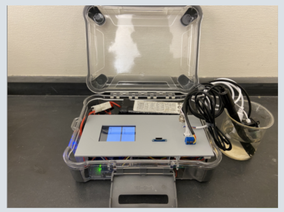
Third Design

   a) Challenge #1: Interference between devices on the SPI bus lanes.
      i. Solution: To resolve this issue, a "software SPI" bus was used to create individual communication lanes to mitigate this interference.
5. Repeated the process from step 4 to continue improvement to the 4th prototype.

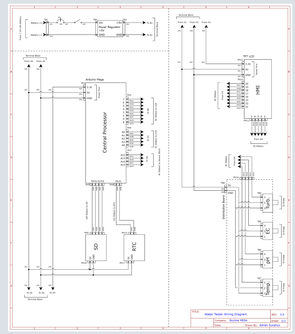


Fourth Design

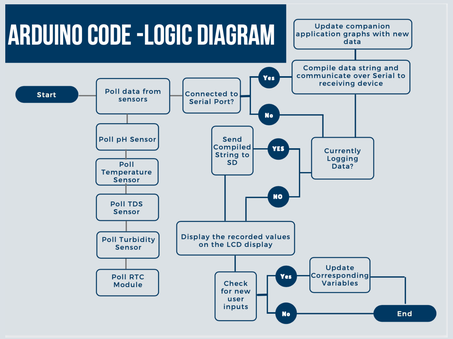
   b) Challenge #1: Resolve the issue with the probe calibration.
      i. Solution: Using a known voltage reference, it is possible to determine the appropriate adjustment constants to apply to the voltages.
   c) Challenge #2: Communicate directly with the device.
      ii. Solution: Usage of the serial bus to transfer data reliably.
6. Future revisions are planned, taking into account feedback from clients and users.



DIAGRAMS



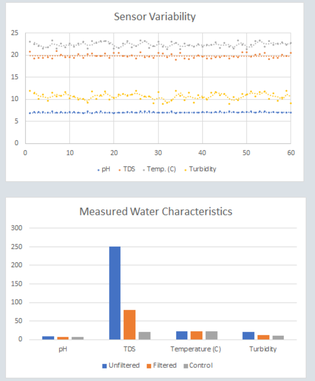
Right: *Wiring Diagram of Prototype Water Tester revision 4*



TESTING AND DATA

How did we test our system?
We exposed the prototypes to many separate samples of water, to make sure that it could detect a differences between them. The three selected samples came from two different residences, one with a recently installed water filtration system, along with another that does not have one installed. To act as a baseline, distilled water was used as it has the highest purity. Another test that was used was to test the drift of the sensors, and how noisy the data was.

Results
We performed a significance test that confirmed that our Arduino and independent sensors provided results that were not significantly different from each other for pH. This shows that our programming and the prototype itself is functional. Our sensor was also only slightly variable when measuring each attribute of the water when they are kept constant. These results show that our measurements are accurate, which means that our product is viable as a tool to decrease the inequity in accessibility to water testing.

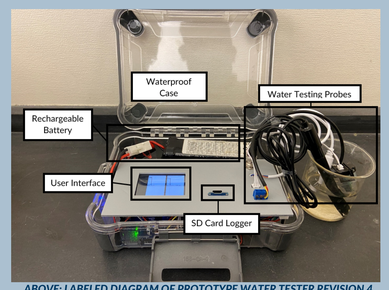


RATIONAL AND FUTURE IMPROVEMENTS

Why did we design our product the way we did?
- **Total Dissolved Solids, pH, Temperature, and Turbidity** are significant metrics to measure water characteristics, especially in regards to human health. The probes that were utilized were also easily replaceable, reducing the environmental impact, while also reducing the cost in the long term.
- **Touchscreen Display** as it is easy for the client to interact and interface with the device without difficulty. The simplicity of using visual buttons for user control and the flexibility of design were also major advantages.
- **SD Card and RTC** in order to allow for longer-term data storage. This means that the card logs water quality over time so the user does not have to manually enter data over time.
- **Waterproof Casing** to prevent accidental damage to the device due to contact with water, and to increase the portability of the device as a whole.
- **Companion Application** to enhance the client's experience by providing a larger and easier to interpret visual display that shows the real-time data collected by each of the sensors.

What are the limitations of our product? How can they be solved in the future?
- Limitation #1: Device will automatically shut down without warning when the battery runs out.
  - Possible Solution: Implement sounds to tell the user that device has run out of battery.
- Limitation #2: Wireless Communication is unavailable
  - Possible Solution: Implementation of a Bluetooth module and a mobile application

Recommendations and the Future:
- In future iterations, the integration of wireless Bluetooth is a high priority. Another possibility for the implementation of this device is with water filtration systems, where it may act as a more "permanent" water logging device.
- Another improvement would be the integration of other sensors, although they would add to the overall cost of the system and are not necessary for basic water testing. They could be offered in other versions of this device



ABOVE: LABELED DIAGRAM OF PROTOTYPE WATER TESTER REVISION 4

MARKETING

- We want to take advantage of our large market Size (128 million households in the US) :
- We will create a website that provides:
  - Information
  - Customer Reviews
- We will advertise on mainstream and social media
  - We will optimize SEOs to increase search results for our product