

CAN A SOLUTION BE CREATED THAT CAN IDENTIFY A LEAK OR OVERFLOW, MEASURE ITS INTENSITY AND NOTIFY INSTANTANEOUSLY?

Aqua Saver

The conservation of water through an arduino-based water sensor product

An easy and inexpensive solution to minimize water leaks and overflows.



ABSTRACT

Water is a very vital resource for all living beings. According to **National Geographic**, there is only **1% of water is available for use** in households, agriculture and industries. **By 2025, two-thirds of the world's population will be facing water shortages.** A lot of research has been focused on water conservation, yet the challenge still remains; to reduce water wastage through leaks and overflows. Household leaks can waste nearly 900 billion gallons of water annually.

One possible way to solve this problem is to create a solution that can detect the leak or overflow, measure the intensity, instantaneously notify of water wastage; and is easy to use.

The product Aqua Saver is a device comprised of two key components, an Arduino Uno Wifi Microprocessor Board and an Arduino compatible water sensor powered by battery.

The data showed that Aqua Saver with its following three features, immediate leak or overflow detection, instant notification and measurement of intensity of the leak or overflow; was able to minimize water wastage. AquaSaver helped proactively avert damages due to a leakage or overflow.

AquaSaver installations from 1 household to 10.7 million households in the US can increase savings of water from 720 gallons to 77 billion gallons of water.

CURRENT CONSUMER OPTIONS

Research for solutions to instantly identify and notify leaks and overflows yielded following results:

1. SCADA: A solution used by SRP which manages water reservoirs for phoenix city.
2. FIBARO: A smart home automation company product.
3. Honeywell Reusable Water Leak Alarm: A widely used economical product for day to day use.

Solutions	Setup & Installation	Cost	Instant Notifications	Leak and Overflow Intensity Measurement
SCADA	Hard	High	Yes	Yes
Honeywell Leak Alarm	Easy	Low	No	No
FIBARO	Easy	Medium	Yes	No
Aqua Saver	Easy	Low	Yes	Yes

Aqua Saver is easy to set up, inexpensive, supports instant notifications and additionally offers the leak and overflow intensity measurement.

RESEARCH

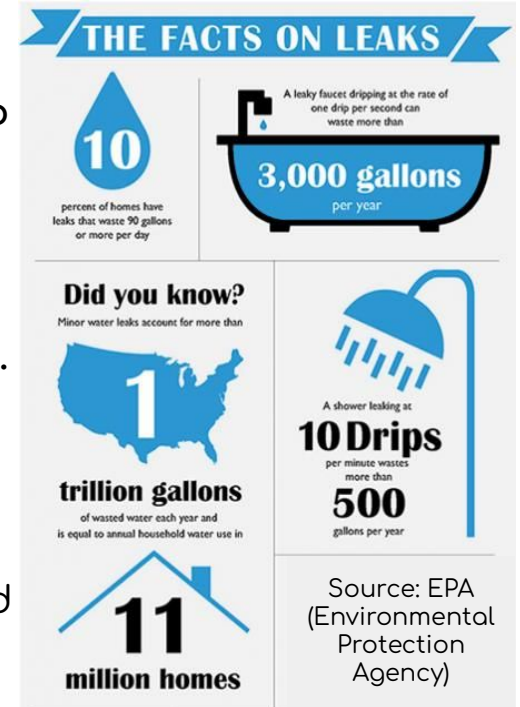
According to National Geographic, 70% of world is covered with water but only 2.5% of it is freshwater. Out of that 1.5% is frozen in glaciers and snow caps. So, there is only 1% of water is available to us for use in households, agriculture and industries.

Today 1.1 billion people lack access to water and 2.7 billion experience water scarcity at least one month a year. By 2025, two-thirds of the world's population will be facing water shortages.

Environmental Protection Agency (EPA) has stated that, **“Wasting Water Is A Much Bigger Problem Than You Think”.**

A lot of research has been focused on water conservation, yet the challenge still remains; to reduce water wastage through leaks and overflows.

Household leaks can waste approximately nearly 900 billion gallons of water annually.



ENGINEERING NEED

Imagine coming home after a long day, walking into the backyard, and realising everything is wet. The pool has flooded and thousands of gallons of water have been wasted. The damages will be very costly to fix. Can a solution be created that can identify a leak or overflow, measure its intensity and communicate it instantaneously?

Wastage of water due to leaks and overflows is a #1 challenge faced by every household and industry. Leak and overflow incidents occur with pools, water heaters, pipes, toilets, water reservoirs, and water tanks. A small leak or overflow can also cause damages and can become an expensive problem to solve.

There is a need for a solution that can detect the leak or overflow, measure the intensity and instantaneously notify of water wastage. It should be inexpensive and easy to use.

DESIGN REQUIREMENTS AND CONSTRAINTS

Design Requirements

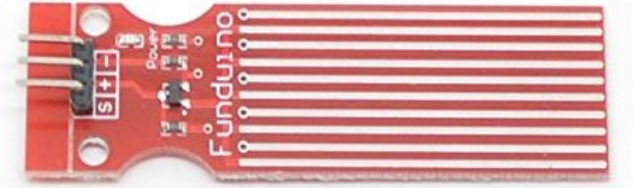
- Detect water leak/overflow
- Measure intensity of leak/overflow
- Communicate real time data
- Usable everywhere and every day (households, industry & agriculture)
- Inexpensive

Design Constraints

- Dependency on internet connectivity/Wifi
- Uninterrupted or accessible power supply for Arduino board

MATERIALS

- 1 Arduino Uno Wifi Rev2 processor board
- 3 Arduino dupont wires (red, blue & green)
- 1 Arduino compatible Water Sensor
- The Arduino IDE software on the computer
- 1 USB Arduino cable
- 1 battery
- Water in a tub or pool
- A phone with the ability to text
- The blynk App
- A computer to write the code, and to display results from the Arduino Sketch
- A Stopwatch



Water Sensor



Arduino Uno Wifi

CODE

```
#include <SPI.h>
#include <WiFiNINA.h>
#include <BlynkSimpleWiFiNINA.h>
char ssid[] = "xxxxxx";      // your network SSID (name)
char pass[] = "xxxxxx";      // your network password
char auth[] = "4db61b17050a48cabd55bb114alf6405";
int status = WL_IDLE_STATUS;
const char* host = "maker.ifttt.com";
const int httpsPort = 443;
void setup() {
  //Initialize 'serial and wait for port to open
  // sets data rate to 9600 bits per second
  Serial.begin(9600);
  while (!Serial) {
    ; // wait for serial port to connect.
  }

  // attempt to connect to Wifi network:
  while (status != WL_CONNECTED) {
    status = WiFi.begin(ssid, pass);
    // wait 10 seconds for connection:
    delay(10000);
  }
  // you're connected now, so print out the data:
  Serial.print("You're connected to the network");
  // connect to Blynk App via Wifi:
  Blynk.begin(auth, ssid, pass);
}
```

```
void loop() {
  int sensor = analogRead(A1);
  // This is a major overflow, which needs immediate attention
  if (sensor >= 550){send_text_message("high");}
  // This is a minor leak, which needs to be fixed soon!
  else if (sensor >= 100 && sensor < 550)
  { send_text_message("medium");}
  else { // This is not a leak or overflow.}
  Blynk.run();
}

void send_text_message(char * intensity)
{
  WiFiClient client;
  Serial.print("connecting to ");
  Serial.println(host);
  if (!client.connectSSL(host, httpsPort)) {
    Serial.println("connection failed");
    return;
  }
  String url = "/trigger/AquaSaver/with/key/j3Cu4Tq4FKz-Q7PvqTbC4";
  // arduino board sending trigger for leak-overflow to maker.ifttt.com
  client.print(String("GET ") + url + intensity + " HTTP/1.1\r\n" +
    "Host: " + host + "\r\n" +
    "User-Agent: BuildFailureDetectorESP8266\r\n" +
    "Connection: close\r\n\r\n");
  Serial.println("request sent");
}
```


BUILD PROCEDURES

Arduino Water Sensor

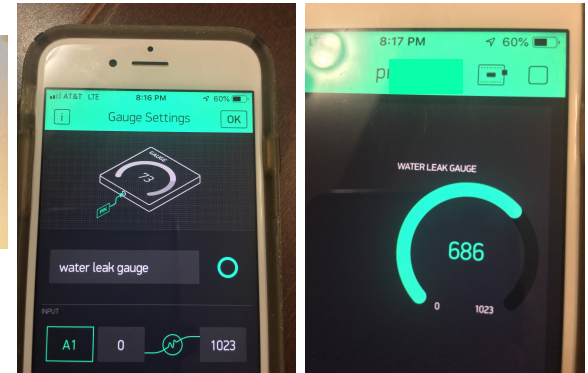
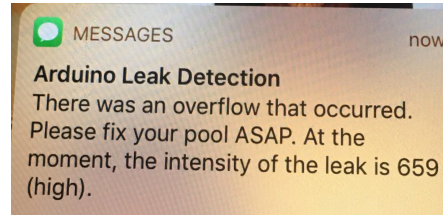
1. Connect the red wire from the S on the water sensor to the A1 under Analog In on the Arduino board.
2. Connect the blue wire from the "+" on the water sensor to the 5V under power on the Arduino board.
3. Connect the green wire from the "-" on the water sensor to the GND under power on the Arduino board.

Arduino Integrated Development Program (IDE) Coding

1. Create a sketch program to 1) connect the arduino board to the wifi, 2) read the sensor data, 3) send a text message when overflow or leak is detected and 4) show the intensity of leak on blynk app via leak gauge.
2. Compile, run and upload code to Arduino board.
3. Test Circuit. Test when water sensor detects water, the numeric data representing intensity of water or level of water is displayed on the Blynk App and a text message is sent.

Phone App and Text Message Programming

1. Download the blynk app
2. Finish setup to connect to Arduino uno Wifi.
3. Add an Intensity Gauge on the App.
4. Specify the port to connect as analog 1
5. The data will pop up as numbers or in a scale



TEST PROCEDURES

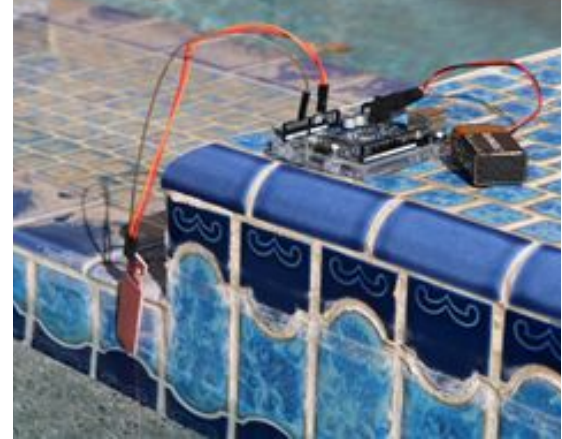
*There can be numerous test cases, however, this test procedure is to detect rising water level of the swimming pool.

Pretest checks

- Power the Arduino board.
- Ensure connection to Wifi.
- Keep phone/app handy.
- Reset timer.

Physical Sensor Placement

- Place or hang the sensor right above the pool water level
- Keep the board secure so it cannot move during the experiment
- Make sure that the board is in a place where the water cannot reach it

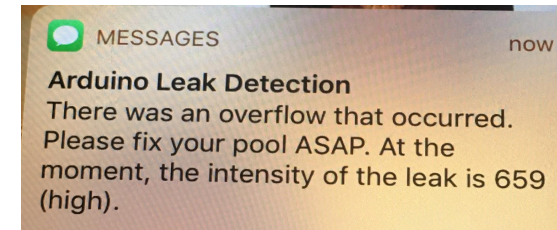


Record Results

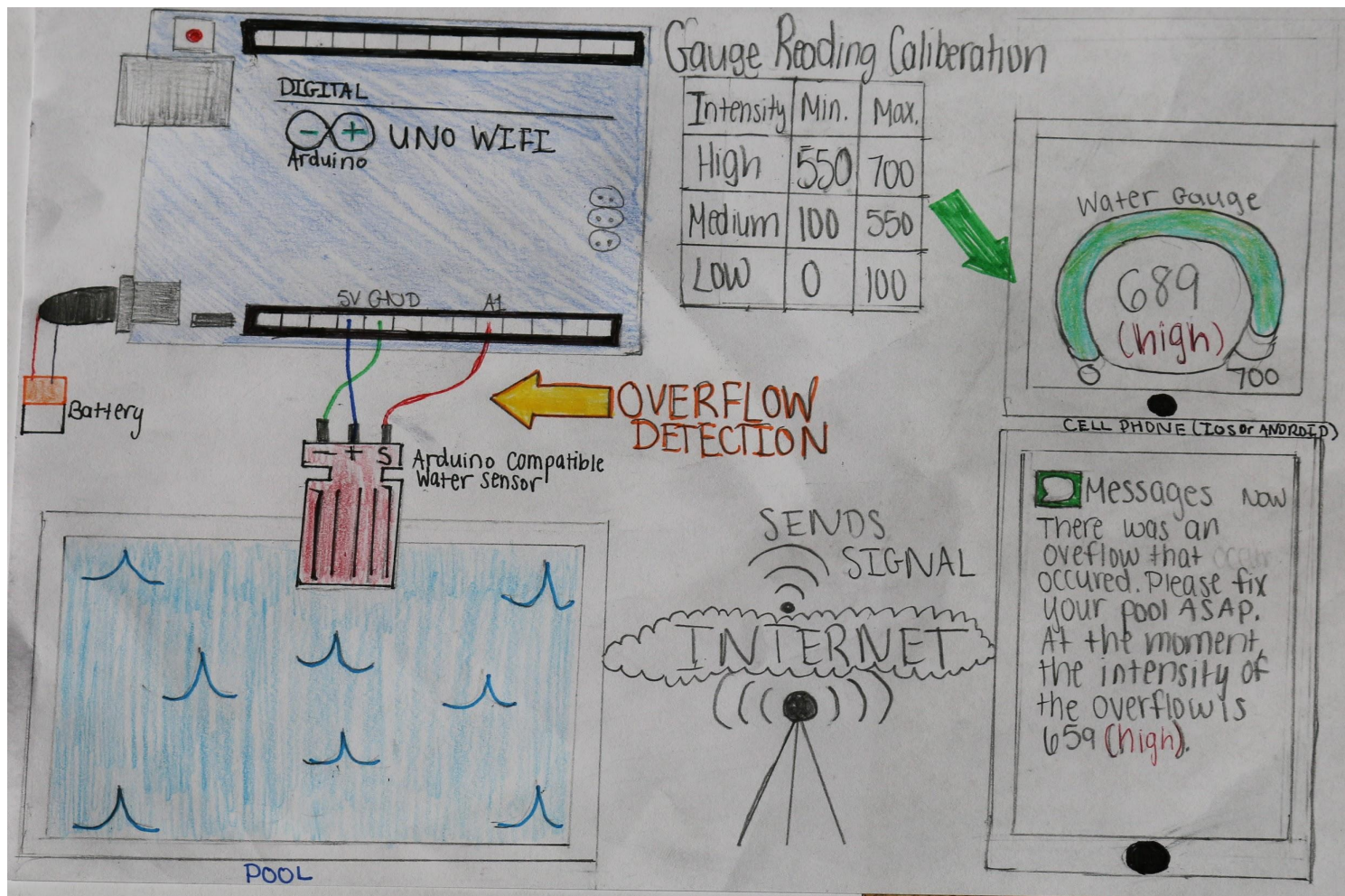
- Start Stopwatch
- Supply water into the pool from external source, check for rise in water level
- Wait until the sensor gets partially covered in water.
- On receipt of first message on phone, stop the timer.
- The message should read that there is a pool overflow and to fix it ASAP.

Then it shows that the sensor works.

Repeat steps 2-4 three more times for the different trials



INITIAL DESIGN

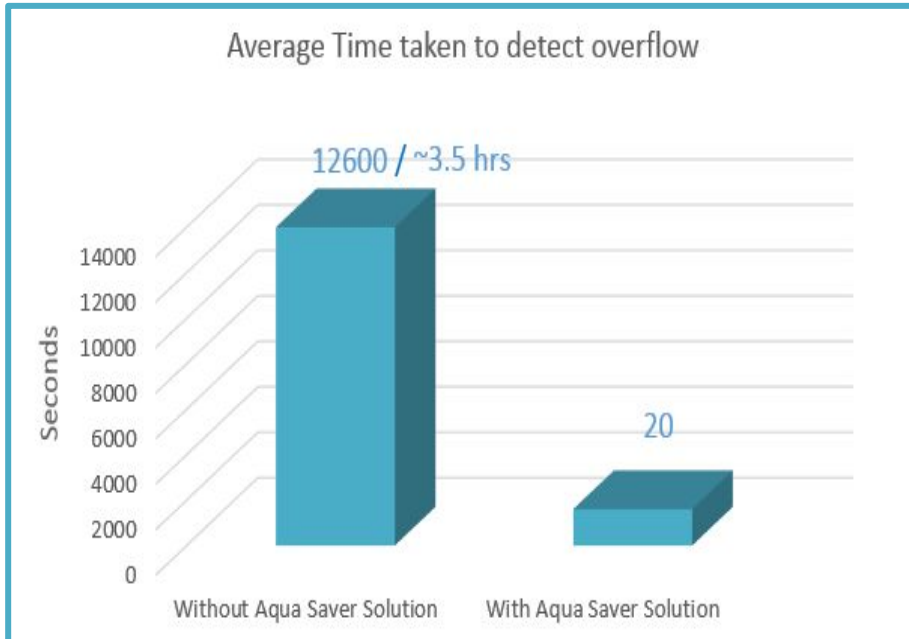


DATA COLLECTION: OVERFLOW DETECTION TIME & WATER

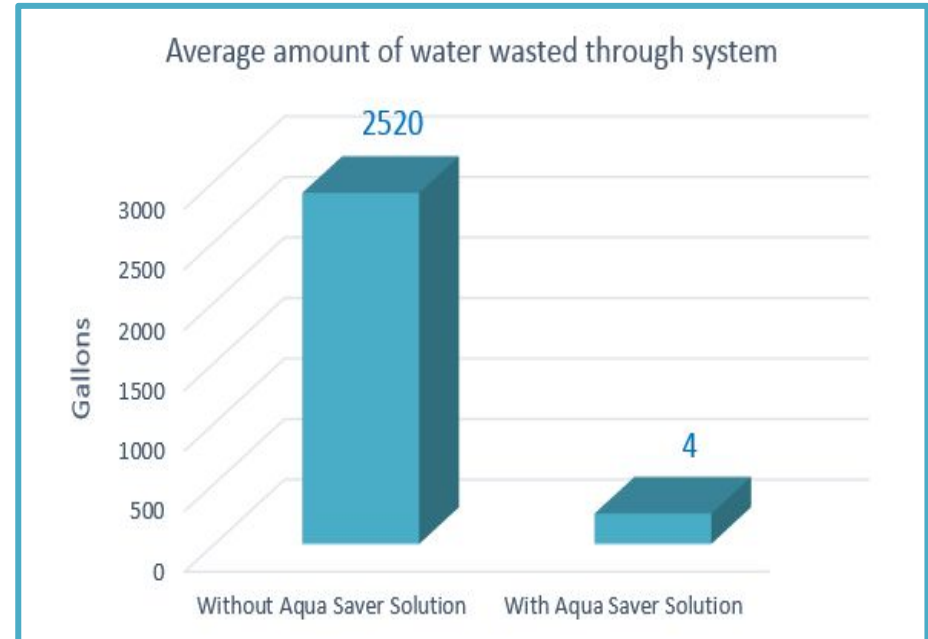
Detection system		Time taken to detect overflow (seconds)	Amount of water wasted (gallons per second)	Total water wasted through system (gallons)
Without Aqua Saver Solution	Trial 1	21600 (6 hours)	.2	4320
	Trial 2	14400 (4 hours)	.2	2880
	Trial 3	3600 (1 hour)	.2	720
	Trial 4	10800 (3 hours)	.2	2160
With Aqua Saver Solution	Trial 1	35	.2	7
	Trial 2	25	.2	6
	Trial 3	17	.2	3.4
	Trial 4	4	.2	.8

GRAPHS

Average time taken to Detect Overflow without and with AquaSaver Solution



Average amount of water wasted due to overflow without and with AquaSaver Solution



MATHEMATICAL ANALYSIS OF DATA

g = number of gallons of water saved

$$g = 720 * t * h$$

t = number of hours of water overflow

h = number of households

720 = is the number of gallons wasted per hour per household (derived from slide #10)

There are 10.7 million residential and public swimming pools in the United States, according to the Association of Pool & Spa Professionals (APSP).

Number of Households (h)	Number of hours of water overflow (t)	Number of Gallons of water saved (g)
1	1	720
1	5	3,600
1	10	7,200
2	2	1,440
2	10	7,200
2	20	14,400
...
10.7 million	10.7 million	77 billion
10.7 million	53.5 million	38 billion
10.7 million	107.9 million	77 billion

Looking at the mathematical data analysis presented, AquaSaver installations from 1 household to 10.7 million households in US can increase savings of water from 720 gallons to 77 billion gallons of water.

CONCLUSION

The data showed that when AquaSaver was installed at a pool, it was able to detect the overflow, measure the intensity and instantly provide notifications; which resulted in saving water. AquaSaver helped proactively avert huge damages due to a pool overflow.

AquaSaver installations from 1 household to 10.7 million households in the US can increase savings of water from 720 gallons to 77 billion gallons of water.

Aqua saver if scaled to industries, households and agriculture across the whole world, it can conserve trillions of gallons of water of the 1% of freshwater on Earth.

CURRENT LIMITATIONS AND FUTURE RESEARCH

Current Limitations:

- Leaks and overflows are detected instantly but the water flow does not stop instantly
- Product is not completely waterproof
- Leaks and overflows are detected but the location is not identified

Future Research:

- Integrating Aqua Saver with a smart water valve to stop water flow as soon as the leak or overflow is detected
- Create a fully waterproof casing for the product
- Adding additional functionalities such as location of the leak or overflow

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