Table of Contents

Introduction 3
Presentation 3
Motivation 4
Objective 4
Problem 5
Requirements 6
Tests 7
Report Structure 7

Introduction

In recent years, technology has transformed ordinary household items into connected devices, a trend often referred to as the “smartification” of everyday objects. From thermostats, watches and lighting systems have become intelligent, these devices now collect data, analyse behavior, and make daily routines more efficient and personalized.

Our product, TRAQUA, is a smart water bottle which is a great example of this evolution. Beyond simply holding water, it actively analyzes the purity of the liquid and monitors the user’s hydration needs. By connecting to a companion app, the bottle provides real-time insights, reminders, and personalized recommendations to help users maintain optimal health. This integration of sensing technology, data collection, and mobile connectivity demonstrates how even a simple object like a water bottle can be transformed into a smart, health-focused device. With TRAQUA, users also gain assurance about the quality of their water. To achieve this, a filter is integrated, minerals are monitored via a TDS sensor, and both the filter and the water are purified. As a result, customers can be confident that their tap water is clean and enjoy greater flexibility.

The following report describes the development of the TRAQUA project.

Presentation

The TRAQUA team (Figure 1) consists of six students from diverse nationalities and academic backgrounds who have come together at ISEP to take part in the European Project Semester (Table 1).

Figure 1: TRAQUA team

Table 1: TRAQUA members, countries and educational background

Name	Home country	Field of Study
Bernardo Alves	Portugal - Luxembourg	Information Technology
Maria Wlodarczyk	Poland	Business, Society & Technology
Guillem Vázquez Rolduà	Spain	Industrial Design & Product Development
Inès Margand	France	Packaging Engineering
Maximilian Salmi	Finland	Electrical & Automation Engineering
Rieke Platthaus	Germany	Environmental & Civil Engineering

Motivation

As a team, we have chosen the European Project Semester because we believe this experience will enrich us both professionally and personally. Working in a multidisciplinary, international team provides us with the unique opportunity to collaborate with people from diverse cultures and academic backgrounds. A central goal for us is to forge international connections and to discover Europe and our respective home countries from entirely new perspectives. We deeply value interdisciplinarity at all levels, both geographically, through cultural exchange, and academically, by synergizing our various fields of expertise. This framework allows us to enhance our creativity and problem-solving skills while preparing ourselves for a global professional work environment.

The idea of developing a smart reusable bottle came about very quickly. It was important to us to create an item that would improve the everyday life of the user. The motivation came from health improvements as well as sustainability reasons. These are explained below.

The development of a smart, reusable water bottle directly addresses environmental concerns. By offering a durable, long-lasting alternative to single-use plastic bottles, the system encourages more sustainable behavior and reduces plastic waste. Users can rely on one high-quality product instead of repeatedly purchasing disposable bottles, contributing to a more eco-friendly lifestyle. Nevertheless, reusable bottles are already part of most people’s everyday lives. Using them saves not only plastic resources but also money, as users do not have to buy plastic bottles.

However, this raises the problem that often not enough attention is paid to the hygiene of the bottle and the quality of the water. At the same time, it is easy to lose track of how much you are drinking. A smart bottle addresses both issues.

The bottle focuses on supporting healthy hydration. By using microcontrollers, it can track the volume of water consumed and monitor the fill level in real time. This helps users ensure they drink enough throughout the day, an especially important factor for individuals with health conditions that require consistent fluid intake.

By linking microcontrollers to obtain values such as minerals, and organic residues, users can be sure of the quality of the water and drink without worry. The bottle therefore supports healthy hydration, while the quality assurance feature can remind users to clean the bottle regularly. People who are particularly dependent on regular water intake, such as those with diabetes or kidney disease, can track the amount they drink. At the same time, the smart bottle can be a helpful device for anyone who wants to stay hydrated and maintain an overview of their intake. To further strengthen motivation, the system can be connected to a user-friendly app that uses gamification elements to make hydration tracking intuitive. This playful approach helps users build lasting habits without effort.

Overall, the project aims to combine sustainability, health awareness, and smart technology into a practical everyday solution that users are motivated to adopt and continue using.

Objective

The purpose of this product is to measure the purity of tap water, as well as encouraging customers to keep themselves hydrated throughout the day. Our main objective is to adapt a smart bottle into the everyday life of people who are concerned about the cleanliness of the tap water at their home, or in a foreign environment. Our intended audience are people who care about their health and are willing to download an app, to track their daily water intake.

Objectives:

- Develop a smart water bottle that monitors tap water quality fast and reliably.
- Measure key water parameters Total Dissolved Solids (TDS), temperature, potential impurities etc.).
- Provide real-time feedback to ensure safe water consumption.
- Use UV-C light to clean water and bottle.
- Track daily water intake through a connected mobile application.
- Deliver personalized hydration goals based on user data.
- Use gamification features (challenges, streaks, rewards) to encourage consistent hydration habits.
- Design the product to be portable, simple, reliable, and easy to integrate into everyday life.
- Target health-conscious individuals concerned about water purity at home or in unfamiliar environments.
- Combine safety, technology, and behavioral motivation into one practical and user-friendly solution.

Problem

Staying hydrated is one of those things we all know we should do, but rarely manage to do well. It is not just about forgetting to drink enough water, it is about the reality that we have no idea if the water we’re carrying is actually good for us.

Right now, the market is split, and honestly, both sides are falling short:

- The Common Bottle: Most reusable bottles on the market are just fancy cups. They do not track your habits, and they definitely do not tell you if the water quality is compromised by poor mineral levels or contaminants. Many bottles become dirty very quikly.
- The Basic Trackers: There are bottles that log your daily intake, sure, but they are essentially one-trick ponies. They ignore the chemistry of the water entirely. They will tell you how much you drank, but not what you drank. There are bottles that clean itself and the water, but they do not mesure anything else.
- The Overpriced/Clunky Tech: Then you have the high-end solutions. Usually they are very expensive and focuse only on one topic. They promise the world but usually come with a price tag that feels more like an investment than a purchase, or they are saddled with buggy, unintuitive apps that make tracking feel like a part-time job.

The current smart bottle market is fragmented, and existing solutions fail to address the problem in a comprehensive and reliable way:

- Conventional Reusable Bottles: Most reusable bottles function as simple containers without any intelligent features. They do not provide feedback on hydration behavior, water quality, or hygiene. As a result, users receive no guidance, while bottles can quickly become contaminated due to insufficient cleaning, leading to unnoticed hygiene risks. Many reusable ottle have a hygiene problem, because they are not cleaned proberly.
- Basic Tracking Solutions: some smart bottles focus on hydration tracking by measuring water intake and providing reminders. However, these solutions are limited in scope. They only quantify how much water is consumed but completely ignore water quality, mineral content, and contamination risks. Similarly, bottles with UV-C cleaning address hygiene but do not provide any data or insights beyond that single function.
- High-End but Limited Systems: More advanced products on the market are often expensive and

tend to focus on isolated features rather than offering an integrated solution. In addition, they may rely on complex or unintuitive apps, which can reduce usability and discourage long-term engagement. The high price point also limits accessibility for a broader user base.

Overall, existing products address individual aspects such as tracking, cleaning, or design, but fail to combine hydration monitoring, hygiene, and water quality analysis into one coherent and user-friendly system.

Requirements

The following requirements have been established to guide through the development of this project. Requirements are uniquely identified for traceability through the project lifecycle.

General Requirements

- Budget Constraints: The team has a total budget of 100 €. That budget should not be exceeded. Priority is given to hardware pieces to have more precise data.
- Adopt the International System of Units (SI) <color #ed1c24>**[1]**.
- All electronic components shall comply with Directive 2011/65/EU (RoHS), restricting hazardous substances **[2]**.
- Wireless communication modules shall comply with Directive 2014/53/EU (RED) **[3]**.
- Other aspects like the EMDC and LVD must also be complied.

App Requirements

- Easy to use
- User-friendly interface
- Core actions shall be reachable within two clicks
- Developed using react
- Error prevention
- The application shall display the user’s cumulative water intake for the current day in millilitres (ml)
- Track water intake, minerals in water and other useful data for the user
- Personal data collection and processing shall comply with Regulation (EU) 2016/679 GDPR **[4]**

Sustainability requirements

- The material used for the bottle should be environmentally friendly
- Use energy-saving technologies during the production process
- Keep the carbon footprint as minimal as possible

User Requirements

- As a user I want to track my total water intake
- The usage must be safe
- As a user I want to know if the tap water I poured in my bottle is safe to drink or not
- As a user I want to have a bottle that both easy to cary and also has a nice design

Key Requirements

- Arduino chip

- Mineral reading sensors

Tests

Before TRAQUA can be successfully deployed, it is essential to ensure that the entire smart water bottle system operates reliably and safely. This requires structured testing at every stage—from the physical sensors up to the mobile application —to catch bugs early and guarantee a seamless user experience.

Our testing focus centers on these key areas:

- Water-Quality Classification & States: The core of TRAQUA is its ability to accurately classify water safety into states (Safe, Warning, Unsafe, or Unknown) based on pH, TDS, and temperature readings. We test this full chain to ensure the physical bottle and the app always display the correct safety verdict.
- Fail-Safe Interlocks (UVC Light): For user safety, the UVC disinfection light must never turn on unless the bottle is fully closed. We strictly test the magnetic reed switch connection to ensure the light safely deactivates if the interlock isn't met.
    - Bluetooth (BLE) Connection Reliability: We need to verify that the ESP32 firmware and the React Native app communicate without a hitch. This includes testing how the app handles poor signal, packet loss, and automatic reconnection if the connection drops.
- Handling Bad Sensor Data: If a sensor sends corrupted data or disconnects, the system must handle it gracefully. We test “Unknown” states using simulated poor readings to make sure the app fails safe rather than showing outdated, dangerous data.
    - Hydration Tracking Accuracy: To ensure consumer features work perfectly, we test the bottle's ability to detect actual drinking events, update daily goal progress, and accurately trigger the 12-hour idle reset logic.
    - Component & Interface Performance: Using physical hardware (like the ESP32, OLED screen, and status LEDs) alongside frontend validation, we test to ensure that on-device alerts match the application's interface feedback instantly.

Report Structure

Chapter
1 Introduction
2 Background and Related Work
3 Project Management
4 Marketing Plan
5 Eco-efficiency Measures for Sustainability
6 Ethical and Deontological Concerns
7 Project Development
8 Conclusion
9 Acknowledgements

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