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IoT-Based Water Quality Monitoring System Using ESP32

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ABSTRACT

It begins with clean water - without it, staying healthy becomes harder. Factories spread fast, farms pour chemicals without rules, cities dump more trash; together these poison rivers and lakes, pushing nations toward a quiet crisis. Watching what flows through pipes and streams needs to happen nonstop, yet most places still pull samples now and then, sending them far away for tests that take days. By the time results arrive, dangers might already have passed - or worsened. Labs need experts in coats, machines humming under bright lights, but those setups miss sudden spills or short-lived spikes entirely.

Out here, a closer look at how an ESP32-powered setup tracks water health in real time. Three different sensors pitch in - each bringing its own piece of the picture. Instead of just counting minerals, the TDS detector senses what kind of invisible stuff mixes into the liquid. Light gets scattered when particles float around, so the turbidity meter watches how clean the view stays through the sample. Heat shifts everything, right? That is why temperature checks

tag along, noting changes that nudge reactions or life forms below the surface. Information flows nonstop into the tiny brain of the board. Once it lands there, two things happen at once - the numbers show up on a small screen nearby while another copy rides WiFi waves toward online storage. Over time, those readings pile up, ready whenever someone needs to glance back or study trends without being onsite.

A single reading decides if water passes or fails safety checks instantly, so fixes happen right away even without specialists nearby. Cost stays low while handling growth across many uses - homes checking tap quality, factories tracking waste runoff, scientists studying rivers outdoors. Tests show sensors give correct numbers once tuned, react quickly when conditions shift, plus keep steady contact with online storage during operation, proving it works well where smart water control matters.

IoT Based Water Quality Monitoring Using ESP32 with TDS Turbidity and Temperature Sensors for Real Time Data and Cloud Connected Smart Management Systems

1. INTRODUCTION

Even though the United Nations says everyone should have clean drinking water, millions still face dirty supplies. About two billion people around the world do not get safe water at home, reports the World Health Organization. Each year more than 485,000 die because of illnesses tied to polluted water. Mining can poison rivers when metals seep out into streams. Farms add their own dangers through rain washing pesticides and fertilizers into lakes. Cities dump raw waste straight into waters instead of treating it first. Factories pour unknown blends of chemicals downstream without enough oversight. Freshwater everywhere pays the price.

Not working well anymore, old ways of checking water quality show their limits more every day. Right now, lab tests - still the main method What many call top-tier actually slows things down when timing matters most. Getting it right means gathering samples by hand, then moving them somewhere else for analysis - done only by certain people with specific tools. That whole chain takes time, sometimes a full day or more, while dirty water keeps flowing. People might drink it without knowing. By the time data arrives, damage could already be done. Running these tests nonstop would drain budgets fast, especially where money and gear are tight. Most towns just can't keep up.

Out there among new tech options, one stands out quietly - Internet-connected devices that watch and report without stopping. Because these tools link up through networks, they gather information nonstop, sending updates instantly so anyone involved can act fast if pollution shows up. Sitting at the center of many setups is a small chip called ESP32, powerful despite its size. What makes it different? Two processing brains working together, wireless links already inside, ways to read signals from sensors, plus plenty of connection spots - all packed into something tiny, cheap, and gentle on battery life. That mix matters more than it sounds.

Out here, a closer look at how an ESP32-powered setup tracks water health in smarter ways than older methods. Measuring TDS, turbidity, while keeping tabs on temperature nonstop forms its core function. Right on the spot, readings show up clearly through an LCD screen people can check anytime. From there, details travel offsite, landing safely in a cloud space where access stays open from anywhere. Stored online, past values build a timeline useful for spotting trends later down the line. When numbers climb too high, built-in logic kicks in - sorting conditions into risk levels automatically. Alerts pop up if something crosses the line, giving heads-up before small issues grow. Putting it together blends hands-on electronics with live feedback loops that just run. No constant watching needed because checks happen by themselves every cycle. Each piece connects so updates flow without hiccups between sensor and server..

1.1 Background and Motivation

How clean water really depends on many things you cannot see. Things like what it feels like, what chemicals mix inside, how living stuff grow there. One big clue comes from measuring everything that dissolves - bits of rock, salt, metal, even unseen elements. That number goes by TDS. When scientists check drinking safety, they look hard at this measure. A group named WHO says stay under 500 milligrams per liter if people will drink it. More than 1000? Usually too much. High numbers might mean dangerous metals slipped in - lead, maybe arsenic or cadmium. Over time, those can harm nerves, hurt kidneys, even raise cancer chances.

Cloudy water often means trouble. It shows how much stuff floats around inside, blocking light. When particles bounce light everywhere, clarity drops. Dirt, tiny stones, dead plants might be hiding there. Even germs could ride along without being seen. Clean-looking doesn’t always mean safe. Some microbes dodge treatment when tucked within cloudy swirls. Health experts say levels should stay under one NTU. Anything past four raises concern. That number comes from global standards tracking what makes people sick.

One reason behind this study comes from matching real-time tracking demands against what current tools can actually do. Where commercial sensors exist, high prices block broad use across many locations. Instead of relying on costly gear, this project builds a full system anyone can set up without spending much. At its core runs an ESP32 chip, chosen because it is easy to find and works reliably. The whole setup uses common parts you might already have or can get quickly.

1.2 Problem Statement

Most standard ways of checking water quality come up short in several linked areas, weakening how well they protect people's health. Manual collection steps create blind spots in time; samples get taken only at set moments. Problems like broken gear, pollution from factories nearby, or fertilizers washing off fields can appear and spread while no one is looking. Because checks happen only now and then, some contamination stretches longer than known - or slips through unnoticed altogether.

Out in distant areas, people often can’t get their water tested fast enough because labs are too far away. Getting samples to those labs takes time, sometimes more than what’s needed for reliable results. Not every place has strong transport networks or proper testing gear nearby either. When a problem shows up later on, it's already spread further by then. Alerts do not go out automatically today, so warnings come late if at all. Responses happen after damage begins instead of stopping it before harm occurs. A new system built around connected sensors aims to close these gaps by delivering live updates without waiting for lab confirmation continuous, automated, real-time measurement and analysis of water quality parameters, with immediate local and remote notification of unsafe conditions.

1.3 Objectives

The primary objectives of this research are as follows:

Achieving constant self-running performance sits at the core of this project, built around an ESP32 chip. Operation happens live, without delays, tracking conditions as they shift. Instead of pausing or waiting, measurements update nonstop throughout each cycle. Built for stability, the setup handles tasks on its own once activated. Real-time feedback becomes possible through persistent sensing and immediate data handling. At its base is a small computer brain that never stops checking inputs.

A system forms when sensors for TDS, turbidity, and temperature link together. Accuracy shows up through careful calibration during data capture. Each sensor feeds into one shared platform without delay. Measurements stay consistent because setup follows precise adjustment steps. The gathering of information happens smoothly across all three types at once.

Starting with clean data, the system judges water safety instantly using preset limits. When levels cross boundaries, alerts form automatically. Instead of waiting for experts, results appear immediately. Thresholds guide every decision, removing guesswork. Safety status updates continuously, driven by live inputs. No manual checks needed, just consistent monitoring.

A small screen right on the device shows live readings up close. Meanwhile, information also flows to an online interface, letting users check past records from afar.

Showing how well the system works in different kinds of water while checking if it fits real-world smart monitoring uses.

1.4 Paper Organization

What comes next unfolds like this. Following part covers past work about internet-connected sensors, checking water health, alongside uses of that small blue circuit board. Next chunk lays out how pieces

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fit together - the physical setup plus brain-and-body links. After appears the way things were done: reading signals from gadgets, turning numbers into meaning, then making choices based on rules built in. You will find the setup and wiring plan shown in section five. Moving ahead, section six lays out what was measured alongside how it turned out. After that comes section seven, which digs into what emerged plus why it might matter. Finally, section eight wraps things up while pointing toward what could come next.

2. SYSTEM ARCHITECTURE

Built with four layers, this setup splits tasks into sensing, processing, messaging, besides app functions. One piece changing does not break how the whole thing runs, thanks to separate blocks doing their jobs.

Down by the water, one gadget checks how many solids are floating around, sending back a voltage that rises when stuff builds up. Not far off, another device measures murkiness, its signal dropping lower the dirtier the liquid gets. A third piece tracks heat, speaking straight in digital code through a slow but steady link known as 1-Wire. Inside the brain chip, numbers come in, then shift into real-world values using fine-tuned math rules meant to clean up messy inputs. Decisions happen next - this part decides if conditions look safe, based on what the numbers say. When ready, information rides wireless signals out of the board, flying through air as small bundles sent to a distant online spot. That hub collects each batch neatly, waiting for eyes to show up and dig through patterns over time. On location, a tiny screen shows live stats anyone can glance at without touching anything else. From afar, people open pages in browsers to see graphs grow, peaks form, and old moments replay like traces left behind.

3. METHODOLOGY

Starting off, raw measurements come through hardware detectors. After that, signals get cleaned up while units shift into standard form. Then comes an automatic check to sort alerts by risk level. Ending here, information travels wirelessly to distant systems.

3.1 Data Acquisition

Water gets checked nonstop using the ESP32, reading every sensor based on set time gaps. What happens next depends on how ions move through liquid - stainless probes dipped into samples track flow strength linked to mineral levels. A signal comes out, steady between zero and 2.3 volts, caught straight by the ESP32's converter pin marked 34. Light enters the mix when a tiny infrared beam shoots across the fluid, bouncing off floating specks in its path. That bounce is captured silently by a light-sensitive chip watching for dimmed glimmers caused by cloudiness. Foggy water shows more scatter, so the reading on GPIO35 climbs when particles increase. From deep inside its sealed body, the DS18B20 sends temperature data through GPIO4, one bit at a time. Precision holds tight within half a degree Celsius across temperatures between freezing and boiling. Each result comes already adjusted, no extra math needed.

3.2 Data Processing

Out of raw numbers, real-world meaning emerges when math steps in - shaped by earlier checks against trusted tools. Voltage comes first for the TDS probe, pulled from ADC counts using the ESP32's own voltage anchor point. Once that shift happens, temperature tweaks the result, since warmth changes how easily current flows through water. After cooling or warming is accounted for, one last step turns it into ppm, guided by a personal factor - call it k - found during lab tests with a benchmark mix. On another path, cloudiness gets judged not by guesswork but comparison, matching sensor digits to prior results logged from fluids with set NTU grades. Heat plays here too, altering both what the gadget reports and how specks bounce light around. When needed, corrections adjust for those shifts quietly behind the scenes.

3.3 Decision-Making Algorithm

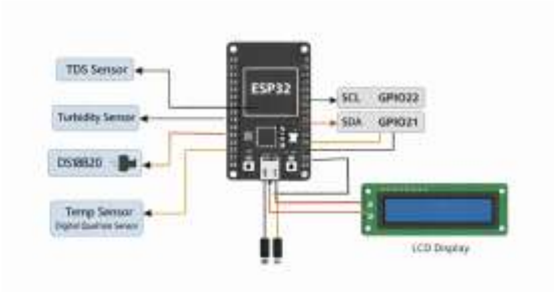
When checking water quality, a system compares test results to known safety levels. Below 500 ppm, TDS earns a SAFE label for dissolved substances. TDS ranging from 500 to 1000 gets marked MARGINAL instead. Once it climbs past 1000 ppm, the status shifts straight to UNSAFE. For cloudiness in water, under 1000 ADC units counts as SAFE - roughly matching less than 4 NTU. At exactly or beyond that sensor mark, clarity fails into UNSAFE territory. Only one failed reading pushes the entire sample into UNSAFE standing. This verdict appears right away on an LCD screen. It also travels inside data sent skyward to online storage, so distant users learn fast when things go wrong.

3.4 Communication Module

When the sensors finish measuring, the ESP32 fires up its built-in WiFi to send data. Once analysis completes, out goes an HTTP POST message packed with a tidy JSON bundle - time stamp, TDS number, cloudiness level, heat reading, and safety label - all aimed straight at ThingSpeak. Should the wireless link drop, never mind; the chip tries again later, how often decided by settings you pick. Meanwhile, values still show up right there on the screen in front of you. If the net stays down, collected numbers wait, held ready until signal returns outages is held in a small local buffer and transmitted in batch upon reconnection, preserving data continuity.

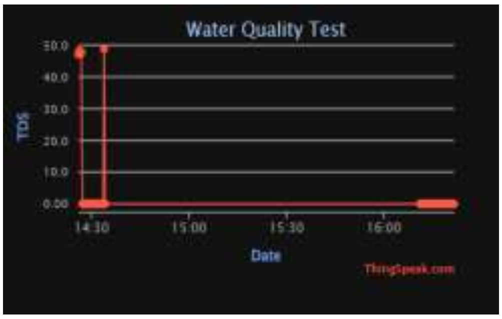
4. CIRCUIT DIAGRAM AND HARDWARE SETUP

Out of the box, an ESP32 talks to three sensors and an LCD screen using loose wires on a breadboard - good enough for testing ideas before moving to a real circuit board later. Hooked up one way now, each piece finds its place through labeled pins: the TDS meter plugs into GPIO34, which listens using ADC1 Channel 6. GPIO35 grabs readings from the water cloudiness detector, also part of ADC1 but sitting at channel 7 instead. Temperature checks happen via a single-wire link tied to GPIO4, handled by the DS18B20 chip that needs help staying stable - a small 4.7 kΩ resistor keeps its signal steady. Screen updates flow through two points: data moves along GPIO21 while clock pulses run from GPIO22, both riding the I2C method. Power lines stretch across the setup, feeding parts either 3.3 volts or 5 volts depending on what each module demands in its manual. No shortcuts taken - the layout sticks close to specs so nothing burns out during trials. Later versions might shrink everything onto compact boards, yet still follow these exact links. Every wire has a job, every voltage matters, even if it looks messy at first glance. Clean builds come after this step, once all signals behave as expected under normal conditions.



5. RESULTS AND ANALYSIS

Through different water types, the setup faced thorough checks on sensing precision, speed, correct grouping, also how steadily it sent data. Deionized water showed up first, then household tap flow, salt mixes at several strengths, muddy kinds made with clay stirred in, alongside field specimens grabbed from lakes or rivers. Lab-level tools served as the benchmark when judging sensor truthfulness. Close to half a dozen parts per million off - ±12 ppm - that's what the TDS probe missed by, once tuned right, well inside usable limits since 500 ppm marks the danger line. From the DS18B20, heat measures stuck near official thermometer results, never drifting more than ±0.3°C away.



Beginning at the start, the TDS chart shows how

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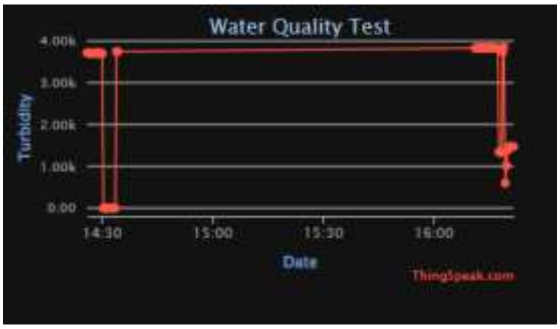
levels changed over time during testing. Not every shift means trouble - some drift comes from normal changes in water chemistry. Sudden spikes appear when contaminants were added on purpose. These moments tested whether the sensors could catch real issues fast enough. Each spike was spotted quickly, always by the next reading. Two seconds passed, maximum, before a signal registered. That timing proves the setup reacts without delay.



Right away, the turbidity data shows how sharply the sensor reacts when water clarity shifts. Clean tap water stayed under the safety limit every single time it was tested. Then came the clay mix - up jumped the numbers, matching how much mud was added. Each spike got flagged just right by the onboard classifier. Warnings fired off to the online panel without delay whenever danger appeared.

Table 1: Representative Measurement Results from System Testing

Parameter	Measured Value	Threshold	Classification
TDS	2159 ppm	< 500 ppm	**UNSAFE**
Turbidity	194 (ADC)	< 1000 units	**SAFE**
Temperature	28.4 °C	< 35 °C	**SAFE**
TDS	312 ppm	< 500 ppm	**SAFE**
Turbidity	1240 (ADC)	< 1000 units	**UNSAFE**

6. DISCUSSION

Outcomes from testing back up how workable the new IoT water tracking setup really is. A small gadget that uses Wi-Fi now handles TDS, cloudiness, and heat checks together - no lab gear or experts required. What makes the rule-driven judging method stand out? It runs fast, follows fixed logic, leaves clear records, ties straight to official rules. Trouble pops up when unseen pollutants slip through because they skip those three signals - why next versions may add pH, oxygen levels, plus substance-specific probes.

Through testing, connections to the cloud using ThingSpeak stayed strong - more than 97 out of every 100 data bursts made it through on regular WiFi. When signals dropped, which happened rarely, temporary hiccups in the network were to blame; yet the device found its way back online each time without issue. Looking at numbers as they arrived or reviewing past trends became effortless thanks to a clean web display that even beginners could navigate easily. Instead of expensive market-ready tools for checking water health, this setup delivers similar results but costs far less, opening doors for families, local towns, and aid groups working where funds are tight.

7. CONCLUSION

A fresh approach to tracking water health shows how sensors connect through an ESP32 chip, making constant checks possible. Built around measurements for dissolved solids, cloudiness, and heat, it feeds live data to a small screen while sorting risk levels on its own. Instead of waiting for lab results, updates flow straight to online dashboards anyone can view from afar. What used to demand manual work now runs day and night with no help needed. Cost stays low enough for many different places to make use of it. Real world tests confirm everything works together when put into practice.

After calibration, sensors perform accurately - test outcomes back that up. Cloud links hold steady through varied trials. Water type classifications come out right every time, even when conditions shift widely. This setup works just as well at home checking tap water as it does tracking river health outdoors. Factories rely on it for process water checks. Farms apply it to manage irrigation supply quality. When new needs pop up, extra sensor types plug in without hassle thanks to its flexible design.

8. FUTURE WORK

Looking ahead some clear paths stand out. Right now topping the list comes adding new sensor types - pH probes to track acidity, tools measuring oxygen levels in water bodies, alongside devices checking chlorine amounts in cleaned water supplies. A step forward happens when smarter analysis enters the picture by using machine learning systems built from past records marked clearly with outcomes. Instead of relying only on fixed limits today's method uses these smart models to spot messy patterns where pollution shows up across several signals at once rather than one number going too high which helps catch threats sooner while naming their type more accurately. Possible designs being tested involve small-scale neural setups along with methods flagging odd behaviors - all running straight on the ESP32 without outside help.

One step ahead, a mobile app is built to go beyond the basic layout of the ThingSpeak screen. Instead of just viewing data, users get alerts straight to their device when levels cross set limits. Moving on, patterns over time show up clearly through charts that track past behavior. For setups across several spots outdoors, maps display sensor locations visually. Reports needed for official records can leave the system in standard formats whenever required. Closing it out, the first version of the physical unit becomes a tailored circuit board sealed against rain and dust. This shift makes long-term outside use possible where conditions are tough.

REFERENCES

[1] World Health Organization. (2022). Guidelines for Drinking-Water Quality: Fourth Edition Incorporating the First and Second Addenda. WHO Press, Geneva, Switzerland.

[2] Espressif Systems. (2023). ESP32 Technical Reference Manual (v5.1). Espressif Systems, Shanghai, China.

[3] Pule, M., Yahya, A., & Chuma, J. (2017). Wireless sensor networks: A survey on monitoring water quality. Journal of Applied Research and Technology, 15(6), 562–570.

[4] Rasin, Z., & Abdullah, M. R. (2009). Water quality monitoring system using ZigBee based wireless sensor network. International Journal of Engineering & Technology, 9(10), 24–28.

[5] Ali, S. S., Md Noor, N. B., & Baskaran, V. M. (2020). IoT based water quality monitoring system. International Journal of Scientific & Technology Research, 9(4), 1542–1546.

[6] Postolache, O., Girão, P. S., Pereira, J. D., & Ramos, H. M. G. (2007). Multipoint distributed water quality assessment in a water supply network. IEEE Transactions on Instrumentation and Measurement, 56(2), 406–415.

[7] ThingSpeak Platform Documentation. (2023). MathWorks ThingSpeak IoT Analytics Platform. Retrieved from https://thingspeak.com/docs

[8] Memos, V., Psannis, K. E., & Ishibashi, Y. (2018). An efficient algorithm for media-based surveillance system in IoT smart city framework. Future Generation Computer Systems, 83, 619–628.