



Condistiller

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Abstract

Electronic waste in Egypt is increasing rapidly, and many discarded components are often assumed to have no further value. In this project, a functional water purification and water testing system was created using recycled and low-cost materials. A simple bottle-based water distiller was assembled from reused plastic bottles, an extracted heating element, and a pump tubing system used for condensation. A conductivity meter was constructed using an IC harvested from e-waste, basic wiring, a reference resistor, and a battery. The IC was programmed to generate the excitation signal and to allow readings to be displayed through both the serial monitor and a 7-segment display. Both devices were calibrated using the chemistry lab's EC meter and distilled water that was produced by the constructed distiller. Research was conducted on five types of water: tap water, distilled water, and three sodium chloride concentrations: 0.021 M, 0.041 M, and 0.513 M. Using calibrations, accurate readings for conductivity and total dissolved solids were collected. It was concluded from these results that electronic waste can be used as a source for low cost yet functional scientific equipment.



Introduction

Access to potable and clean drinking water in many regions of Egypt is still a persistent issue due to the outdated distribution systems, lack of upkeep, and an increasingly high level of contamination (Bin Hasbullah, et al., 2025). An integrated systems approach has been adopted to create an affordable and easy-to-use system for purifying water and providing basic information on water quality. The system is comprised of two components: a low-cost distilled water, bottle-based distillation unit; and an electronic module for measuring water voltage through conductivity. The system not only was developed to produce distilled water; but it will also directly benefit from recycling components taken from discarded electronic goods, thereby reducing the waste caused by using up unwanted electronics by reusing them to create functional products. The bottle-based distillation unit was constructed from used plastic bottles, an extracted heating element from a previously-owned appliance, flexible tubing, and a small pump used to transport vapor into a receiving container. Tap water was converted into distilled water by a simple low-cost operation that integrated distillation in a low-volume apparatus that reused all materials. This process reduced both the environmental impact associated with creating new products and the costs associated with producing and maintaining them. The second part of the system included a conductivity-measurement module that was designed using salvaged parts: an integrated circuit, a 10-Kohm resistor, connecting wires, a plug connection, and a battery for power, as well as 16 MHz crystal for frequency stabilization. The integrated circuit was programmed during assembly and once assembled, operated autonomously. Calibration was performed using reference solutions from a laboratory. Following calibration, five different samples of distilled water produced by the prototype, tap water from the local municipality, and three sodium chloride solutions comprising concentrations of 0.021 M, 0.041 M, and 0.513 M were analyzed. Conductivity readings of these samples were converted into TDS (Handandi, et al., 2024). The system represents an effective way to purify water that is also inexpensive and demonstrates how repurposed electronic wastes may be harnessed for educational and scientific purposes.



Materials & Methods

Materials:

Table one

Items	Usage	Image
Silicone water hose	Vapor transfer in water distiller.	
Heater Wire	To make the water boil.	
plastic containers	Water will be boiled in one place, and distilled water will be collected in another.	
AC plug	Generate a small alternating current across the electrodes	
ATmega328P	It can send the data to the computer and calculate the required values.	
pump aquarium	steam condensation	
Resistor 10K- ohm	prevent the passage of a high current that could burn out the component.	
Jumper Wires	Connecting the components together easily	

Methods :

Distillation of tap water was performed using a simple setup made from recycled materials. Water from the tap was heated in an electric heater recovered from old electronic devices until continuous boiling occurred in **Fig.1**. The vapor generated was routed through flexible tubing into a reused plastic



Fig.1: Water distiller

bottle condenser. Cooling water was circulated within the condenser by a small pump, which was used to provide efficient vapor condensation, and the condensed distilled water was collected. Evaporation rate, vapor transport, and condensate quality were monitored to ensure consistent operation.

For conductivity measurements, an integrated circuit recovered from electronic e-waste was programmed and was placed in a standalone circuit containing a reference resistor, standard wiring, and a crystal oscillator **Fig. 4**. The IC was used to generate the excitation signal and to process voltage responses from water samples **Fig. 2**. Calibration was performed using NaCl solutions to produce a calibration curve and to determine a conversion factor (K) for TDS calculation.

Safety: Gloves and lab coats were worn. Electrical components were handled carefully, and all procedures were supervised by the physics department.

Test Plan

Evaluation was initiated by activating the electric heater to ensure stable boiling of tap water and continuous vapor formation. Vapor flow through the flexible tubing was monitored to detect leaks or premature condensation. Condenser performance was verified by confirming pump circulation and consistent production of distilled water across repeated trials **Fig. 5**.

The measurement circuit was tested independently to verify IC functionality. Voltage across the resistor was observed to ensure stable excitation and accurate signal processing.

Calibration trials using NaCl solutions were repeated to validate reproducibility. Tap-water conductivity was measured manually by recording electrical resistance and applying the conductivity equation. Results from manual calculations and IC readings were compared to confirm reliability and agreement between methods.

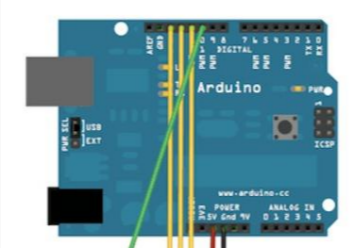


Fig.2: Schematic (IC)

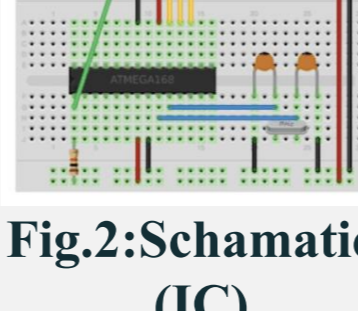


Fig.3: IC programming

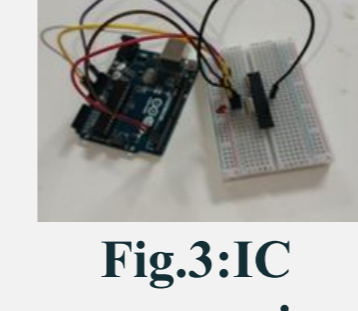


Fig.4: 7-segment

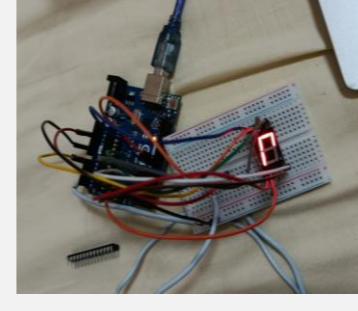


Fig.5: TDS & EC



Results

Initial EC readings were obtained using an Arduino, where the measured resistance was processed and was displayed through the serial monitor. After verification, the Arduino was removed, and the measurement circuit was transferred to the reused IC system.

Five samples were measured, as shown in the attached table, and the same samples were tested using the chemistry lab EC meter to determine the error percentage. A measurement error of approximately $\pm 2\%$ was observed.

To confirm the accuracy of the recycled-components measurement system, each prepared solution and water sample was tested using the laboratory EC/TDS meter. The recorded values were compared to the prototype readings, and the deviation was found to remain within the acceptable $\pm 2\%$ range. This confirmed that the resistance-based method and the calibration equation were functioning correctly, as shown in **Table 3**. During early trials, the distillation unit was operated incorrectly because no condensation stage was included in **Table 2**.

Water vapor was released directly through a hose into a container, which prevented proper collection. After the issue was identified, a full condensation system was implemented. A fish tank pump was used to create a pressurized water-cooling jacket, allowing the vapor to condense efficiently before collection. This modification significantly improved the stability of the distillation process.

	Mass of Solt(g)	Volume(mL)	Molari ty(M)	TDS(PPM)
con1	3	100	0.513	6500
con2	0.60	250	0.041	505
con3	0.61	500	0.021	233

Table 2 : Molarity& TDS

Measured quantity	TDS Meter(ref.)	TDS Meter(Made)
0.513M NaCl	6632.65 PPM	6500 PPM
0.041M NaCl	494 PPM	505 PPM
0.021M NaCl	228.5 PPM	233 PPM
Tap Water	217.16 PPM	221.5 PPM
Distilled water	11.27 PPM	11.5 PPM

Table 3 Calibration table



Analysis

A Distillation unite that is constructed to distill tap water and the installation of conductivity meter, shown the ability to demonstrate the practical potential of reusing components extracted from old electronic devices to create a functional system that supports research and scientific applications.

In the distillation function: It was concluded from that the tap water consumes more time to evaporate. Hence, the Evaporation increases when the temperature increases.

Heat transfer law was applied to measure the heat energy needed to boil:

$$Q = m \times C \times \Delta T$$

In the Conductivity meter: it was installed to measure the conductivity and TDS.

The equation for conductance, taking into consideration the distance between electrodes (d), the surface area of the electrodes (A) and conductivity (κ), looks like this: $S = \kappa \frac{A}{d}$

K= is the sum of all ions in the solution

To obtain the nearest values of the TDS, factors affecting conductivity were shown below:

1- Concentration of ions.

2- Temperature.

3- Type of solution and water purity.

The salt solutions was prepared with different concentrations to measure the conductivity.

The Molarity of the salt solutions is calculated using the first learning outcome of chemistry molarity rules: $M_1 V_1 = M_2 V_2$

The solutions molarity are: 0.513M, 0.041M and 0.021M. The conductivity meter measured the EC of the previous salt solutions, tap water and distilled water obtained from the distiller unite in **graph 1**.

The reading of the constructed instrument are mentioned in **graph 3**. The calibration was done reference to TDS/EC calibrated device with its standard solution. As a result, the accuracy was calculated to using the following rule:

$$\text{Accuracy (\%)} = \frac{|\text{Measured Value} - \text{True Value}|}{\text{True Value}} \times 100$$

Considering the random errors due obtaining more than one reading, the standard deviation was calculated:

A trial was failed due to entering wrong numerical values for the K_{cell} (The ratio d/A is constant for any given measurement and is called the cell constant). As a result, it was corrected on the other trial. After obtaining more than one reading for the conductivity, the average was calculated in **graph 2**. The schematic diagram displayed the connection of one 7 segment to the chip. Hence, the following numbers shows the guide for the displayed values on the 7 segment:

0= no current flow

1= distilled water conductivity (0.2 – 2 $\mu\text{S/cm}$)

2= tap water conductivity (200 – 800 $\mu\text{S/cm}$)

3= 0.513M salt solution conductivity (6000-7000 $\mu\text{S/cm}$)

4= 0.041M salt solution conductivity (480-550 $\mu\text{S/cm}$)

5= 0.021M salt solution conductivity (230-280 $\mu\text{S/cm}$)

Conductivity_{ionic sol} = \sum (ion concentration \times molar conductivity).

Molar conductivity for $\text{Na}^+ = 0.05011$

Molar conductivity for $\text{Cl}^- = 0.07635$

EC ($\mu\text{S/cm}$) = $12600 \times c$ (for NaCl at 25°C)

EC₂₅ = EC measured / $1 + \alpha(T - 25)$

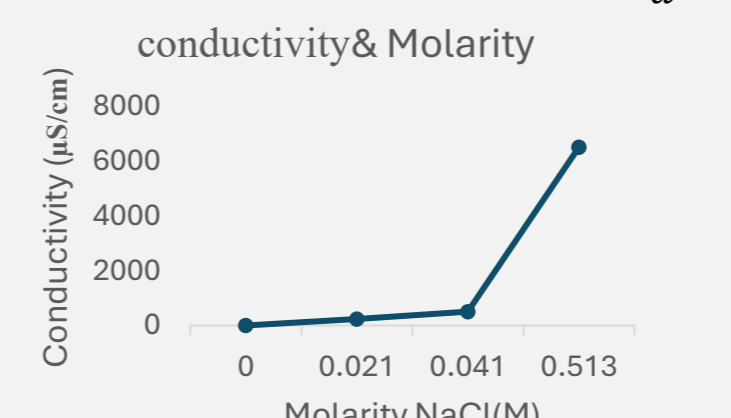
α = (the temperature coefficient of conductivity) $\approx 0.02/^\circ\text{C}$.

For every degree Celsius that the temperature of the water goes above

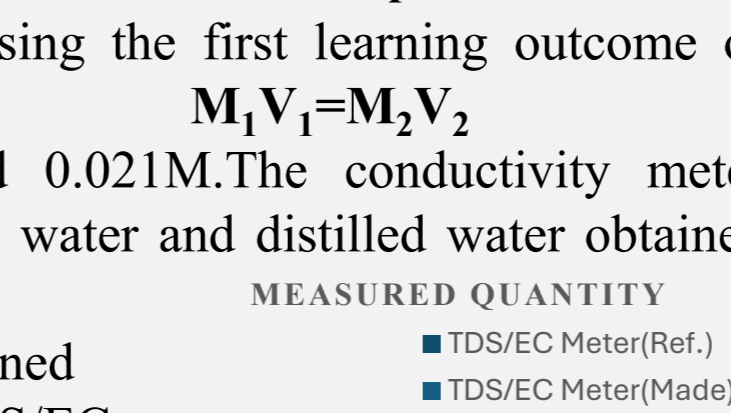
25°C, the conductivity increases by about 2%. So, if the water is warmer than 25°C, the EC

reading naturally goes up. If it's colder, the EC reading goes down.

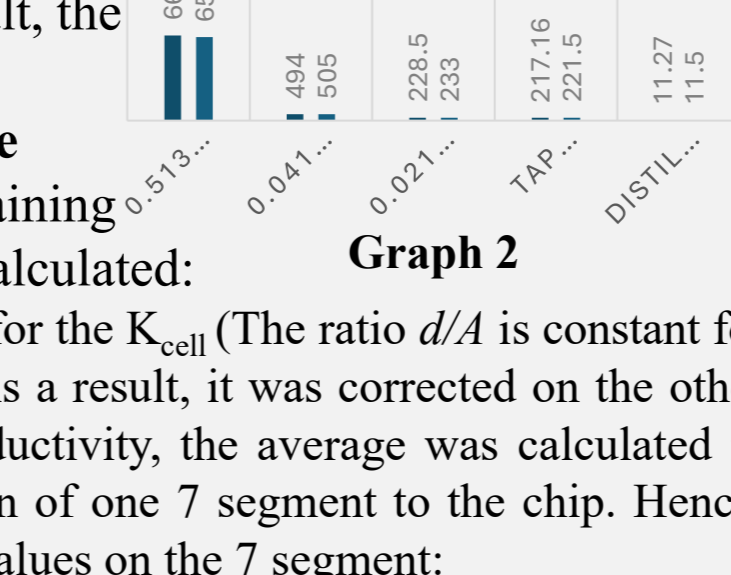
To calculate the TDS (mg/L) = $K_{\text{TDS}} \times \text{EC}_{25}$ ($\mu\text{S/cm}$)



Graph 1



Graph 2



Graph 3

Learning transfer:

Table 4

Chem.2.01	Concepts of water purification, solubility, and quantitative analysis were applied to design, operate, and evaluate a low-cost distillation system with TDS measurement.
Chem.2.07	I.O guides interpretation of TDS and linking distillation to water's ionic and acid-base behavior.
Phy.2.03	The conductivity was studied as it is the reciprocal of the resistivity. In addition to conductivity rule.
Phy.2.04	Used Kirchoff's laws to design and analyze series and parallel resistor circuits.
Math.2.01	Polynomial functions model TDS reduction, illustrating water purification efficiency.
ENW.1.1.1	All content should be written in an academic style, with correct grammar and spelling, and based on trustworthy sources.



Conclusion

The distillation unite and EC meter were successfully achieved their purpose and suiting the design requirements. The components were extracted from old discarded instruments regrading the precautions. Simple materials as jug, hose and IC were utilized to built the prototype to work efficiently. The primary function of the prototype which is the distiller successfully distilled the tap water and provides distilled water with electric conductivity acting as an indicator for the purity is ranged from (0.2-2 $\mu\text{S/cm}$). The secondary function of the prototype is the conductivity meter. The instrument measured the conductivity of tap, distilled and 0.513M, 0.041M, 0.021M NaCl solutions. The TDS calculations were based on direct proportionality rule and Temperature correction rule. As the K factor depends on water type and strong electrolyte assumption regarding NaCl as it fully dissociates. Calibration was done through already calibrated TDS/EC meter. The rules of molarity and kinetics were used. It is concluded from the obtained results that low-cost, small-scale discarded electronics can reliably estimate EC and TDS, making it useful in preliminary water quality testing, and field monitoring.



Recommendations

I) In this project, the addition of a DS18B20 temperature sensor was recommended so that accurate temperature readings can be applied to increase the accuracy of the EC and PPM values.

II) The use of an EC meter in hydroponic systems was also recommended to ensure that nutrient concentrations are continuously monitored and maintained within the suitable range necessary for stable plant growth.

III) In addition, regular calibration with standard conductivity solutions was recommended to reduce sensor drift and keep all measurements consistent throughout the experiment.

IV) Finally, the integration of an LCD display module was recommended so that real-time EC, PPM, and temperature readings can be viewed directly, clearly, and more efficiently during testing.



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