

RAPID DEHYDRATION DETECTION USING SALIVA

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Technology degree in Biomedical Engineering

By

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DEPARTMENT OF BIOMEDICAL ENGINEERING
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SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A++" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Tejaswini S (40240042), Manasa V (40240016)** who have done the project work as a team and carried out the project entitled "**RAPID DEHYDRATION DETECTION USING SALIVA**" under our supervision from June 2023 to April 2024.

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DECLARATION

We, **Tejaswini S (40240042)** and **Manasa V (40240016)** hereby declare that the Project Report entitled "**RAPID DEHYDRATION DETECTION USING SALIVA**" done by us under the guidance of **Ms. Sindu Divakaran** is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Biomedical Engineering.

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ABSTRACT

Dehydration is a condition which is characterized excessive loss of body fluids and possess significant health risks if left undetected or untreated. Timely detection is vital to prevent adverse health consequences, particularly in populations such as athletes, elderly individuals, and those suffering from certain medical conditions. Traditional methods of dehydration assessment often involve invasive or time-consuming procedures thereby limiting their practicality in rapid detection scenarios.

The goal of the proposed work is to create a novel approach for rapid dehydration detection such as a Point-of-care (PoC) dehydration detection kit which uses saliva as the analyte. Saliva, a readily accessible bodily fluid, offers a non-invasive and convenient medium for dehydration detection. Recent advancements in technologies have enabled the identification and quantification of salivary biomarkers associated with hydration status, such as chlorine concentration and other factors like PH.

Keywords— Dehydration, Non-invasive, Point-of-care, Saliva

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LIST OF ABBREVIATIONS

ABBREVIATIONS	DEFINITIONS
AgCl	Silver chloride
HRV	Heart rate variability
pH	Power of Hydrogen
PoC	Point-of-care
Nm	Nanometer
UV	Ultra-violet

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CHAPTER 1

INTRODUCTION

The human body consistently and precisely controls its fluid requirement through a complex mechanism. Significant fluid loss from the body can cause an imbalance in fluid status and can lead to dehydration. In extreme clinical situations, progressive negative changes in fluid status can have a direct impact on numerous organ systems, including the possibility of life-threatening circulatory collapse. Dehydration occurs when the body lacks sufficient fluids, causing abnormal bodily function. Common causes include sweating, diarrhea, and vomiting (Chen C.H *et al.*, 2021).

Dehydration can be mild, moderate, or severe, with severity determined by the amount of fluid missing in an adult. In children, dehydration is determined by the amount of body weight lost due to inadequate fluid intake. Mild dehydration symptoms include dry mouth, reduced sweating and urination, and thirst. Mildly dehydrated children lose 3%-5% of their body weight in fluids. At-home treatments for mild dehydration include electrolyte drinks, water, or over-the-counter oral rehydration solutions. In adults, the amount of fluid missing determines the severity of dehydration. In children, the degree of dehydration is determined by the amount of body weight lost due to malnutrition.

Older people who are dehydrated have a greater chance of death and impairment. It's also been linked to falls in the elderly and is thought to have a major role in how well soccer players perform under pressure. A person suffering from dehydration may not exhibit any symptoms prior to the development of a critical illness, and an early fluid imbalance may not give rise to evident clinical manifestations. As a result, it's critical to identify fluid imbalances early in order to stop the clinical condition from getting worse later. Dehydration is currently assessed using a number of blood and urine biomarkers. However, due to its invasiveness, continuous serum osmolality monitoring is not practical in clinical practice (Barley OR *et al.*, 2020). Urine voiding isn't possible at any time, despite the fact that collecting urine specimens is easy and non-invasive. Urine production is also decreased by severe dehydration, which makes urine collection more challenging.

On the other hand, saliva collection is a practical option since it can be done directly using a straightforward method that doesn't require any specialized equipment and can be done even outside of a clinical setting (Pittman T.W *et al.*, 2023). Saliva collection is a non-invasive technique. After ingesting fluids, salivary conditions can indicate fluid status and can stabilize in thirty seconds (Gray M *et al.*, 2023 and R. ELY *et al.*, 2011). We recently developed a Point-of-care (PoC) dehydration detection kit which uses saliva as the analyte to measure the dehydration level in the body by accessing the parameters like chlorine concentration and PH of the saliva and give results based on colorimetric indication.

Dehydration can occur due to various reasons, including:

- **Inadequate Fluid Intake:**
Not drinking enough water throughout the day, which can happen due to forgetfulness, lack of access to clean water, or deliberately limiting fluid intake (for example, in attempts to lose weight).
- **Excessive Sweating:**
Intense physical activity, particularly in hot or humid environments, can lead to significant fluid loss through sweat, especially if adequate hydration is not maintained.
- **Diarrhea and Vomiting:**
These conditions result in the loss of large amounts of fluids and electrolytes from the body, leading to dehydration, especially if fluid intake is not replaced promptly.
- **Fever:**
When you have a fever, your body temperature rises, leading to increased sweating and subsequently fluid loss, which can contribute to dehydration.

- **Increased Urination:**
Certain medications (such as diuretics) and medical conditions (like diabetes) can cause excessive urination, leading to dehydration if fluid losses are not replenished adequately.
- **Illnesses:**
Certain illnesses such as infections, particularly those involving the gastrointestinal tract (e.g., gastroenteritis), can lead to dehydration due to fever, vomiting, and diarrhea.
- **Environmental Factors:**
Hot and dry climates, high altitudes, and prolonged exposure to the sun or heat without adequate hydration can increase the risk of dehydration.
- **Alcohol and Caffeine Consumption:**
Both alcohol and caffeine are diuretics, meaning they can increase urine production and contribute to dehydration if not balanced with sufficient fluid intake.
- **Older Age:**
As people age, their sense of thirst may decrease, and their kidneys may be less able to conserve water, making older adults more susceptible to dehydration.
- **Chronic Conditions:**
Certain chronic conditions such as kidney disease, adrenal gland disorders, and cystic fibrosis can increase the risk of dehydration due to their effects on fluid balance in the body.

It's important to recognize the signs and symptoms of dehydration and take steps to prevent it by staying adequately hydrated, particularly during periods of increased fluid loss or when exposed to risk factors for dehydration.

1.1. PHYSIOLOGY OF DEHYDRATION

To ensure proper electrolyte balance, fluid levels in the human body must be carefully selected to regulate chemical processes essential to life. Symptoms include thirst, malaise and fatigue, and even mild dehydration of just a few percent result in fluid loss and a one-third reduction in physical performance. If left untreated, death may occur if there is no balance in fluid and exceeds $\pm$ twenty percent of regular. However the predominant condition studied is water loss, it is important to remember that over consumption of water can also be equally hazardous, especially if combined with forceful physical action in a scorching environment. (Arseth H. A *et al.*, 2018)

1.2. SALIVA AS POTENTIAL BIOMARKER

Saliva can serve as an indicator of dehydration due to its composition and how it responds to changes in the body. Plasma osmolality, salivary secretion, dryness, urine markers and heart rate variability (HRV) can accurately diagnose mild intracellular dehydration. Tear osmolality, saliva osmolality, HRV, and blood pressure changes during posture were incorrect in diagnosing extracellular dehydration. However, dehydration can change the properties of saliva and provide valuable information about the body's fluid content. Several studies have examined the relationship between saliva composition and fluid status and confirmed its potential as an indicator of dehydration.

CHAPTER 2

LITERATURE REVIEW

Brennan *et al.*, (2019) proposed that the portable system can provide farmers with reliable information about their hydration status using a small amount of saliva. This significantly increases the willingness of potential patients to follow the recommendations and thus monitor their daily fluid status. It therefore represents a practical method for the real-time prevention of chronic kidney disease.

Melendez *et al.*, (2022) Chloride concentration in Saliva during exercise can be used to create a conversion table for Cl saliva samples that were linked to the percentage of water lost in the subjects' bodies.

Shaheen *et al.*, (2018) concluded that water health education should be effectively implemented to recommend drinking enough water and maintaining optimal hydration levels. The results of various studies concluded that saliva can be used as a potential biomarker for dehydration detection.

According to GRA *et al.*, (2018), easily accessible bodily fluids including saliva, sweat, blood, or urine have been used for non- or minimally invasive collection

Villiger.M *et al.*, (2017), investigated the perplexing relationship between hydration status and well-being has been the center of various considerations. This write-up synthesizes discoveries from earlier investigations, emphasizing the imperative part of hydration observation. From salivary conductivity to systemic wellbeing suggestions, the account unfurls the importance of keeping up ideal hydration.

J. Frith *et al.*, (2023) Studied that maintaining good hydration status has been shown to positively affect urolithiasis (Ib) and may be beneficial in treating urinary tract infection (IIb), constipation (III), hypertension (III), venous thromboembolism (III), fatal coronary heart disease (III), stroke (III), dental disease (IV), hyperosmolar.

E. Kaufman *et al.*, (2002) studied that past well-being conditions, and drying out develop as an intervening figure influencing decision-making in male soccer competitors. This sheds light on the basic part of hydration in optimizing athletic execution.

E. Perrier *et al.*, (2023) the importance of hydration checking gets to be indeed more clear for helpless populaces, particularly the exceptionally youthful and elderly. Considers uncover that elderly people in long-term care offices confront the next chance of lack of hydration compared to intensely sick hospitalized partners.

N. P. Walsh *et al.*, (2003) reported that a later drift in diagnostics investigates spit as a non- invasive biofluid. With its wealth and openness, spit offers a promising medium for identifying biomarkers related to hydration status. Stabilizing arrangements improve comfort and decrease irresistible dangers amid test control.

Faidah *et al.*, (2020) found that plasma osmolality, salivation, dryness, urinary markers, and heart rate variability can accurately diagnose benign intracellular dehydration. Meanwhile, postural changes in heart rate can identify mild extracellular dehydration.

Owen *et al.*, (2019) stated that tear osmolarity, salivary osmolality, Heart rate variability, and postural blood pressure changes were not accurate in diagnosing extracellular dehydration. The findings suggest that changes in the autonomic nervous system associated with hydration levels are more pronounced in intracellular dehydration.

Atjo, N. M *et al.*,(2022) reported that salivary and blood glucose levels are entwined, understanding this association remains challenging. The complexity of connecting salivary glucose concentration to restorative movement underscores the requirement for encouraging examination.

N. A. S. Taylor *et al.*,(2012) observed novel investigation which proposes that Cl- concentration in spit, balanced by physical workout and thoughtful anxious framework

action, might be a potential marker for hydration status. Noteworthy changes in Cl-concentration are watched amid gentle parchedness levels.

S. C. Killer *et al.*, (2015) studied the potential of salivary biomarkers to the challenges in decoding glucose levels, the investigation of hydration elements is pivotal for educated healthcare homes. The appropriation of non-invasive strategies and custom-fitted checking gets to be basic, especially for powerless populaces, in our continuous interest of ideal well-being and execution

CHAPTER 3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

Dehydration occurs when your body loses more fluids than it takes in, leading to an imbalance in the body's electrolytes. This can happen for several reasons, including not drinking enough fluids, excessive sweating, vomiting, diarrhea, or a combination of these factors. Symptoms of dehydration can range from mild to severe and may include thirst, dry mouth, dark urine, decreased urine output, fatigue, dizziness, confusion, rapid heartbeat, and even fainting. In severe cases, dehydration can lead to serious complications such as heatstroke, kidney failure, and seizures.

The aim of the proposed work is to create a novel approach for rapid dehydration detection such as a Point-of-care (PoC) dehydration detection kit which uses saliva as the analyte which is seamlessly integrated with a hydration log app, to enhance healthcare outcomes through timely interventions and personalized hydration management. The scope of the work include:

1. To develop a point of care device available for all sectors of society.
2. To make dehydration detection simple and efficient
3. To develop a non-invasive testing system which can prevent the usage of blood to identify dehydration.
4. Ultimately, the objective is to enhance healthcare outcomes by enabling timely interventions and personalized hydration management strategies based on individual needs.

CHAPTER 4

MATERIALS AND METHODS

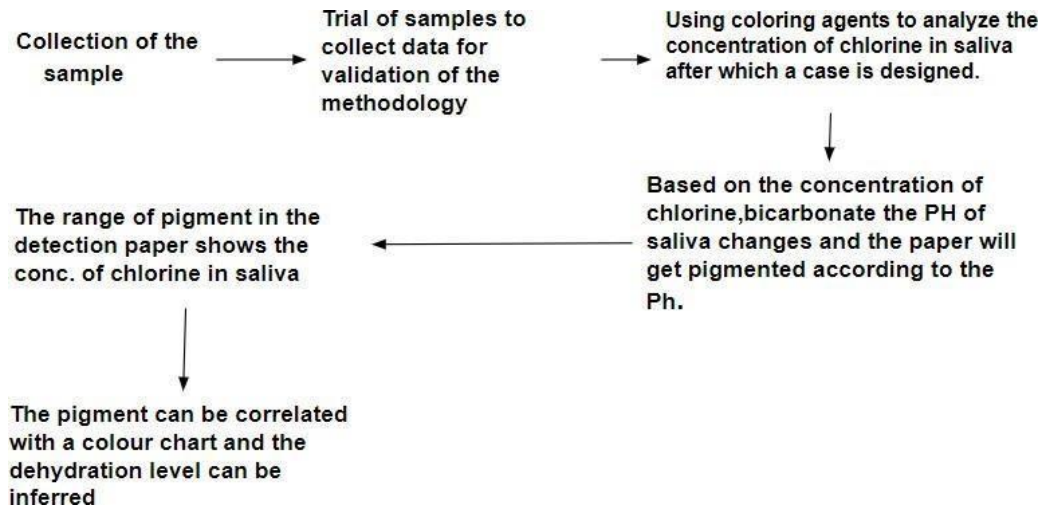


Fig. 4.1 Workflow of the prospective methodology

4.1 COLLECTION OF SAMPLE:

Fig 4.1 describes our methodology followed in a concise form. For the collection of dehydrated samples, participants were advised to avoid eating, drinking, smoking, or vigorous physical activity for at least 5-6 hours before sample collection to ensure accurate results.

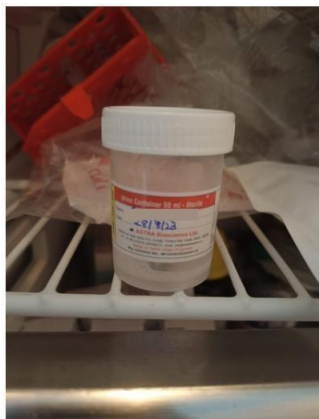


Fig. 4.2 Collection and storage of samples

Sterile saliva collection equipment is prepared, and participants are instructed to rinse their mouth with water to remove debris. Participants were asked to spit directly into a 25 ml container. An adequate volume of saliva is collected and each sample is labeled with a unique identifier for traceability as shown in Fig 4.2.

The samples were stored at an appropriate temperature to preserve the integrity of the biomarkers until analysis, and insulated containers with ice packs are used for transport to a laboratory. For the collection of hydrated samples, the participants were advised to drink at least 1 liter of water and their sample was collected after 2-3 hours.

4.2 TESTING OF SAMPLE COLLECTIONS TO GATHER DATA FOR VALIDATING THE PROOF OF CONCEPT AND METHODOLOGY

The concentration of chlorine ions was analyzed from saliva using a UV spectrophotometer (Ultra-Violet spectrophotometer). Chlorine ion concentration cannot be detected by spectrophotometer as such. So, chemicals such as starch iodide and silver nitrate were used to convert the chlorine in saliva to silver chloride whose concentration can further be detected by UV spectrophotometer.

When this mixture was analyzed in a UV spectrophotometer it resulted in the following peaks. Analyzing the concentration of chlorine ions from saliva using a UV. In a hydrated state typically, the pH (power of Hydrogen) of hydrated saliva can range from 6.2 to 7.6. This range reflects a slightly acidic to slightly alkaline pH.

In a dehydrated state the pH of saliva may increase in a dehydrated state, potentially reaching values slightly above 7.6



Fig. 4.3 Preparing chemical concoction

Fig 4.3 shows the overall preparation of the chemical concoction for validation of methodology.

4.2.1 Preparation of Starch Iodide Solution:

After being heated to complete dissolution, 0.1 g of starch was dissolved in 100 mL of distilled water. After that, the solution was let to cool to room temperature. A few drops of potassium iodide solution were added after cooling.

4.2.2 Mixing of Saliva with Starch Iodide Solution:

About 0.5 mL of the prepared starch iodide solution was combined with 0.5 mL of saliva in a sterile test tube. Before mixing, the saliva was brought to room temperature. After the contents were carefully blended, changes were noticed.

4.2.3 Preparation of Silver Nitrate Solution:

To ensure exact stoichiometry, we carefully measured and dissolved the right amount of silver nitrate in distilled water. The final mixture was thoroughly blended to achieve homogeneity. A consistent 0.01 M concentration was obtained using this method, making it appropriate for use in further laboratory tests.

4.2.4 Addition of Silver Nitrate Solution:

The saliva-starch iodide mixture was gradually mixed with a few drops of the 0.01 M silver nitrate solution. The presence of chlorine ions in the saliva was indicated by the formation of a white precipitate of silver chloride (AgCl) upon contact. The effectiveness of the analytical process was confirmed by this response.

4.2.5 Allowing Precipitation:

For complete silver chloride precipitation, the mixture was allowed to stand for a few minutes. The full settling of the precipitate during this waiting period verified that chlorine ions were indeed detected in the saliva-starch iodide mixture.

4.2.6 Measuring absorbance:

The liquid component, known as the supernatant, was delicately moved to a cuvette so that the UV spectrophotometer could measure its absorbance. A suitable wavelength was chosen to measure the absorbance of silver chloride. This analytical method made it possible to quantify the amount of chloride ions in the sample.

4.2.7 Reference Blank:

Silver nitrate solution, starch iodide solution, and distilled water were used to create a reference blank. The same parameters as the sample were used to measure its absorbance. By taking this step, the accuracy of the background absorbance correction was guaranteed, which improved the analytical measurements' dependability.

4.2.8 Assessing Concentration:



Fig. 4.4 Increased coloured turbidity indicating presence of more chlorine concentration

An estimate of the concentration of chlorine ions in the saliva can be obtained by comparing the absorbance of the sample with that of the reference blank as prepared in Fig 4.4. This comparative analysis helps with quantitative evaluation by providing insightful information about the chloride ion content of the sample solution.

The concentration of chlorine ions was analyzed from saliva using a UV spectrophotometer. When this mixture was analyzed in UV spectrophotometer it resulted in the following observations.

Initially, peaks were observed around 4 in all three samples, including the control, hydrated, and dehydrated samples, primarily attributed to background noise

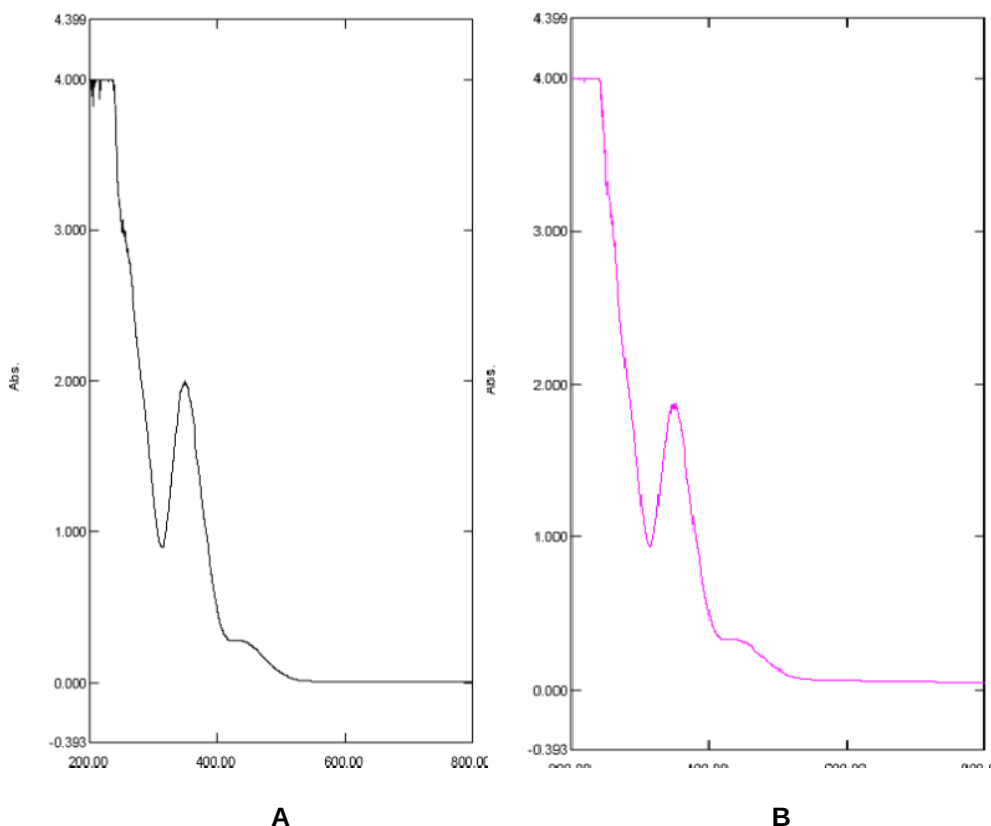


Fig. 4.5 UV spectroscopy graph of control (A) and rehydrated (B) sample

Subsequent analysis revealed that in the control Fig 4.5 -A and hydrated Fig 4.5-B samples , the peaks shifted to around 2. This shift indicated a lower concentration of chlorine within the wavelength range typically used for chlorine measurement (350 nm - 450 nm). This observation suggested an optimal electrolytic balance contributing to the lower chlorine concentration in these samples. The optimal electrolytic balance implies a stable distribution of ions, including chlorine, resulting in a regulated concentration within the specified range.

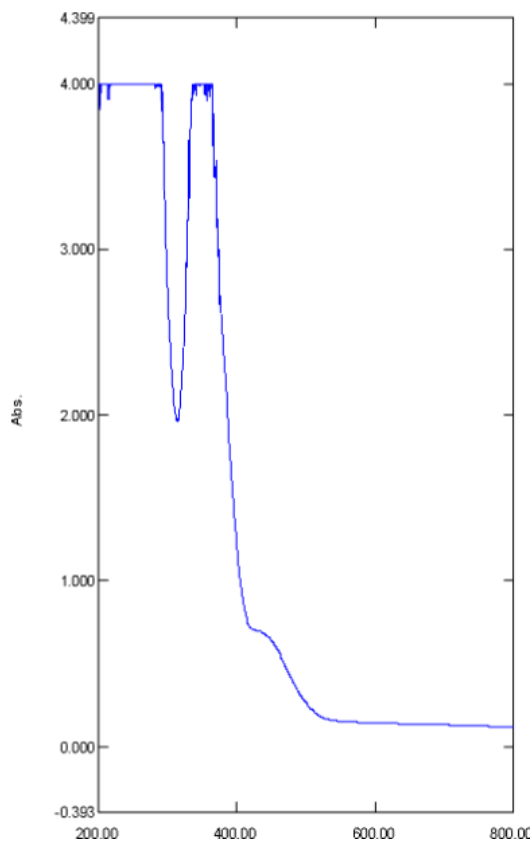


Fig. 4.6 UV spectroscopy graph of dehydrated sample

In the dehydrated sample Fig 4.6, it was observed that the peak remained around 4, indicating a higher concentration of chlorine compared to the control and hydrated samples. This observation confirms that chlorine concentrations increase with dehydration. The increase in chlorine concentration serves as a compensatory mechanism to offset electrolyte loss associated with dehydration. This phenomenon underscores the dynamic interplay between electrolyte balance and hydration status, emphasizing the role of chlorine in maintaining homeostasis.

**Table no. 1 (Control sample-
UV spectrophotometer)**

No	Wavelength (nm)	Abs
1	431.5	0.279
2	349.5	1.995
3	233	4
4	220	4

**Table no. 2 (Rehydrated sample-
UV spectrophotometer)**

No	Wavelength (nm)	Abs
1	433	0.332
2	351	1.869
3	230	4
4	423.5	0.33

**Table no. 3 (Dehydrated sample-
UV spectrophotometer)**

No	Wavelength (nm)	Abs
1	363	4
2	352.5	4
3	342.5	4
4	338	4

Table no.1, Table no.2, Table no. 3 shows UV spectrophotometer results of Control , Rehydrated and dehydrated samples with absorbance peaks 1.995 , 1.869, 4 around 350 nm respectively. Rehydrated samples exhibit similar peaks as control, with notable peaks at 1.995 and 1.869 nm. Dehydrated samples display a distinct peak at 4 nm, differing from control and rehydrated samples, indicating a significant difference in spectral characteristics.

4.3 USING COLORING AGENTS TO ANALYZE DEHYDRATION STATUS

Following collection, the patient's sample undergoes treatment with a colouring agent. The sample is then exposed to the agent and monitored for pigmentation, reflecting the levels of chlorine, bicarbonate, and saliva ph. Colouring agents form coloured complexes with saliva electrolytes, providing a colorimetric indication. The intensity of the pigment correlates with a colour chart, facilitating dehydration level inference.

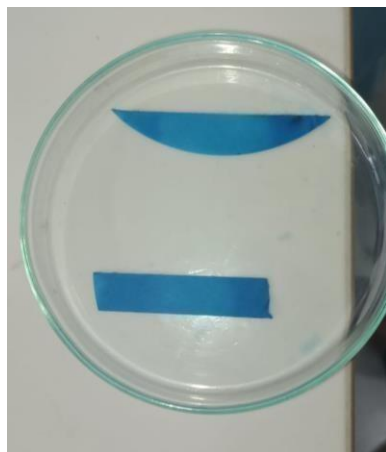


Fig. 4.7 Indigo Carmine reaction on dehydrated and rehydrated sample

Initially, dehydrated and rehydrated saliva samples underwent testing with indigo carmine. However, no dominant difference in pigmentation was discerned between the samples as shown in Fig 4.7, suggesting limitations in indigocarmine's discriminatory ability for electrolyte level variations with respect to saliva. This prompted the exploration of alternative colouring agents like phenol red, renowned for its sensitivity to pH changes and distinct colour transitions. The unsuccessful outcome with indigo carmine underscored the necessity of selecting more sensitive colouring agents tailored to the nuances of dehydration assessment.



Fig. 4.8 Phenol red reaction on dehydrated (left) and rehydrated (right) sample

Upon transitioning to phenol red from indigo carmine, a marked improvement in discriminatory capacity was observed.

Phenol red's distinctive colour scale, ranging from yellow to fuchsia, facilitated clearer differentiation between samples, enhancing the precision of electrolyte and pH assessments. Phenol red's clear colour scale as tested in Fig 4.8 facilitates visual interpretation, making it accessible for point-of-care testing and field applications.

The perceptible colour transitions offered by phenol red simplified the identification of subtle differences in saliva composition, thus streamlining the dehydration evaluation process.

4.4 DESIGNING THE CASE

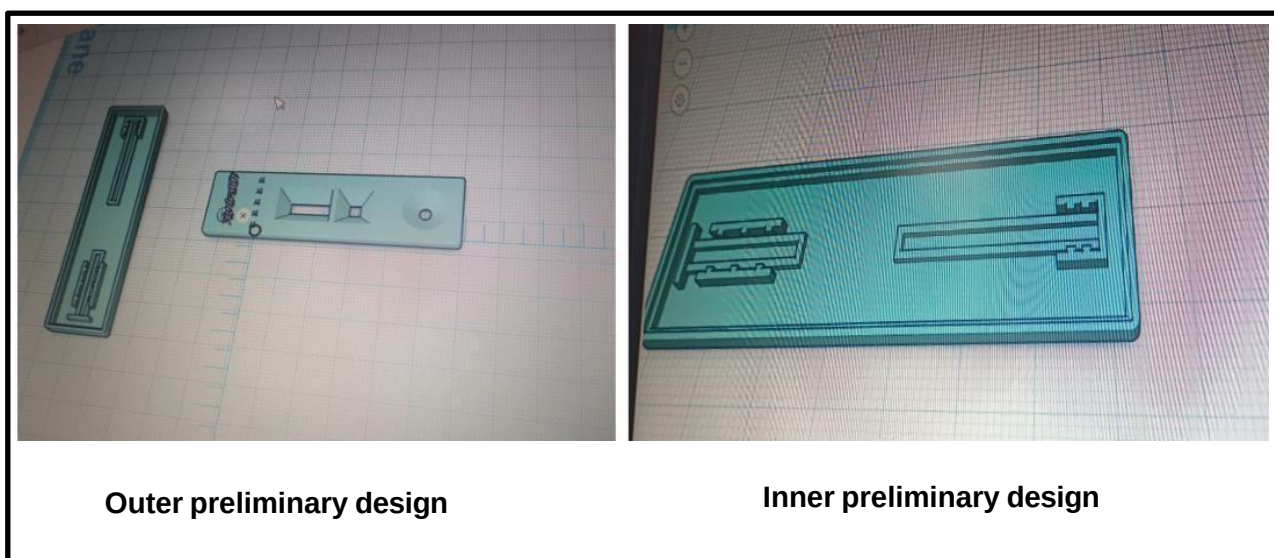


Fig. 4.9 Preliminary internal design of casing

The case serves as a housing unit for inserting the strip and adding saliva into the groove, facilitating ease of handling during testing. To ensure optimal functionality and user experience, a preliminary design of the case was crafted using SolidWorks software as shown in Fig 4.9 and subsequently 3D printed. Initially, a custom internal design was tailored to evaluate the case's appearance and functionality. This trial design allowed for critical assessment of factors such as strip insertion, saliva application, and overall ergonomics.

However, during testing, concerns arose regarding the stability of the outer structure. Consequently, iterative modifications were made to enhance the case's structural integrity and durability. These adjustments included reinforcing key components and refining the overall design to withstand handling and usage stresses effectively.

Through a systematic design iteration process, the final version of the case was refined to ensure optimal performance, durability, and user satisfaction.

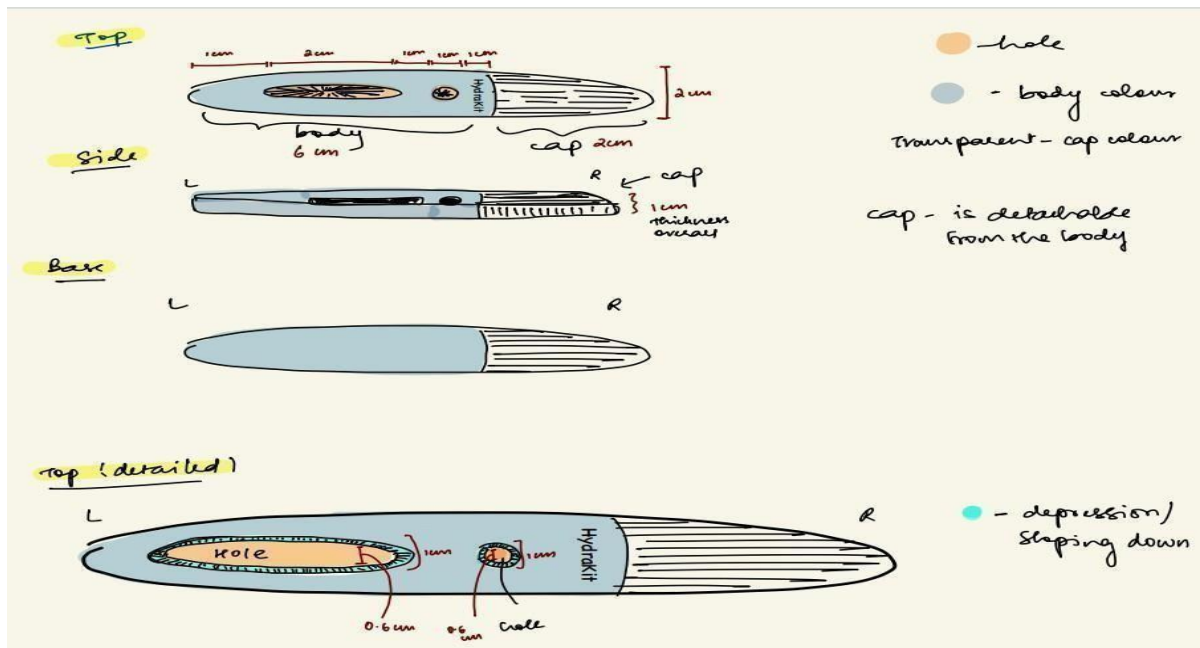


Fig. 4.10 Preliminary hand-drawn external casing design with specific measurement

To address issues identified during preliminary testing, we undertook a hands-on approach to refine the design of both the internal and external components of the case as depicted in Fig 4.10. Initially, we hand-drew customize designs, meticulously calculating measurements to correct errors observed in the initial prototype. These drawings were informed by insights gained from practical testing and user feedback, ensuring that the revised design met the desired specifications.

For the internal design, we focused on optimizing the layout to accommodate multiple test strips efficiently. By strategically positioning grooves or compartments within the case, we aimed to enhance usability by enabling users to insert and secure multiple strips for a single casing. This approach not only streamlined the testing process but also promoted cost-effectiveness by allowing the reuse of the case for multiple strips instead of making it a one-time use and throw device. Simultaneously, we revisited the external design to improve handling and portability. Drawing on ergonomic principles, we simplified the form factor and introduced features such as rounded edges and textured surfaces to enhance grip and user comfort.

Additionally, we incorporated a secure closure mechanism to prevent accidental spillage or damage to the contents. Throughout the design refinement process, we remained cognizant of the need to balance functionality, usability, and manufacturability. By iteratively refining our designs based on practical testing and user input, we ultimately achieved a more user- friendly and versatile case solution that met the diverse needs of our target audience.

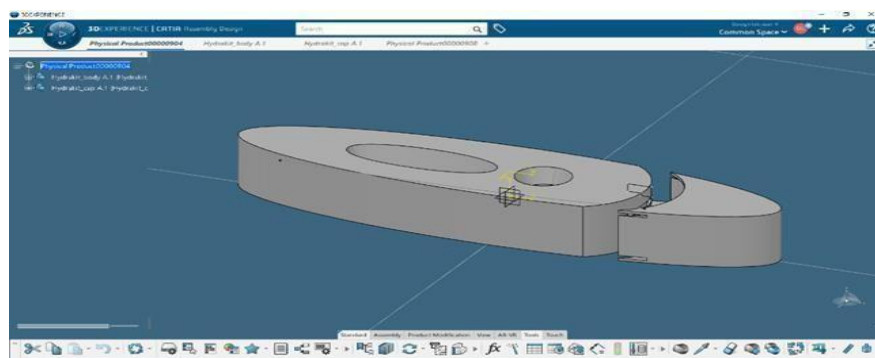


Fig 4.11 Final 3D Design using SolidWorks CATIA

As shown in Fig 4.11, the device features a streamlined body design with a transparent cap, allowing users to easily ascertain whether a strip is present inside. This transparent cap offers visibility into the device's interior, enabling users to confirm the presence of the strip before and after use. Additionally, the cap serves as a protective cover, safeguarding the strip from external contaminants when not in use.



Fig 4.12 Final casing prototype after 3D printing

As depicted in Fig 4.12, internally, the device comprises two distinct grooves: a circular groove and an oval groove. The circular groove is designated for saliva application, providing a precise location for users to deposit their samples. This design ensures consistent and accurate placement of saliva, optimizing the testing process. The oval groove accommodates the test strip, where the results are displayed. This groove is specially designed to fit the strip snugly, preventing slippage or misalignment during testing. As the strip reacts with the saliva sample, any color changes indicative of electrolyte levels or pH variations are visually assessed within the oval groove. This layout enables users to conveniently monitor the progression of the test and interpret the results with ease. After use, the strip can be replaced with a new one by simply removing the transparent cap and disposing of the used strip. The transparent cap also facilitates easy insertion of a new strip into the device's body, ensuring a seamless testing experience for users. This design feature promotes cost-effectiveness and efficiency by allowing for the continuous use of the device with minimal downtime between tests.

4.5 INSERTING THE STRIPS WITH THE CASE

We opted for Whatman No. 40 paper to coat the coloring reagents on top due to its unique porous structure, which effectively retains coloration. Unlike other paper types, Whatman No. 40 paper offers enhanced color retention properties, ensuring that the coloring reagents remain vivid and stable over time. This porous structure allows for efficient absorption and distribution of the reagents, facilitating consistent and reliable color development.



Fig 4.13 Testing of prototype after 3D printing

After cutting the strip to match the case length, we coated it with the reagent and allowed it to air dry. Subsequently, we conducted a test to assess its functionality by inserting it into the case. Once inserted, a saliva sample was poured into the well.

Upon contact, the saliva reacted with the reagent-coated paper, triggering a chemical response that led to a visible color change as shown in fig 4.13. This change in color served as an indicator of the presence or concentration of specific analytes in the saliva, providing valuable diagnostic information.

4.6 MOBILE APPLICATION - HYDRATION LOG

Our mobile application (nicknamed as Hydration log), was meticulously designed to enable users to log their hydration status conveniently. It encompasses various features, including a nutrition diary log, workout diary log, and a main hydration log.

Prior to usage, users are prompted to input their medical history and healthy habits, facilitating seamless navigation and ensuring healthcare providers are informed. A submission history page allows users to review their previous logs for tracking and analysis.

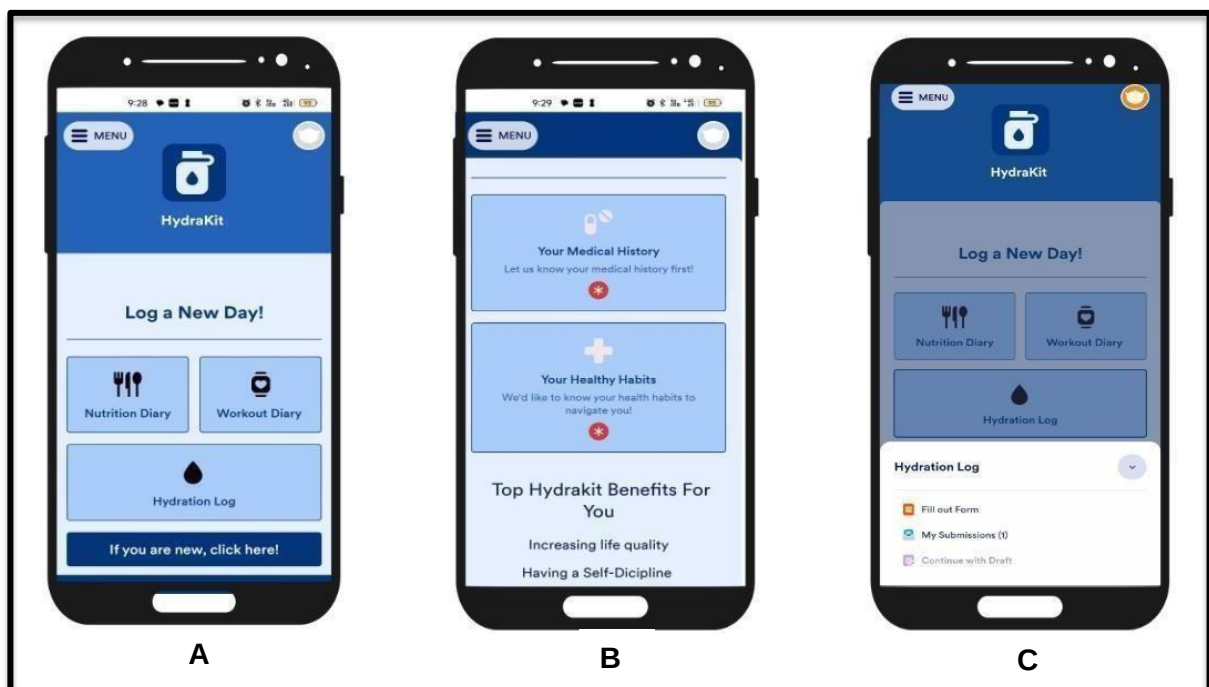


Fig. 4.14 Hydration log application

Fig 4.14 shows the app display. The hydration log within the app offers comprehensive functionalities. It automatically records the date and time of each entry, simplifying the logging process. Users input the amount of fluids consumed, activities undertaken, current weather conditions, and even upload a picture of their test strip after testing.

Upon submission, users receive a confirmation email, ensuring the accuracy of their data entry. The app provides a user-friendly platform for monitoring hydration status, integrating essential features for comprehensive health tracking.

After submitting the log for the day, the user interface displays a concise summary of the logged information, including date, time, fluid intake, activities, weather, and uploaded.

CHAPTER 5

RESULT AND DISCUSSION, PERFORMANCE ANALYSIS

Dehydration is a serious issue as it leads to fluid loss in the body. So, it is always recommended to consult a doctor and diagnose it in its early stages. In order to reduce the workload of healthcare professionals and reduce the time of diagnosis a unique method is proposed which uses saliva as the analyte. Saliva, a readily accessible bodily fluid, offers a non-invasive and convenient medium for dehydration detection. This method uses quantification of salivary biomarkers associated with hydration status, such as chlorine concentration (main) and other factors like PH to detect hydration status.

After validation of the method testing of the strips were done which yielded visible colour differences in the strips. From the colour change the following observations are inferred.

Lighter shades of yellow indicate that the person is more dehydrated. As the colour shifts towards to more darker side (fuchsia, deep pink) it indicates the person is less dehydrated. The intensity of the colour is inversely proportional to the dehydration level. This was tested with 20 volunteers.

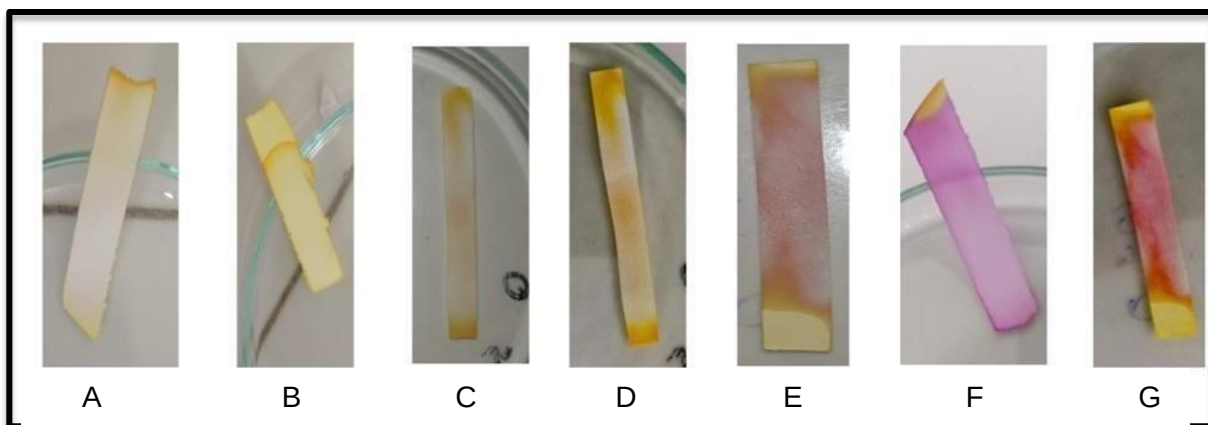


Fig 5.1. Visible colour differences is observed in the strips

In Fig 5.1, the strips A,B and C lie in the yellow range that shows that the user is severely dehydrated while strips D,E have a mix of both yellow and fuchsia and shows that the user is mildly dehydrated whilst the strip F and G are in shades of fuchsia indicating that the user is adequately hydrated. Based upon the colour changes observed in the trial samples a colour chart is formulated with which the user can interpret his/her hydration status by comparing the colour in the test strip with the colours given in the colour chart.



Fig 5.2. Curation of the colour chart

The testing strips and our hydration log app worked together seamlessly to create a user-friendly experience that made it easy for users to keep track of their hydration levels. First of all, the app made sure that users understood the procedure without any confusion by offering clear instructions on how to use the testing strips. This included instructions on when and how to use the strips in addition to precise interpretation of the results by comparing with the colour chart as shown in Fig 5.2.

Once the user performed the hydration test using the strips, they inputted the results into the app. The app then seamlessly incorporated this data into the user's hydration log, displaying it in an easily understandable format. This integration eliminated the need for manual tracking or interpretation of results, streamlining the process for the user.

This process allowed us to assess the effectiveness and accuracy of our hydration log app inconjunction with the testing strips over an extended period.

Hydration Log

Saturday, March 2, 2024

Your name

Chitra Sundar

Today's date

Saturday, March 2, 2024

At what time did you last record your hydration status ?

10:15 PM

Take photo of the strip (after use)



Activity level

moderate

Hydration source since last assessment

Water

Amount of water consumed since last assessment

500 ml

Current weather

Hot

List any special circumstances

Nil

Location

Madurai

Fig. 5.3 Real-time application generated result for user

The application smoothly integrated this information into the user's hydration log, presenting it in a user-friendly format as depicted in Fig 5.3.

My personal hydration log

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	Submission Date	Source App	Your name	Today's date	At what time did you last record your hydration status ?	Take photo of the strip (left)
1	Mar 10, 2024	HydraKit	Sundar Ganesh	Mar 10, 2024	06:18 PM	
2	Mar 10, 2024	HydraKit	Chitra Sundar	Mar 10, 2024	06:15 PM	
3	Mar 9, 2024	HydraKit	Chitra Sundar	Mar 9, 2024	11:45 PM	
4	Mar 9, 2024	HydraKit	Sundar Ganesh	Mar 9, 2024	11:30 PM	
5	Mar 8, 2024	HydraKit	Sundar Ganesh	Mar 8, 2024	10:20 PM	
6	Mar 7, 2024	HydraKit	Sundat Ganesh	Mar 7, 2024	10:51 PM	
7	Mar 6, 2024	HydraKit	Sundar Ganesh	Mar 6, 2024	11:30 PM	
8	Mar 6, 2024	HydraKit	Chitra Sundar	Mar 5, 2024	10:30 PM	
9	Mar 4, 2024	HydraKit	Chitra Sundar	Mar 4, 2024	10:35 PM	
10	Mar 3, 2024	HydraKit	Chitra Sundar	Mar 3, 2024	10:45 PM	
11	Mar 2, 2024	HydraKit	Chitra Sundar	Mar 2, 2024	10:15 PM	

Fig. 5.4 8-day user-tested submissions in application

My personal hydration log

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	Submission Date	Activity level	Hydration source since last assessment	Amount of water consumed since last assessment	Current weather	As List a
1	Mar 10, 2024	moderate	Water	1.5 l	Humid	Diabetes
2	Mar 10, 2024	moderate	Water, buttermilk, fresh juices	2 litre	Humid	Nil
3	Mar 9, 2024	moderate	Water, buttermilk, fresh juices	2 litre	Hot	Nil
4	Mar 9, 2024	moderate	Water	1.5 l	Hot	Diabetes
5	Mar 8, 2024	moderate	Juices and water	2 litre	Humid	Diabetes
6	Mar 7, 2024	moderate	Water, buttermilk	2 litre	Moderate	Diabetes
7	Mar 6, 2024	moderate	Juices and water	2 litre	Humid	Diabetes
8	Mar 6, 2024	moderate	Juices and water	1 litre	Cold	Nil
9	Mar 4, 2024	moderate	Water	Less than 1.5 l	Hot	Nil
10	Mar 3, 2024	moderate	Water	Few ml	Hot	Nil
11	Mar 2, 2024	moderate	Water	800 ml	Hot	Nil
Total 16						

Give Feedback

Fig. 5.5 8-day user-tested submissions in application (extended)

We asked a user to test our hydration log application over the course of eight days using our testing strips as shown in Fig 5.4 and Fig 5.5. The user diligently used our app to record their hydration levels during this time, and they cross-referenced their readings with the information from the testing strips. These outcomes were painstakingly recorded and arranged for thorough analysis on a single sheet.

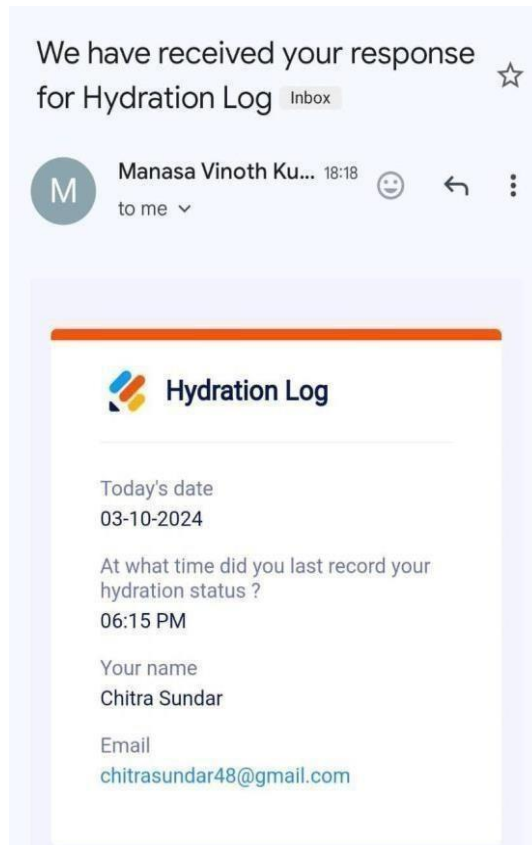


Fig. 5.6 Real-time application notification interface on user end

In summary, our dehydration detection device, equipped with innovative strips and a convenient hydration log, represents a groundbreaking solution for personal health management. The app also sent email notifications of submissions as shown in Fig 5.6. By seamlessly combining real-time monitoring with easy-to-use tracking capabilities, our device offers individuals a reliable tool to safeguard against dehydration and promote hydration awareness. With its user-centric design and precision engineering, this technology not only empowers users to take control of their hydration levels but also holds the promise of revolutionizing preventive healthcare practices.

CHAPTER 6

SUMMARY AND CONCLUSION

The developed point-of-care device presents a unique method for detecting dehydration using saliva, with the primary aim of developing a non-invasive testing system. This innovative approach eliminates the need for uncomfortable and intrusive blood tests, offering immediate outcomes compared to the time-consuming conventional methods. By focusing on the concentration of chlorine, bicarbonate, and the pH of saliva, which vary according to hydration status, the work proposes a reagent-coated paper that changes color based on these factors.

The successful identification of dehydration served as evidence of the effectiveness of this approach. It has potential for widespread adoption in a variety of settings, such as healthcare facilities, sports training centers, and even personal use, because it offers a straightforward but accurate method of assessment. The method's non-invasiveness makes it especially desirable for routine monitoring since it doesn't put people through any pain or inconvenience.

The utility and accessibility of the system are improved by integration with digital tools like the hydration log app, which goes hand in hand with advancements in diagnostic technology. The non-invasive testing method is enhanced by the hydration log app, which offers a smooth platform for users to track and record their hydration levels over time. This integration makes proactive management of hydration and general well-being possible by providing people and healthcare professionals with an extensive toolkit for tracking health metrics. This creative approach not only raises the standard of care but also gives people the confidence to take charge of their own health.

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