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Projeto Integrado IoT - PLASMαC

Objetivo

Criação de um sistema automatizado de captação de água, tratamento com plasma atmosférico e irrigação de cultivo de hortaliças.

Referencial Teórico

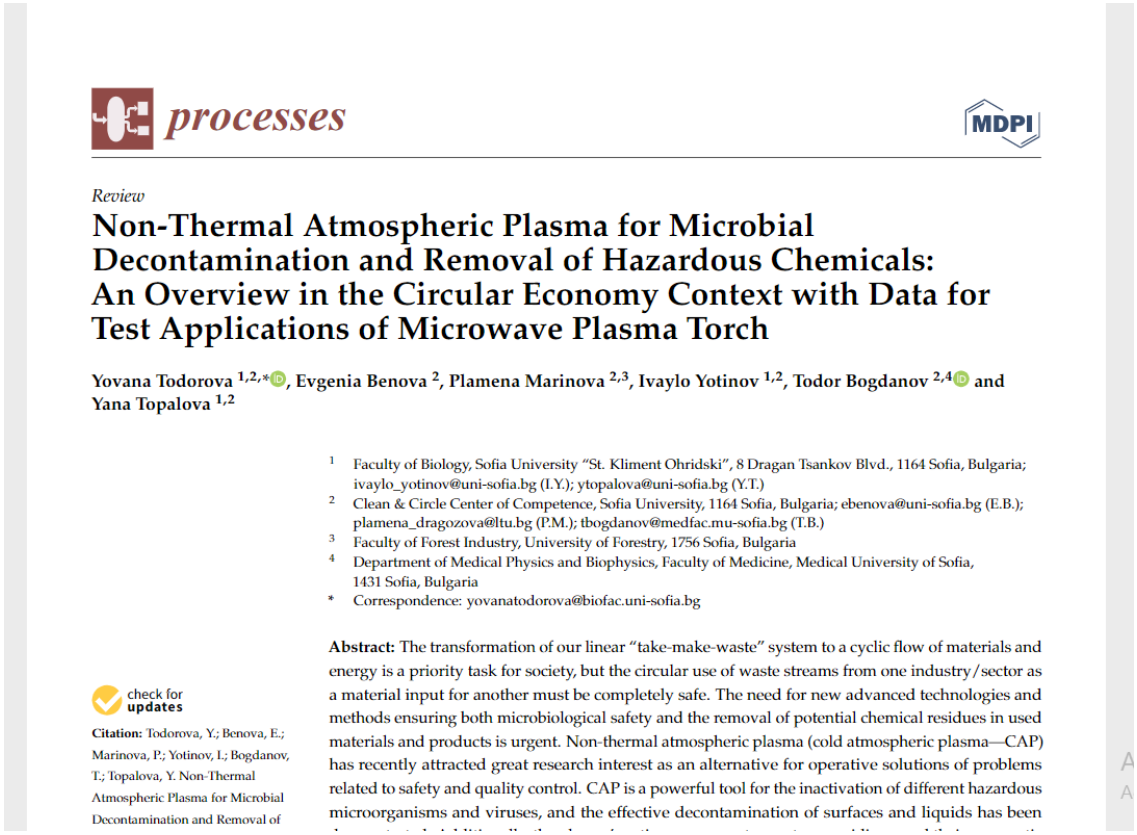
As frutas, legumes e verduras constituem uma parte importante da dieta humana, porém são veículos de propagação de doenças, principalmente devido ao uso de água imprópria para a irrigação e o cultivo em solo contaminado e por isso aumenta cada vez mais a necessidade do desenvolvimento de novas tecnologias para descontaminação de água e alimentos que preservem a sua qualidade e sejam sustentáveis.

O uso da tecnologia de plasma atmosférico no tratamento e funcionalização de água tem se mostrado bastante promissora, uma vez que propicia a degradação de contaminantes químicos e biológicos, além de promover a formação de espécies reativas de oxigênio e nitrogênio que podem desempenhar papel importante na germinação e crescimento de plantas.

Utilizamos os artigos abaixo para o embasamento teórico do nosso projeto:

Descontaminação a plasma

Todorova, Y.; Benova, E.; Marinova, P.; Yotinov, I.; Bogdanov, T.; Topalova, Y. Non-Thermal Atmospheric Plasma for Microbial Decontamination and Removal of Hazardous Chemicals: An Overview in the Circular Economy Context with Data for Test Applications of Microwave Plasma Torch. *Processes* **2022**, *10*, 554. https://doi.org/10.3390/pr10030554



processes

MDPI

Review

Non-Thermal Atmospheric Plasma for Microbial Decontamination and Removal of Hazardous Chemicals: An Overview in the Circular Economy Context with Data for Test Applications of Microwave Plasma Torch

Yovana Todorova [1,2,*], Evgenia Benova [2], Plamena Marinova [2,3], Ivaylo Yotinov [1,2], Todor Bogdanov [2,4] and Yana Topalova [1,2]

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[2] Clean & Circle Center of Competence, Sofia University, 1164 Sofia, Bulgaria; ebenova@uni-sofia.bg (E.B.); plamena_dragozova@ltu.bg (P.M.); tbogdanov@medfac.mu-sofia.bg (T.B.)
[3] Faculty of Forest Industry, University of Forestry, 1756 Sofia, Bulgaria
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Abstract: The transformation of our linear "take-make-waste" system to a cyclic flow of materials and energy is a priority task for society, but the circular use of waste streams from one industry/sector as a material input for another must be completely safe. The need for new advanced technologies and methods ensuring both microbiological safety and the removal of potential chemical residues in used materials and products is urgent. Non-thermal atmospheric plasma (cold atmospheric plasma—CAP) has recently attracted great research interest as an alternative for operative solutions of problems related to safety and quality control. CAP is a powerful tool for the inactivation of different hazardous microorganisms and viruses, and the effective decontamination of surfaces and liquids has been

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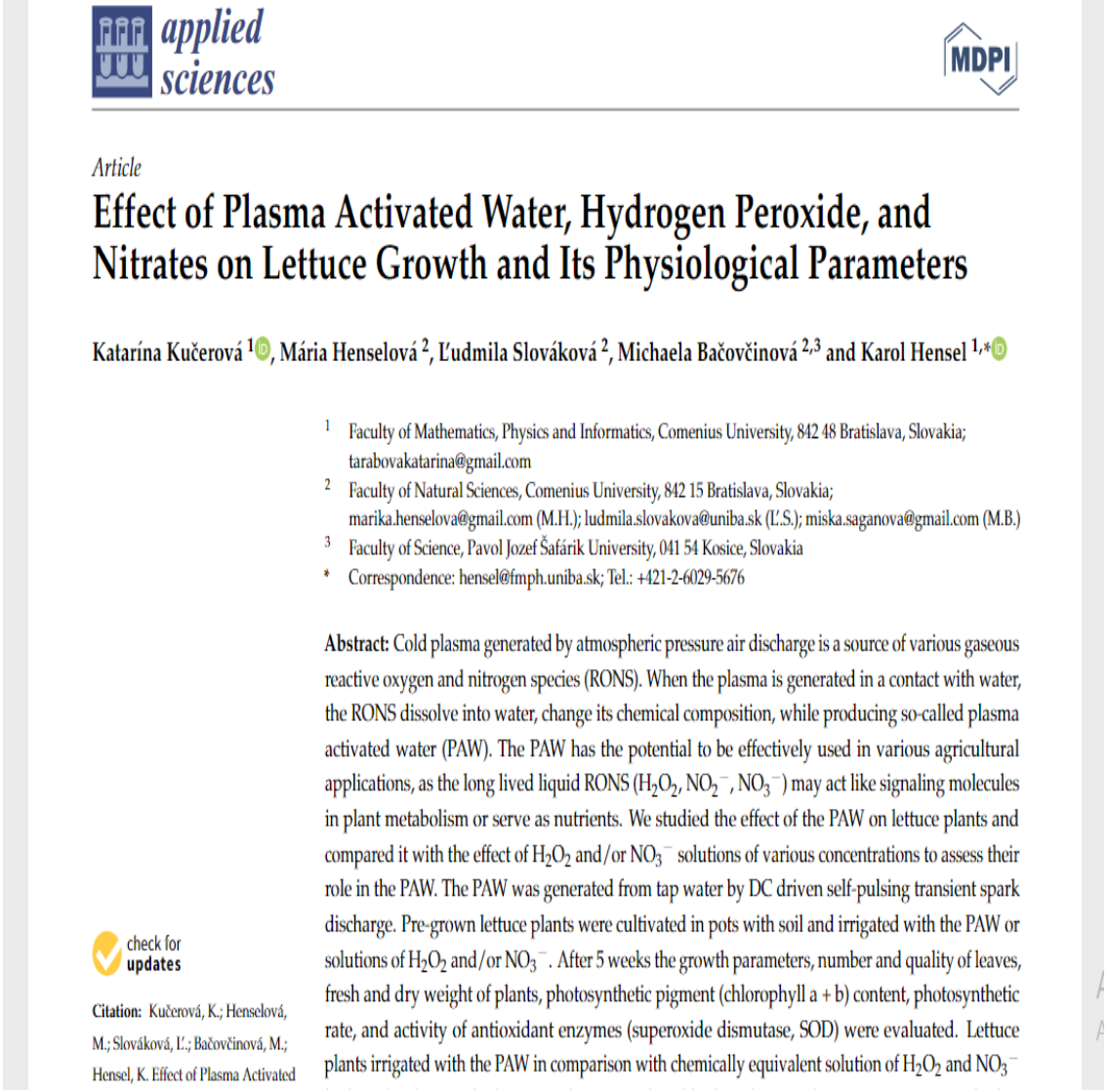
Citation: Todorova, Y.; Benova, E.; Marinova, P.; Yotinov, I.; Bogdanov, T.; Topalova, Y. Non-Thermal Atmospheric Plasma for Microbial Decontamination and Removal of

Irrigação de cultivo com água ativada por plasma (PAW)

Kučerová, K.; Henselová, M.; Slováková, Ľ.; Bačovčinová, M.; Hensel, K. Effect of Plasma Activated Water, Hydrogen Peroxide, and Nitrates on Lettuce Growth and Its Physiological Parameters. *Appl. Sci.* **2021**, *11*, 1985. https://doi.org/10.3390/app11051985



applied sciences

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Article

Effect of Plasma Activated Water, Hydrogen Peroxide, and Nitrates on Lettuce Growth and Its Physiological Parameters

Katarína Kučerová [1], Mária Henselová [2], Ľudmila Slováková [2], Michaela Bačovčinová [2,3] and Karol Hensel [1,*]

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Abstract: Cold plasma generated by atmospheric pressure air discharge is a source of various gaseous reactive oxygen and nitrogen species (RONS). When the plasma is generated in a contact with water, the RONS dissolve into water, change its chemical composition, while producing so-called plasma activated water (PAW). The PAW has the potential to be effectively used in various agricultural applications, as the long lived liquid RONS (H_2O_2, NO_2^-, NO_3^-) may act like signaling molecules in plant metabolism or serve as nutrients. We studied the effect of the PAW on lettuce plants and compared it with the effect of H_2O_2 and/or NO_3^- solutions of various concentrations to assess their role in the PAW. The PAW was generated from tap water by DC driven self-pulsing transient spark discharge. Pre-grown lettuce plants were cultivated in pots with soil and irrigated with the PAW or solutions of H_2O_2 and/or NO_3^-. After 5 weeks the growth parameters, number and quality of leaves, fresh and dry weight of plants, photosynthetic pigment (chlorophyll a + b) content, photosynthetic rate, and activity of antioxidant enzymes (superoxide dismutase, SOD) were evaluated. Lettuce plants irrigated with the PAW in comparison with chemically equivalent solution of H_2O_2 and NO_3^-

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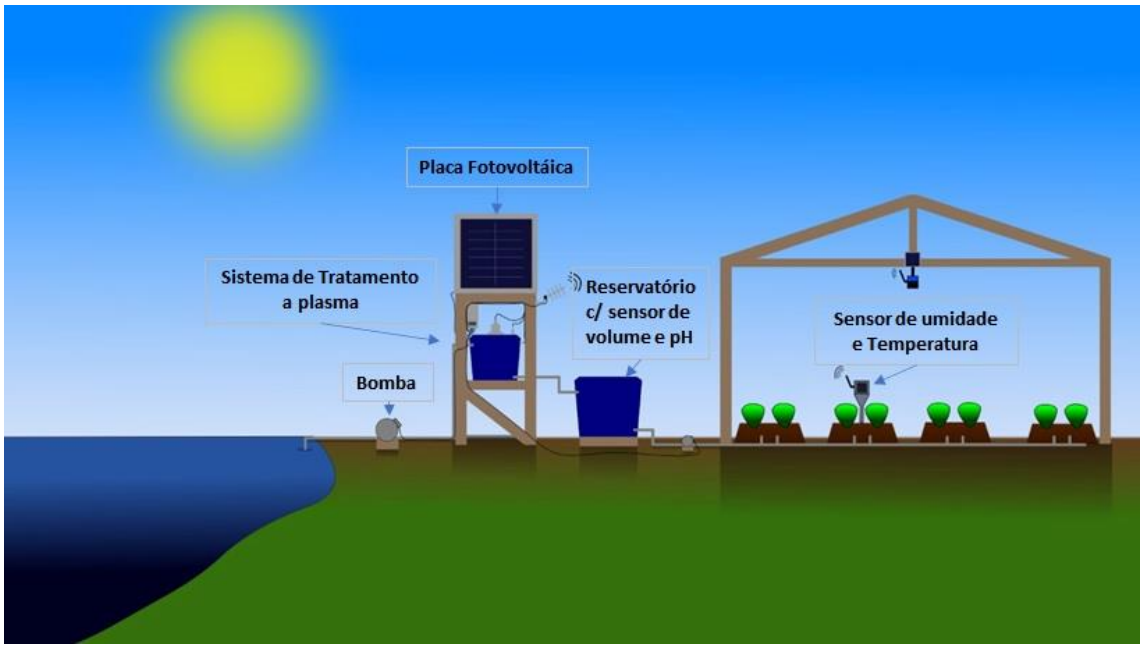
Citation: Kučerová, K.; Henselová, M.; Slováková, Ľ.; Bačovčinová, M.; Hensel, K. Effect of Plasma Activated

Esquema geral do projeto

O projeto consiste na captação de água e tratamento com plasma atmosférico para descontaminação e posterior utilização de cultivo de hortaliças, sendo todo o processo automatizado e podendo ser controlado remotamente.



Estufa de 200m^2

Capacidade de cultivo: 4mil cabeças de alface

Irrigação 3x/dia => 10 minutos cada

Esquema Arduino Umidade/Temperatura

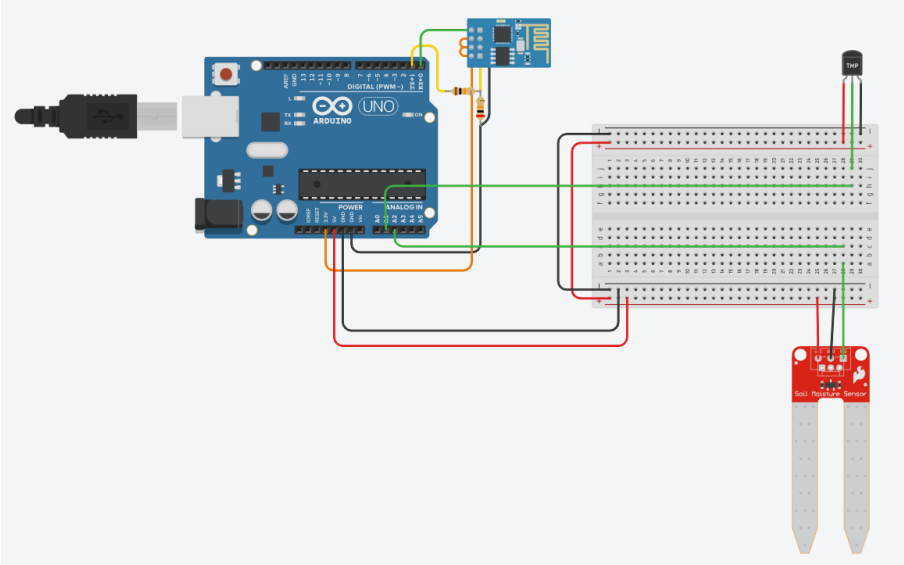
Potência do Reator de plasma: 25W

Volume tratado: 250L/15 min

Frequência de tratamento: 8 ciclos/dia

Esquema Arduino Umidade/Temperatura

A simulação dos circuitos foi feita no Thinkercad e usada linguagem c++

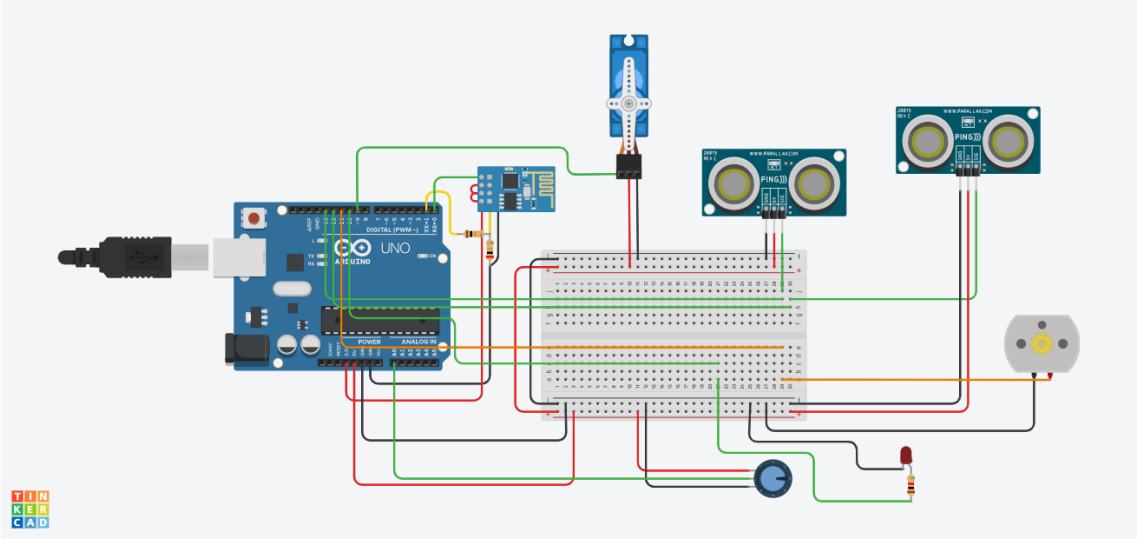


Nome	Quantidade	Componente
U1	1	Arduino Uno R3
U2	1	Módulo Wifi (ESP8266)
R1	1	20 kΩ Resistor
R2	1	10 kΩ Resistor
SEN1	1	Soil Moisture Sensor
U3	1	Sensor de temperatura [TMP36]

```ino
#include <Servo.h>

String ssid = "Simulator Wifi";
String password = "";
String host = "api.thingspeak.com";
const int httpPort = 80;
String uri = "/update?api_key=8WJGRADBRFX6KLWI&field1=";

int temp  = A1;
int soil = A2;
int valorSoil;
float valorTemp;
int valorSolar;
String status;

int setupESP8266(void)
{
  Serial.begin(115200);
  Serial.println("AT");
  delay(10);
  if(!Serial.find("OK"))return 1;
  Serial.println("AT+CWJAP=\"" + ssid + "\",\"" + password + "\"");
  delay(10);
  if(!Serial.find("OK"))return 2;
  Serial.println("AT+CIPSTART=\"TCP\",\"" + host + "\"," + httpPort);
  delay(50);
  if (!Serial.find("OK")) return 3;
  return 0;
}
void sendData(String dados,String dados2,String status){
  String httpPacket = "GET " + uri + dados2+"&field2="+dados +"&field3="+status +" HTTP/1.1\r\nHost: " + host + "\r\n\r\n";
    int length = httpPacket.length();
    Serial.print("AT+CIPSEND=");
    Serial.println(length);
    delay(10);
    Serial.print(httpPacket);
    delay(10);
   if (!Serial.find("SEND OK\r\n")) return;
}

```

```
40
41  void setup()
42  {
43    pinMode(temp, INPUT);
44    pinMode(soil, INPUT);
45   setupESP8266();
46  }
47
48  void loop()
49  {
50    valorSoil = analogRead(soil);
51    valorTemp = map(((analogRead(temp)-20) * 3.04), 0, 1023, -40, 125);
52    if(valorSoil < 350){
53      if(valorTemp < 38 ){
54        status="1";
55        sendData(String(valorSoil),String(valorTemp),status);
56        delay(12000);
57      }else{
58        status="2";
59        sendData(String(valorSoil),String(valorTemp),status);
60        delay(12000);
61      }
62    }else{
63    status="3";
64    sendData(String(valorSoil),String(valorTemp),status);
65    delay(12000);
66  }
67  }
```

Esquema Arduino pH/ Volume



Nome	Quantidade	Componente
U1	1	Arduino Uno R3
U2	1	Módulo Wifi (ESP8266)
R1	1	20 kΩ Resistor

R2	1	10 kΩ Resistor
Rpot1	1	250 kΩ Potenciômetro
SERVO1	1	Posicional Micro servo
PING1	2	Sensor de distância ultrassônico
M1	1	Motor CC
D1	1	Vermelho LED
R3	1	1 kΩ Resistor

```ino
#include <Servo.h>

String ssid = "Simulator Wifi";
String password = "";
String host = "api.thingspeak.com";
const int httpPort = 80;
String uri = "/update?api_key=O7PGAXF4L6Y0GZJ8&field1=";


Servo myservo;
int sensorPh =A0;
int potValue;
int signal = 13;
int signal2 = 12;
int motor = 11;
int led = 10;
float pH;
int distanciaCaixa1;
int distanciaCaixa2;
int status;
unsigned long pulseduration=0;


int setupESP8266(void)
{
  Serial.begin(115200);
  Serial.println("AT");
  delay(10);
  if(!Serial.find("OK"))return 1;
  Serial.println("AT+CWJAP=\"" + ssid + "\",\"" + password + "\"");
  delay(10);
  if(!Serial.find("OK"))return 2;
  Serial.println("AT+CIPSTART=\"TCP\",\"" + host + "\"," + httpPort);
  delay(50);
  if (!Serial.find("OK")) return 3;
  return 0;
}
void sendData(String dados,String dados2, String status){
  String httpPacket = "GET " + uri + dados+"&field2="+dados2 + "&field3="+status + " HTTP/1.1\r\nHost: " + host + "\r\n\r\n";
    int length = httpPacket.length();
    Serial.print("AT+CIPSEND=");
    Serial.println(length);
    delay(10);
    Serial.print(httpPacket);
    delay(10);
   if (!Serial.find("SEND OK\r\n")) return;
}
void measureDistance()
{
 pinMode(signal, OUTPUT);
 digitalWrite(signal, LOW);
 delayMicroseconds(5);
 digitalWrite(signal, HIGH);
 delayMicroseconds(5);
 digitalWrite(signal, LOW);
 pinMode(signal, INPUT);
 pulseduration=pulseIn(signal, HIGH);
}

void measureDistance2()
{
 pinMode(signal2, OUTPUT);
 digitalWrite(signal2, LOW);
 delayMicroseconds(5);
 digitalWrite(signal2, HIGH);
 delayMicroseconds(5);
 digitalWrite(signal2, LOW);
 pinMode(signal2, INPUT);
 pulseduration=pulseIn(signal2, HIGH);
}
```

```
void setup()
{
 pinMode(led,OUTPUT);
 pinMode(signal2, OUTPUT);
 pinMode(signal, OUTPUT);
 pinMode(sensorPh, INPUT);
 pinMode(motor, OUTPUT);
 myservo.attach(9);
 setupESP8266();
}

void loop()
{
  measureDistance();
  pulseduration=pulseduration/2;
  distanciaCaixa1 = int(pulseduration/29);
  measureDistance2();
  pulseduration=pulseduration/2;
  distanciaCaixa2 = int(pulseduration/29);

  potValue = analogRead(sensorPh);
  pH = (14 * potValue / 1023);

  if(distanciaCaixa1 > 100){
    myservo.write(90);
    digitalWrite(motor,HIGH);
    status = 1;
    sendData(String(distanciaCaixa1),String(pH), String(status));
    delay(12000);
  }else{
    digitalWrite(motor,LOW);
    if(pH <= 7 && pH >= 6){
      if(distanciaCaixa2 > 100){
        status = 3;
        myservo.write(0);
        sendData(String(distanciaCaixa1),String(pH), String(status));
        delay(12000);
      }else{
        status = 4;
        myservo.write(90);
        sendData(String(distanciaCaixa1),String(pH), String(status));
        delay(12000);
      }
    }else{
     digitalWrite(led,HIGH);
      status = 2;
      sendData(String(distanciaCaixa1),String(pH),String(status));
      delay(12000);
      digitalWrite(led,LOW);
    }
  }
}
```

Aplicativo

O aplicativo para controle remoto do sistema foi desenhado no software Adobe XD e consiste em uma tela pra login, seguida de uma tela principal contendo informações climáticas, como temperatura e umidade, além de acesso aos dados de tratamento da água captada e irrigação do cultivo. Na tela de irrigação é possível ver um histórico com a média de umidade do solo, status da irrigação diária e histórico da temperatura na estufa, além de um botão para acionamento manual da irrigação. Já na tela de tratamento da água é possível verificar o pH da água no reservatório, o nível do reservatório e botão para acionamento manual do tratamento de água.

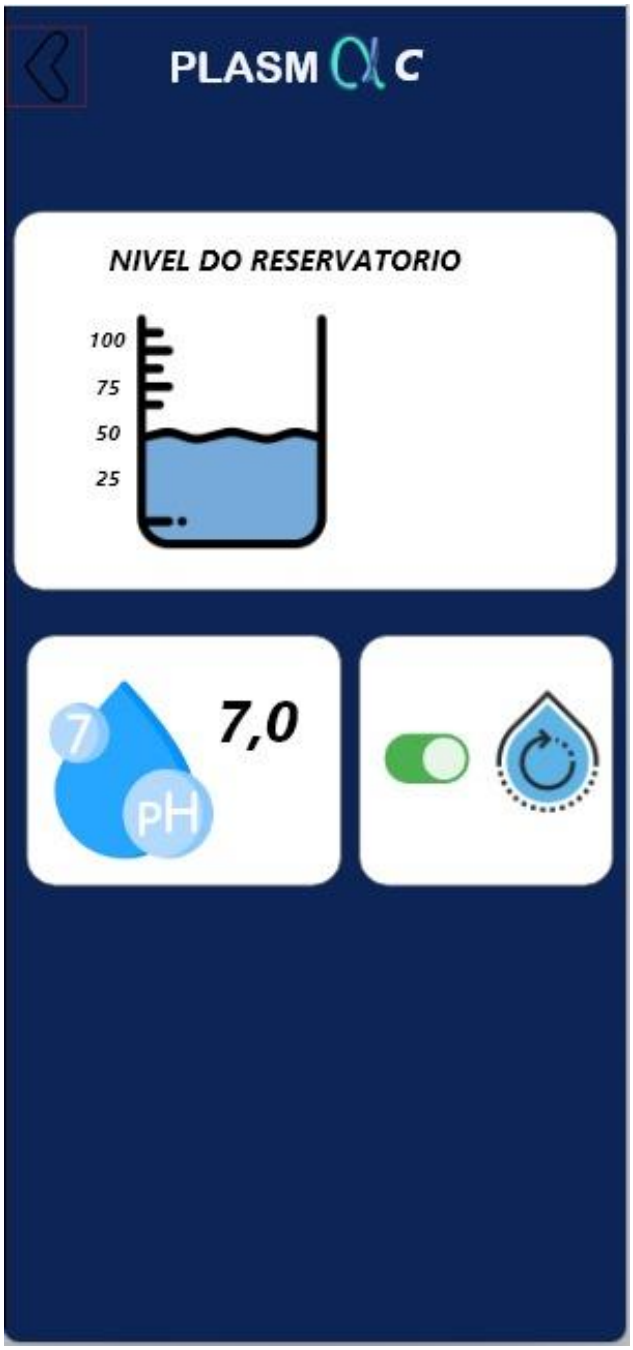
Tela de Acesso


Pα
PLASMαC
ENTRAR

Tela Principal

Tela de Irrigação

Tela de Tratamento de água



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