LABORATÓRIO NACIONAL
DE ENGENHARIA CIVIL

UBEST FIELD CAMPAIGNS

5th Campaign: Tagus Estuary, September 27, 2018

UBEST – Understanding the biogeochemical buffering capacity of estuaries relative to climate change and anthropogenic inputs

FCT – Fundação para a Ciência e a Tecnologia

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R&D HYDRAULICS AND ENVIRONMENT

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Title

UBEST FIELD CAMPAIGNS
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UBEST FIELD CAMPAIGNS

5th Campaign: Tagus Estuary, September 27, 2018

Abstract

The present report summarizes the 5th field campaign of the project UBEST, performed in the Tagus estuary on September 27, 2018. This campaign was the second in the Tagus estuary and was representative of summer conditions. Seven stations were chosen along the estuary. *In situ* measurements of temperature, salinity, pH and dissolved oxygen (% and mg/L) were carried out and water samples were collected to determine in laboratory the concentration of nutrients, chlorophyll *a*, total suspended solids, and confirm dissolved oxygen and pH on samples where pH sensors were not available.

The data acquired will contribute to a better understanding of the biogeochemical functioning of the Tagus estuary and to calibrate and validate numerical models (hydrodynamic and biogeochemical), that will attempt to predict the response of the estuary to future scenarios of climate change and anthropogenic inputs.

Keywords: Tagus estuary / Field campaign / Water samples / Physico-chemical parameters

CAMPANHAS UBEST

5ª Campanha: Estuário do Tejo, 27 de Setembro de 2018

Resumo

O presente relatório sumariza a quinta campanha do projecto UBEST, realizada a 27 de Setembro de 2018 no estuário do Tejo. Esta campanha foi a segunda a ser realizada neste estuário e é representativa das condições de verão. Foram selecionadas sete estações ao longo do estuário, onde se realizaram medições *in situ* de temperatura, salinidade, pH e oxigénio dissolvido (% e mg/L) e a recolha de amostras de água, que foram posteriormente tratadas em laboratório para determinar a concentração de nutrientes, clorofila *a*, sólidos suspensos totais, e confirmar os valores de oxigénio dissolvido e pH em amostras de estações onde os sensores de pH não se encontravam funcionais.

Os resultados obtidos irão contribuir para a melhor compreensão do funcionamento biogeoquímico do estuário do Tejo e para calibrar e validar modelos numéricos (hidrodinâmico e biogeoquímico), que tentarão prever a resposta do estuário a futuros cenários relacionados com o aquecimento global e pressões antropogénicas.

Palavras-chave: Estuário do Tejo / Campanha / Amostras de água / Parâmetros físico-químicos

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List of Acronyms

APA – Agência Portuguesa do Ambiente

CWB – Coastal Water Body

DO – Dissolved Oxygen

FCT – Fundação para a Ciência e a Tecnologia

HMWB – Heavily Modified Water Bodies

LNEC – Laboratório Nacional de Engenharia Civil

MARE – Marine and Environmental Sciences Centre

UAlg – University of Algarve

UBEST – Understanding the biogeochemical buffering capacity of estuaries relative to climate change and anthropogenic inputs

WB – Water Body

1 | Introduction

This report describes the 5th field campaign of the project UBEST- Understanding the biogeochemical buffering capacity of estuaries relative to climate change and anthropogenic inputs (PTDC/AAG-MAA/6899/2014), performed in the Tagus estuary. The project UBEST is funded by the *Fundação para a Ciência e a Tecnologia (FCT)* and aims at improving the understanding of the biogeochemical buffering capacity of the estuaries and their susceptibility to future scenarios of anthropogenic inputs and climate change, that will support the short and long term management of these systems. This goal will be achieved by the deploying of «observatories» in two Portuguese coastal systems, the Ria Formosa lagoon and the Tagus estuary. These two systems were chosen due to their distinct characteristics, allowing for a generalization of the project conclusions.

This campaign was the second campaign in the Tagus estuary, UBEST 5, and was performed on September 27, 2018, aiming to be representative of the summer conditions. To assure the coverage of the entire estuary, seven stations throughout the system were chosen. In each station physical, chemical and biological data were collected during almost one semidiurnal tidal cycle (~12 hours). In order to better understand the functioning of the estuary, one more field campaign is planned in the Tagus estuary, that will be representative of autumn conditions.

This report is divided into two sections, besides the introduction. Chapter 2 presents the location of the sampling stations and the weather conditions, and describes the field and laboratorial work. On Chapter 3 a brief evaluation of the campaign is presented.

2 | Description of the field campaign

2.1 Objective of the field campaign

This campaign aimed to characterise the summer biogeochemical conditions of the Tagus estuary, through the collection of water samples and *in situ* measurements of physical and chemical parameters. This data will also support the modelling of the estuary, through hydrodynamic and biogeochemical models.

2.2 Sampling stations

The seven sampling stations were chosen to allow the best coverage of the entire estuary, including the different water bodies (WB) described by *APA (Agência Portuguesa do Ambiente)* (Figure 2.1). Table 2.1 presents the coordinates of each station and Figure 2.2 presents the satellite image of each station, referring the water body where each station is situated. P1 is situated in the water body Tagus river (HMWB – *Jusante Bs. Castelo do Bode e Belver*).

The sampling stations P1 (*Muge/Valada*) and P7 (*Cascais*) are representative of the river and oceanic boundary conditions, respectively. The other five stations are distributed longitudinally through the estuary. P2 is situated in *Vila Franca de Xira*, in the south margin of the estuary, and the water samples were collected from a floating platform. P3 is located in *Santa Iria* at a fixed platform of the VALORSUL facilities, situated on the north margin. The two next stations (P4 and P5) are located in channels of the estuary, near the *Vasco da Gama* Bridge and *Barreiro*, respectively. The sampling at these two stations was performed by boat, supported by Azimuth Globe. P6 is located near the mouth of the estuary, in *Algés*.

Figure 2.1 – Location of the sampling stations (source: ArcMap). Legend: Green – Tagus water bodies (WB); Light Blue – Coastal water bodies (CWB); Dark Blue – Heavily modified water bodies (HMWB)

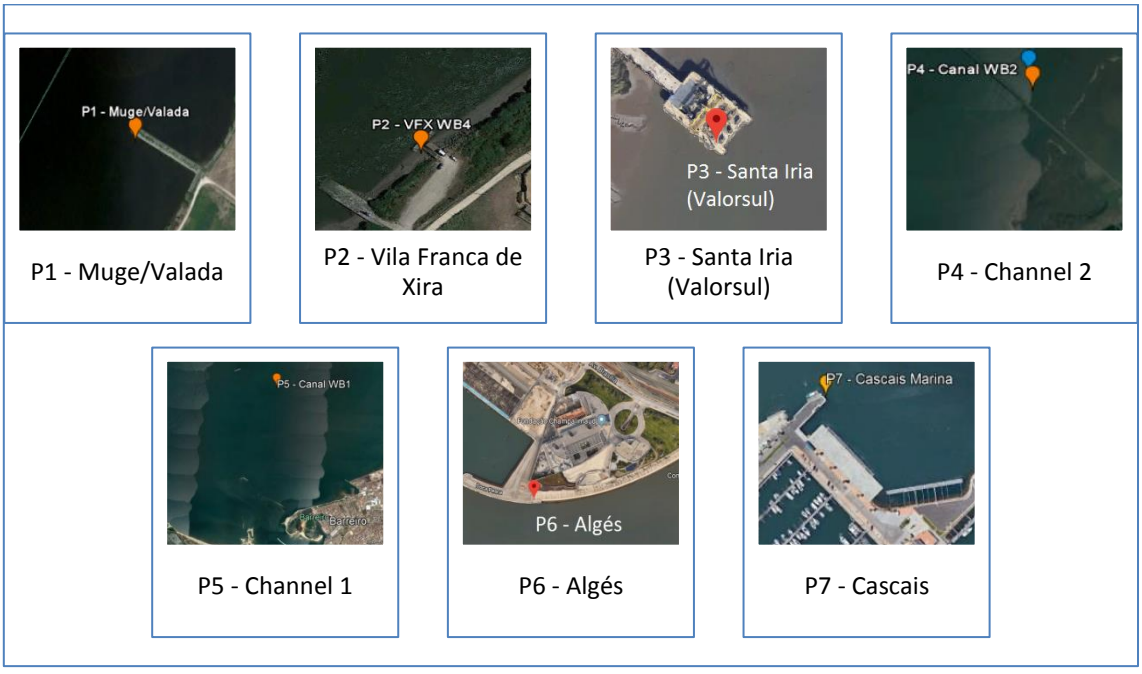

Figure 2.2 – Satellite image of each station (source: Google Earth)

Table 2.1 – Coordinates of the sampling stations

Station	Location	Latitude	Longitude
P1	Muge/Valada	39°5'27.66" N	8°44'46.17" W
P2	Vila Franca de Xira	38°57'13.97" N	8°58'41.55" W
P3	Santa Iria	38°49'40.00" N	9°4'45.64" W
P4	Channel 2	38°45'19.52" N *	9°1'42.09" W *
P5	Channel 1	38°41'39.43" N *	9°6'0.10" W *
P6	Algés	38°41'32.2" N	9°13'23.1" W
P7	Cascais	38°41'40.77" N	9°24'59.56" W

Obs: *Expected coordinates, real coordinates in Appendix I

2.3 Weather conditions

Table 2.2 presents the mean values and range of the air temperature, humidity, pressure and wind speed, and the wind direction in locations near the UBEST stations. The data were retrieved from Weather Underground (source: https://www.wunderground.com/, October 18, 2018) and were recorded in *Parede (Oeiras), Cais do Sodré (Lisboa)*, *Montijo* Air Base and *Vila Franca de Xira.*

Table 2.2 – Mean (minimum and maximum) temperature (°C), relative humidity (%), pressure (hPa), wind speed (km/h) and wind direction in *Parede*, *Cais do Sodré*, *Montijo* Air Base and *Vila Franca de Xira* on September 27, 2018 (source: Weather Underground)

Location	Temperature (°C)	Humidity (%)	Pressure (hPa)	Wind Speed (km/h)	Wind Direction
Parede	**26.4** (22.6-30.3)	**59** (45-73)	1021-1025	**3** (High – 13)	NNW
Cais do Sodré	**25.8** (20.8-30.9)	**64** (47-84)	1021-1025	**8** (High – 18)	NNE
Montijo	**25** (18-32)	**69** (39-96)	1019-1024	**8** (High – 18)	NNW
Vila Franca de Xira	**29.6** (22.5-36.6)	**52** (35-70)	1020-1024	0	North

No rainfall occurred during the day of the campaign, which eased the collection of samples. In terms of tides, in Cascais the low tide was at 10:30 am (0.7 m) and the high tide was at 4:44 pm (3.5 m) (source: http://www.hidrografico.pt/ , September 20, 2018), so the sampling hours were chosen around this hours.

Figures of the daily variability of temperature, relative humidity, sea level pressure and wind velocity recorded in the Lisbon airport during the day of the campaign are presented in Appendix II. These data were obtained in *tempo.pt* website (source: https://www.tempo.pt/lisboa.htm, October 15, 2018). Figures retrieved from Weather Underground are also presented in Appendix II.

2.4 Field work

The field campaign UBEST 5 was performed on September 27, 2018, during approximately one semidiurnal tidal cycle (~12 hours). The sampling was supported by five vehicles: three cars from LNEC, one van with a driver from LNEC, and one car from the University of Algarve. The teams in each vehicle were responsible for the transport of the team members and all the material and equipment. During the day the teams from P1, P7 and Paula Freire (transported by the van) were responsible for the delivery of the samples to the laboratory located in LNEC.

The *in situ* measurements of temperature, salinity, pH and dissolved oxygen (DO) (concentration in mg/L and saturation %) were performed with YSI multiparameter probes, one in each station. Their calibration was performed previously to the field survey with the adequate calibration solutions. The distribution of the equipment in each station is presented in Table 2.3. Each station also had a specific device to collect water samples (a Niskin bottle, a Van Dorn bottle or a sampling cup). The water samples were collected for the determination of dissolved oxygen, nutrients and total suspended solids compounds (1 L), chlorophyll *a* (2 L) and to quantify photosynthetic pigments[1] (5 L). In the stations with the Niskin or Van Dorn bottles water was collected at two levels of the water column: surface and bottom. In order to preserve the quality of the water samples, these were preserved in thermal containers until the laboratory treatment started.

Table 2.3 – Multiparameter probes and samplers distribution

Station	Location	Multiparameter Probe	Parameters	Samplers
P1	Muge/Valada	YSI	Cond, T	Sampling Cup
P2	Vila Franca de Xira	YSI 660 XL	T, DO, Sal	Sampling Cup
P3	Santa Iria	YSI 556 MPS	T, DO, pH, Sal	Van Dorn Bottle
P4	Channel WB2	YSI 556 MPS	T, DO, pH, Sal	Niskin Bottle
P5	Channel WB1			
P6	Algés	YSI 8620	T, DO, pH, Sal	Van Dorn Bottle
P7	Cascais	YSI 556 MPS	Cond, T, DO, pH, Sal	Niskin Bottle

The sampling intervals were as follows:

- Stations P2, P3 and P6 – sampling was performed with intervals of two hours;
- Stations P1 and P7 – sampling was performed during the low and high tide;
- Stations P4 and P5 – sampling was performed by boat at four instants.

[1] The list of the photosynthetic pigments is presented in the Appendix. This quantification is for the work of Rui Cereja, which is not included in the UBEST program.

All the information related to the sampling is presented in Table 2.4. Aspects of the sampling stations are presented in Figure 2.3 to Figure 2.8. In station P2 water levels were also measured along the sampling period. The multiparameter probes used in stations P1 and P2 did not have the pH sensor working properly, so the pH measurement was conducted in the laboratory.

Table 2.4 – Sampling specifications (parameters, depths and hours). Legend: T – temperature; DO – Dissolved Oxygen; Cond – Conductivity; Sal – Salinity. Winkler – Water collection for laboratorial confirmation of dissolved oxygen concentration acquired by the probes

Station	Intervals of Sampling	Depths	Measurements	Sampling
P1	10:30am, 5:00pm	Surface	T , Sal, pH, Cond, Dissolved Oxygen (DO)	Water, Winkler
P2	7:30am, 9:00am, 10:30 am 12:30am, 2:30pm, 5:00pm, 7:30pm	Surface	T, Sal, pH, Dissolved Oxygen (DO)	Water, Winkler*
P3	7:30am, 9:00am, 10:30 am 12:30am, 2:30pm, 5:00pm, 7:30pm	Surface and Bottom	T, Sal, pH, Dissolved Oxygen (DO)	Water, Winkler*
P4	8:00am, 10:30am, 2:30pm, 7:00pm	Surface and Bottom	T, Sal, pH, Dissolved Oxygen (DO)	Water, Winkler
P5	8:00am, 10:30am, 2:30pm, 7:00pm	Surface and Bottom	T, Sal, pH, Dissolved Oxygen (DO)	Water, Winkler
P6	7:30am, 9:00am, 10:30 am 12:30am, 2:30pm, 5:00pm, 7:30pm	Surface and Bottom	T, Sal, pH, Dissolved Oxygen (DO)	Water, Winkler*
P7	10:30am, 5:00pm	Surface and Bottom	T, Sal, pH, Dissolved Oxygen (DO)	Water, Winkler

Obs: * 7:30am, 10:30am, 5:00pm, 7:30 pm

Figure 2.3 – Sampling Station P1: Muge/Valada

Figure 2.4 – Sampling Station P2: Vila Franca de Xira

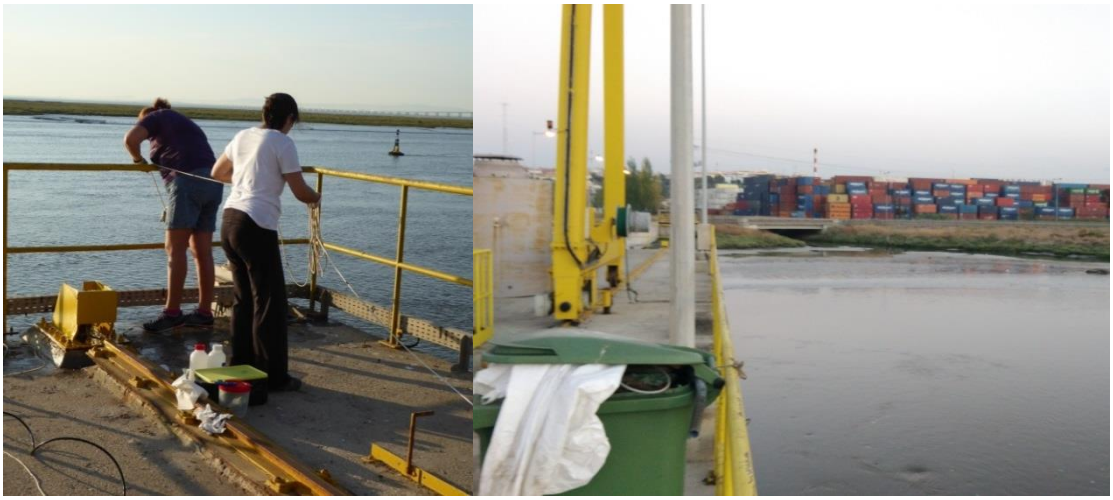

Figure 2.5 – Sampling Station P3: Santa Iria

Figure 2.6 – Sampling Station P4/P5: Channels

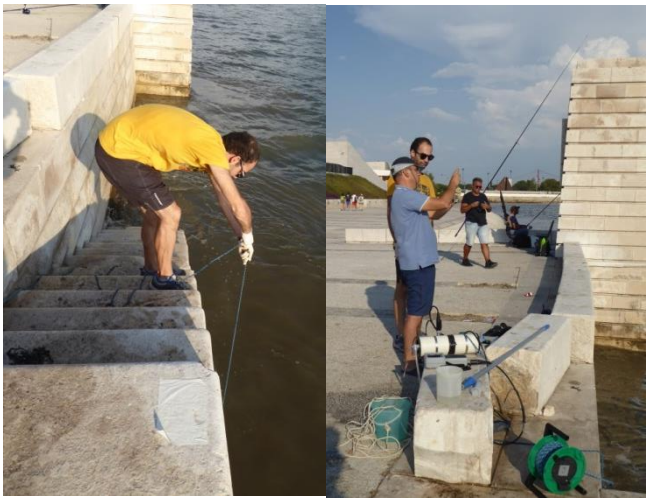

Figure 2.7 – Sampling Station P6: Algés

Figure 2.8 – Sampling Station P7: Cascais

2.5 Team

Table 2.7 presents the team that participated in the campaign, both in the sampling stations and in the laboratory. The team included persons from the *Laboratório Nacional de Engenharia Civil* (LNEC), the University of Algarve (UAlg) and *Faculdade de Ciências da Universidade de Lisboa* (FCUL).

Table 2.5 –Team of the field campaign UBEST 5

Station/Laboratory work/ Car	Name	Institution
Co–coordination of the campaign and delivery of samples to the laboratory (Car 3)	Paula Freire	LNEC
P1 and delivery of samples to the laboratory (Car 1)	Américo Louro	LNEC
	Simões Pedro	LNEC
P2 (Car 2)	André Fortunato	LNEC
	Pedro Lopes	LNEC
P3 (Car 2)	Ana Rilo	LNEC
	Anabela Oliveira	LNEC
P4/P5 (Car 3)	Alberto Azevedo	LNEC
	Daniela Santos	LNEC
	Juan Barceló	FCUL
	Rui Cereja	FCUL
	Teresa Camelo	FCUL
P6 (Car UAlg)	João Rogeiro	LNEC
	José Jacob	UAlg
P7 and delivery of samples to the laboratory (Car 4)	Fernando Brito	LNEC
	Marta Rodrigues	LNEC
Co-coordination of the campaign and laboratory work	Alexandra Cravo	UAlg
Laboratory work	Cátia Correia	UAlg
	Alexandra Rosa	UAlg

2.6 Laboratorial procedures

The processing of the water samples was performed in the laboratory of the *Estação Experimental de Sedimentos Coesivos* of LNEC by the team members of the University of Algarve. The water samples were filtered according to specific protocol and type of filters: for suspended solids, Gellman-Pall filters of mixed esters of cellulose with 0.45 µm porosity, and for chlorophyll *a* filters Whatman GF/F with 0.7 µm porosity.

The filtered water samples through 0.45 µm filters were used to subsequent determination of the nutrients concentration (nitrate, nitrite, ammonium, phosphate and silicate), through specific spectrophotometric methods described in Grasshoff *et al*. (1983).The filters Whatman GF/F, 0.7 µm filters were used to determine the chlorophyll *a*, through the spectrophotometric method described by Lorenzen (1967). To determine the total suspended solids concentrations the gravimetric method described in APHA (1992) was used. The chemical analyses for the determination of the nutrients and chlorophyll *a* concentration will be performed at the University of Algarve, by the UALG team of the UBEST project.

In order to confirm the value of the dissolved oxygen concentration measured *in situ*, the Winkler method was performed in the laboratory at LNEC. Figures 2.9 and 2.10 show some of the equipment used to process the water samples in the laboratory.

Figure 2.9 – Aspects of the laboratorial procedures: laboratorial analyses for the determination of oxygen concentration (left); filtration system used to determine the concentration of chlorophyll *a* (right)

Figure 2.10 – Aspects of laboratorial procedures: filtration system used to determine suspended solids and further nutrient concentrations

3 | Conclusions

The general objective of the campaign was successfully accomplished. The results acquired in this campaign will also help the planning of the next campaign, through the knowledge acquired.

The aspects to be improved in the future are:

- The P3 team had difficulties during the collection of the water due to the strong tidal currents and the weight of the full sampling bottle. These difficulties led to some delay in the sampling;
- The sampling carried out by boat (stations P4 and P5) had some delay in the afternoon, due to the need of refilling the gas tank. This delay led to miss the delivery of the samples in the interval between the two sampling hours;
- By the end of the afternoon, the light available was not enough to perform the sampling procedures. It is important to take this into account in the next campaign, which will have less light even earlier. Headlights need to be supplied to all the teams;
- In some stations, the teams faced some difficulties with the Winkler procedures;
- As already mentioned, due to lack of properly working pH sensors at stations P1 and P2, the pH of the samples was measured in the laboratory.

Acknowledgments

This work was funded by *Fundação para a Ciência e a Tecnologia* project UBEST - Understanding the biogeochemical buffering capacity of estuaries relative to climate change and anthropogenic inputs (PTDC/AAG-MAA/6899/2014). This project also funds the grants of Alexandra Rosa (UALG) and Daniela Santos (LNEC).

The authors would like to thank the volunteers from the *Faculdade de Ciências da Universidade de Lisboa* (FCUL), Teresa Camelo and Juan Barceló, the PhD student from LNEC/FCT Ana Rilo, and Rui Cereja[2] (*Instituto Dom Luiz* (IDL – FCUL) and Marine and Environmental Science Centre (MARE – FCUL)), Cátia Correia from CIMA – University of Algarve, for their support in the campaign and on the laboratorial work, Marine and Environmental Science Centre (MARE – FCUL) for equipment availability, *VALORSUL*, *Administração do Porto de Lisboa* and *Marina de Cascais* for the authorization to use their facilities for sampling.

[2] PhD research grant (PD/BD/135064/2017) attributed by *Fundação para a Ciência e Tecnologia* (FCT) with financing from *Programa Operacional Capital Humano* (POCH) by the Portugal2020 program.

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APPROVED

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Annexes

ANNEX I
Coordinates of P4 and P5

Table I.1 – Coordinates of P4 during the hours of the campaign

Time	Depths (m)	Latitude	Longitude
09:00	0.00	38°45'18.4"N	9°01'47.1"W
09:08	8.00	38°45'18.3"N	9°01'47.1"W
11:51	0.00	38°45'15.9"N	9°01'41.8"W
11:55	7.00	38°45'15.9"N	9°01'41.8"W
15:58	0.00	38º45’21.8”N	9º01’44.2”W
15:59	5.10	38º45’21.8”N	9º01’44.2”W
18:18	0.00	38º45’19.5”N	9º01’43.5”ºW
18:20	10.0	38º45’19.5”N	9º01’43.5”ºW

Table I.2 – Coordinates of P5 during the hours of the campaign

Time	Depths (m)	Latitude	Longitude
07:35	0.00	38°41'30"N	9°06'11.6"W
07:45	10.00	38°41'26.9"N	9°06'28.1"W
10:55	0.00	38°41'29.6"N	9°06'02"W
10:55	8.00	38°41'29.6"N	9°06'02"W
14:55	0.00	38º41’50.4”N	9º06’33.8”W
15:00	3.40	38º41’50.4”N	9º06’33.7”W
17:11	0.00	38º41’30.0”N	9º05’55.3”W
17:15	10.0	38º41’30.0”N	9º05’55.3”W

ANNEX II
Weather Conditions

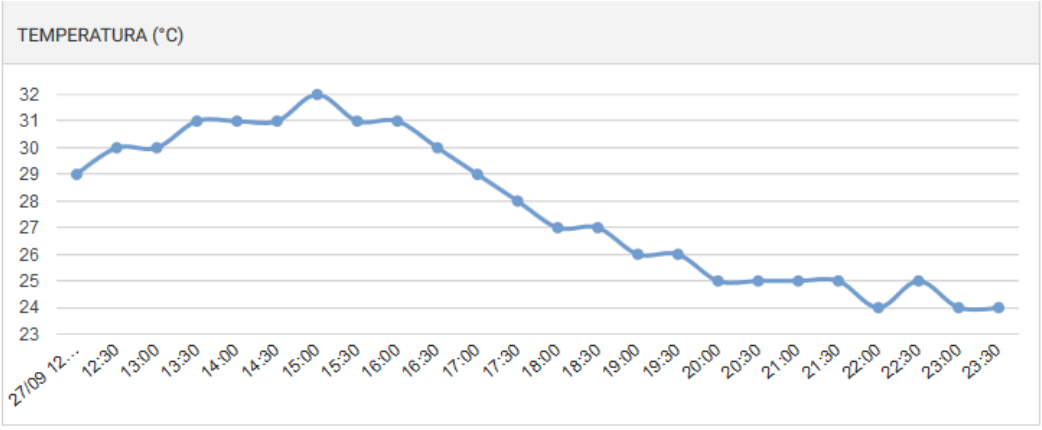

Figure II.1 – Temperature (°C) variation during September 27, 2018 (source: https://www.tempo.pt/, October 15, 2018)

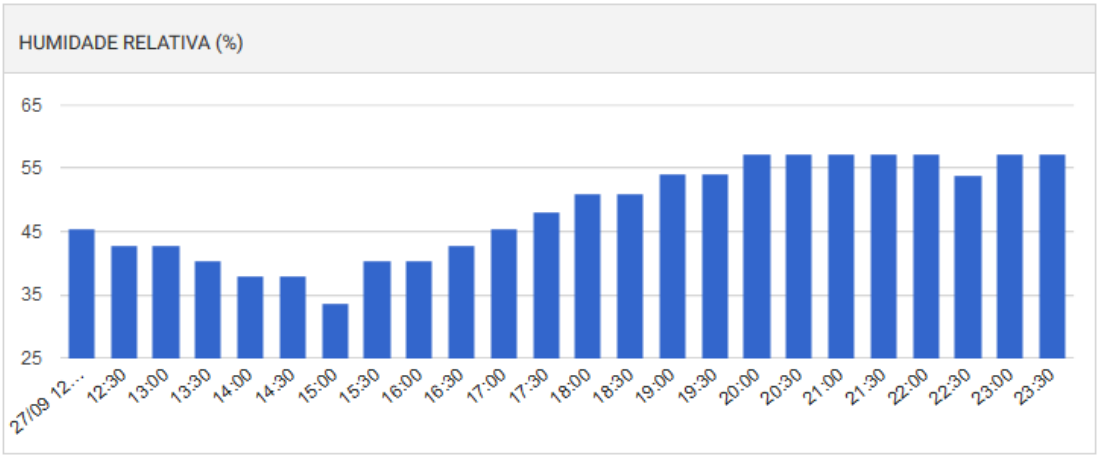

Figure II.2 – Relative humidity (%) variation during September 27, 2018 (source: tempo.pt, October 15, 2018)

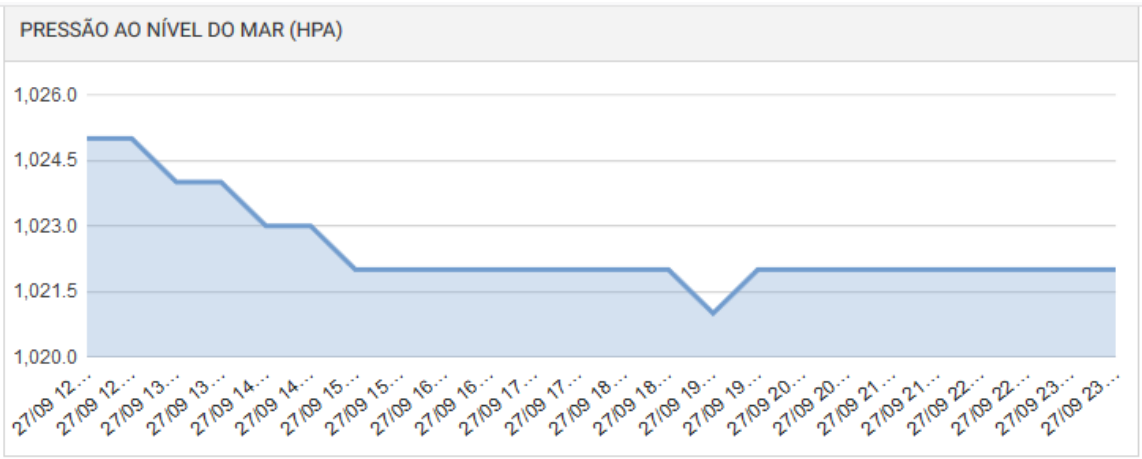

Figure II.3 – Pressure at sea level (HPA) variation during September 27, 2018 (source: https://www.tempo.pt/, October 15, 2018)

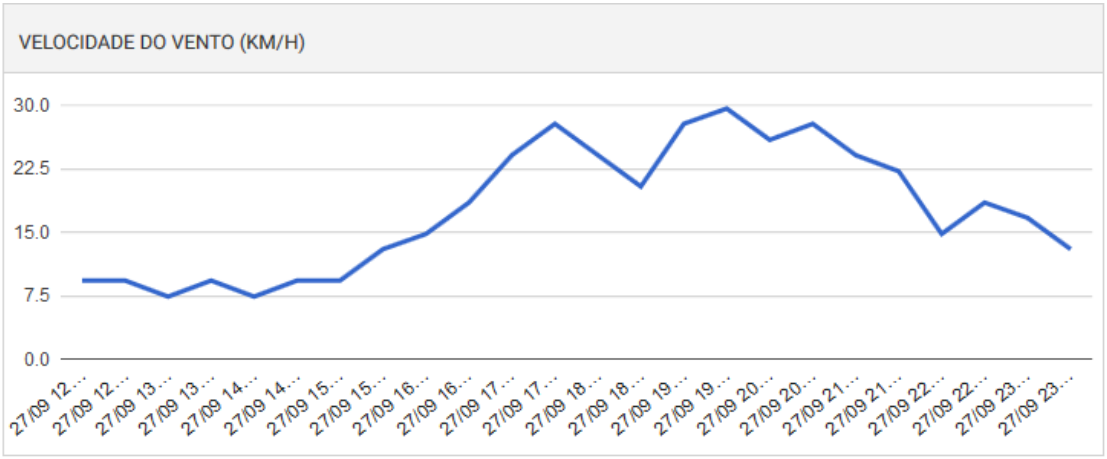

Figure II.4 – Wind velocity (km/h) variation during September 27, 2018 (source: https://www.tempo.pt/, October 15, 2018)

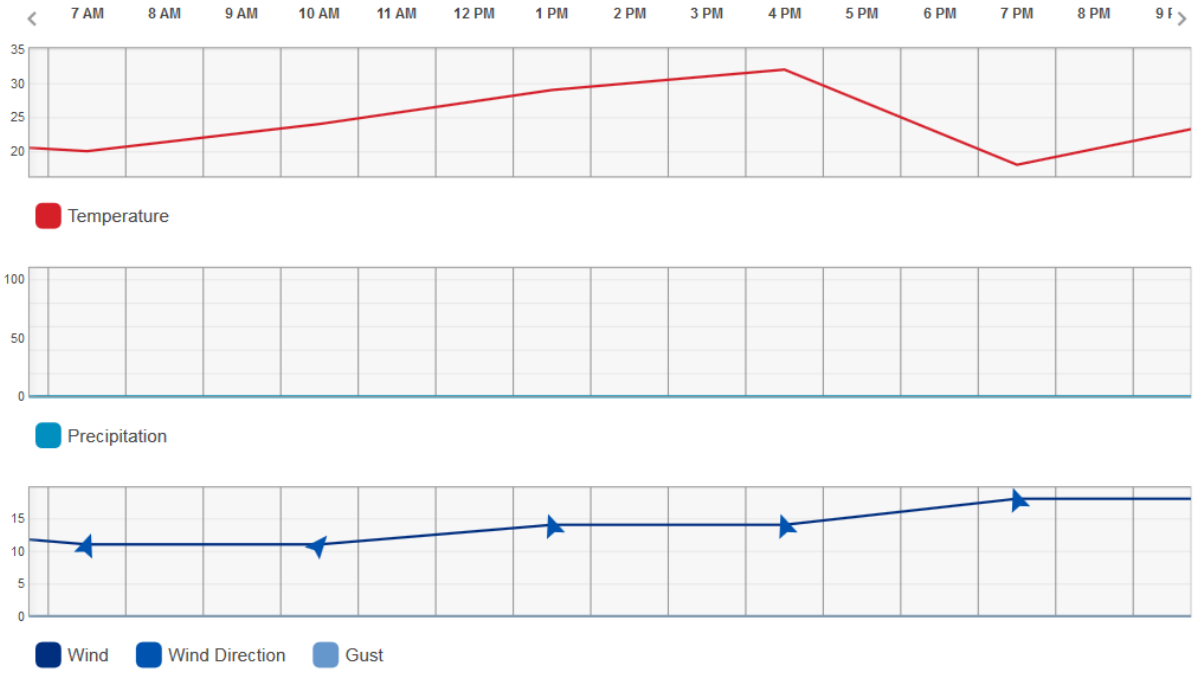

Figure II.5 – Temperature (°C), precipitation (mm) and wind (km/h) variation during September 27, 2018 (source: https://www.wunderground.com/history/daily/po/montijo/LPMT/date/2018-9-27, October 18, 2018)

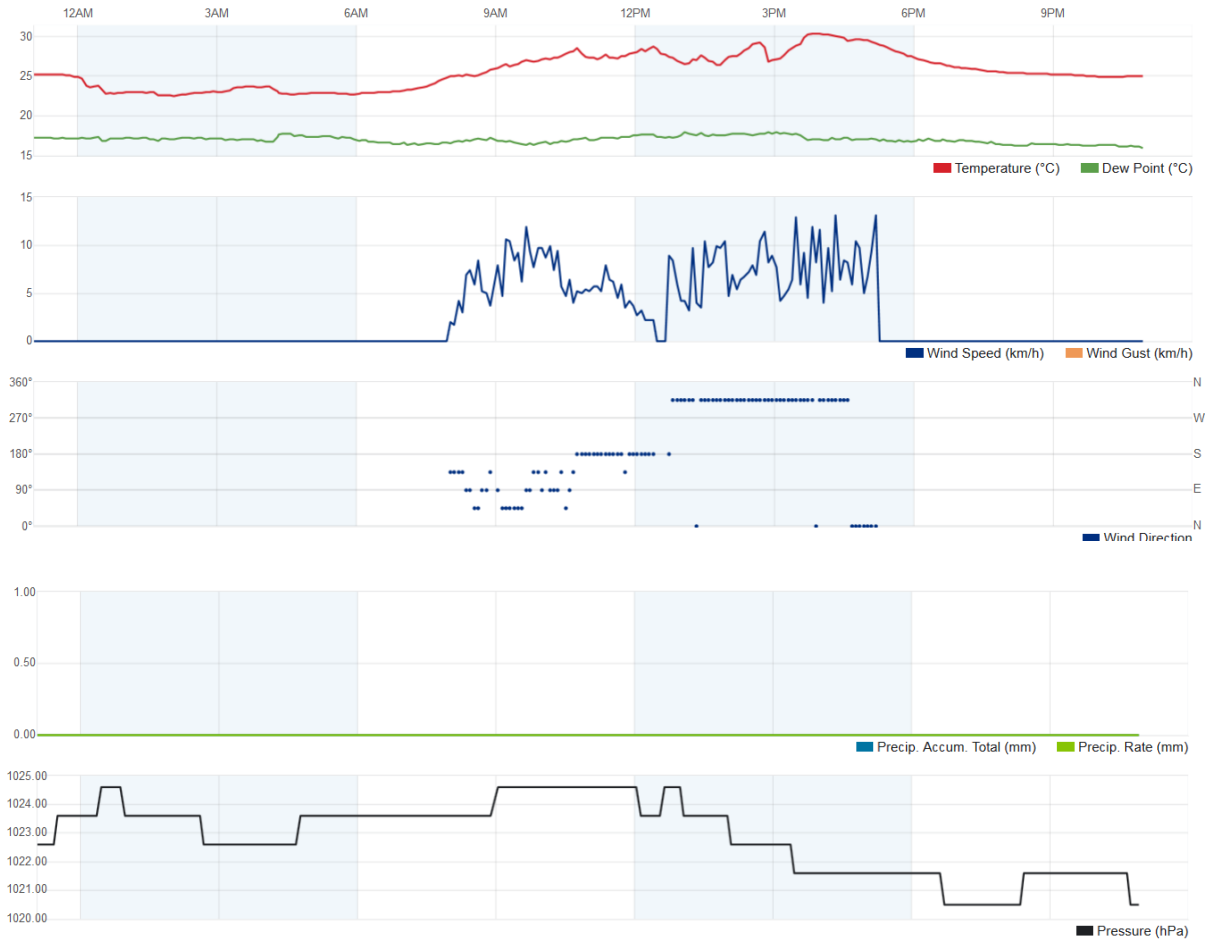

Figure II.6 – Temperature (°C), dew Point (°C), wind speed (km/h), wind direction, precipitation rate (mm) and pressure (hPa) variation during September 27, 2018 in Parede, Oeiras (source: https://www.wunderground.com/personal-weather-station/dashboard?ID=ILISBOAP3# history/tdata/s20180927/e20180927/mdaily, October 18, 2018)

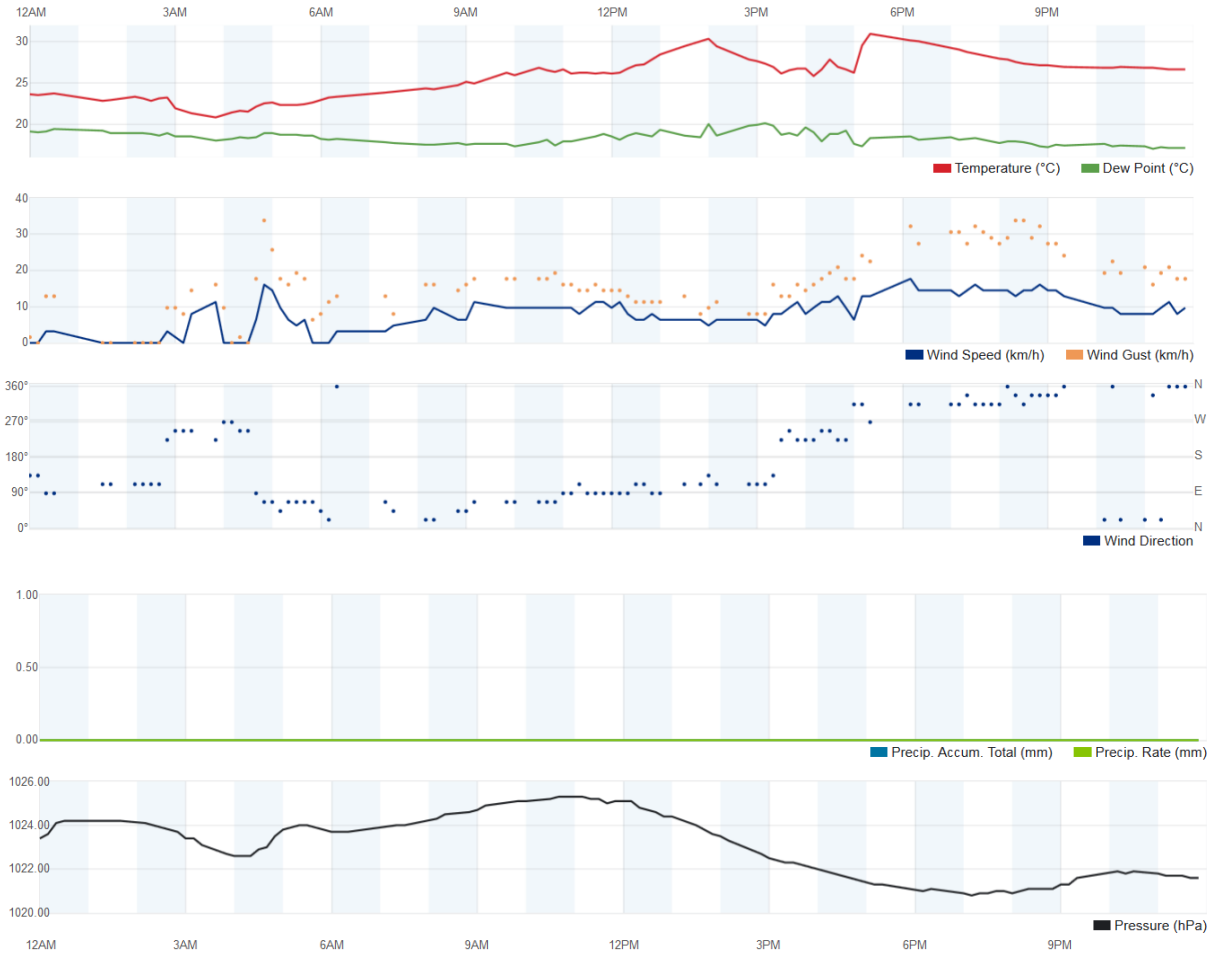

Figure II.7 – Temperature (°C), dew point (°C), wind speed (km/h), wind gust (km/h), wind direction, precipitation rate(mm) and pressure (hPa) variation during September 27, 2018 in Cais do Sodré, Lisbon (source: https://www.wunderground.com/personal-weather-station/dashboard?ID=IPORTUGA25#history/s20180927/e20180927/mdaily, October 18, 2018)

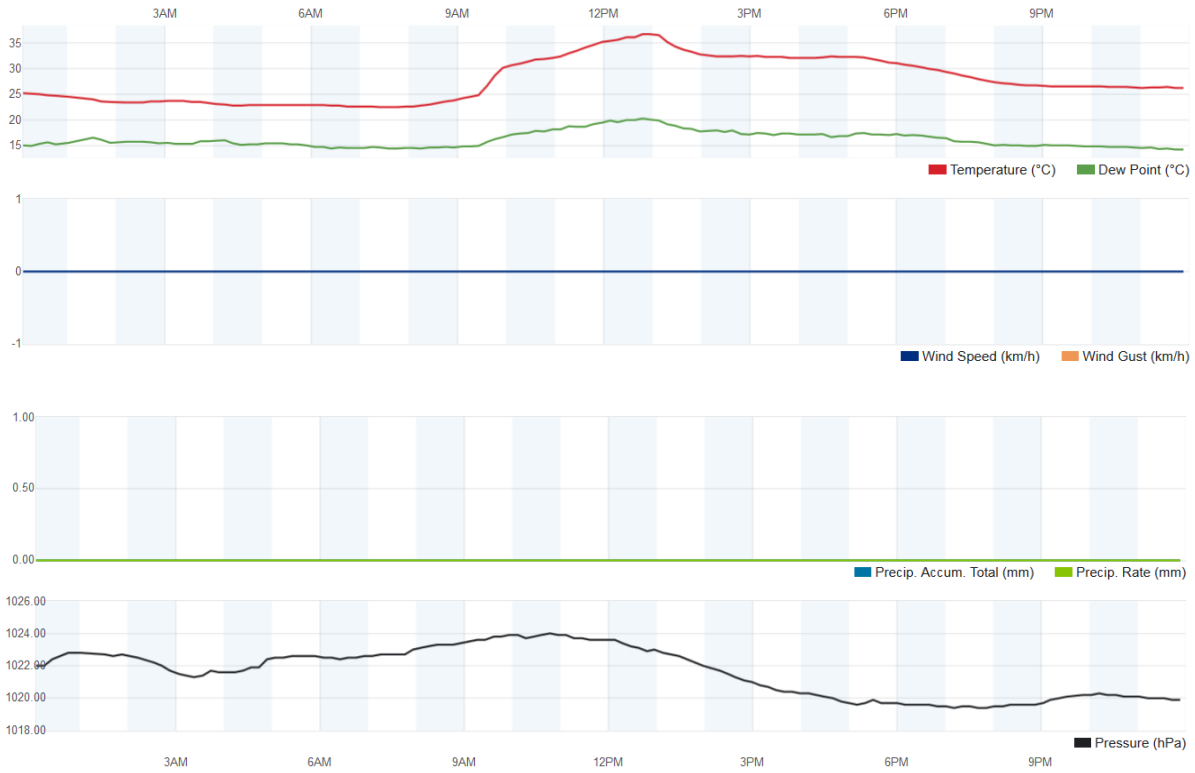

Figure II.8 – Temperature (°C), dew point (°C), wind speed (km/h), precipitation rate(mm) and pressure (hPa) variation during September 27, 2018 in Vila Franca de Xira (source: https://www.wunderground.com/personal-weather-station/dashboard?ID=IVILAFRA15#history/s20180927/e20180927/mdaily, October 18, 2018)

ANNEX III
Photosynthetic Pigments list

Photosynthetic pigments read by HPLC:

- Zeaxanthin
- Prasinoxanthin
- Violaxanthin
- Feofitin a
- Feoforbide a
- Peridinin
- Neoxanthin
- Lutein
- Fucoxanthin
- Mg DVP
- Divinil chl a
- Diatoxanthin
- Diadinoxanthin
- Chlorophyll *a*
- Chlorophyll c3
- Chlorophyll c1 + c2 (does not separate)
- Chlorophyll b
- β-carotene
- Anteraxanthin
- Aloxanthin
- α-carotene
- 19-hexa-fucoxanthine
- 19-buta-fucoxanthin