Analysis of relative humidity variation in Autumn 2009

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Abstract— In the present paper, relative humidity variation was analyzed every week from autumn months of 2009, and analysis was done for the 1st day of September and the last day of December 2009. Relative humidity variation analysis was made based on the records of the atmospheric parameters of the weather station equipment from Biotechnical Engineering Faculty of the University "Politehnica" of Bucharest (UPB). Based on records maintained by AWS weather station type / EV, we have achieved the statistical analysis of relative humidity in the months of the autumn 2009 and also in december, highlighting the maximum and minimum relative humidity. We using GECO Using Data Acquisition software which are operating system runs under Microsoft Windows 95, 98, ME, Win NT, Windows 2000, XP. With this equipment, meteorological time is measured, recorded and transmitted automatically in real time with specific systems and also stored on computer databases. Primary meteorological Stored in databases on WAS will be subject to the evaluation process, statistical calculated and analyzed. The Relative Humidity Sensor RH %, from this device it is an electronic sensor, based on a thin film element (temperature compensated capacitive Polymer) which have the capacity to variations linearly with the relative air humidity. RH % it is also an analogue sensor, have a good accuracy of measurements (the signal ranging linearly between o V and + 1 V which measuring between 0-100% and have sensitivity on the full scale +/- 2 % and a response time less than 15 second), which could give us an adequate monitoring of analyzed parameters.

Key-Words: Relative humidity, Weather station, Statistical analysis of obtained data

I. Introduction

The System for Environmental and Meteorological Monitoring mod AWS/EV is a product from the need, always very frequent, to control (monitor) the environment variables [1]-[8]. The system is composed of a data acquisition control box, several environmental sensors, the software enabling the remote monitoring and the data processing and all the mechanical accessories necessary to scarry out a proper installation. It is a complete system that enables to acquire the wished environmental parameters and to memorize them to prevent their scattering. It is possible to monitor in real time the acquired data directly on the control board. Or, with external PC, it is possible to monitor the acquired data directly as well as to carry out their processing.

For this last possibility, it is necessary to transfer the data from the control box to an external PC, using one of the following procedures:

- connecting an external PC, to the control board,
- connecting a modem according to the available telephone line (dedicated or switched) [1]-[3].

Air humidity represents the amount of water vapor which is in the atmosphere [1] –[4]. *Furthest*, they come from the evaporation of surface water and superficial layers of soil, from plant and animal respiration and from some technology process.

Atmospheric humidity can be expressed in 3 ways: relative, absolute and maximum. Physical sizes witch *quantify* air humidity are:

Absolute humidity - H_{abs} - represents the amount of water contained in a defined volume of air.

$$H_{abs}=\text{Water volume / Air volume } [g / m^3] \quad (1)$$

Saturation humidity - H_{sat} - represents the maximum amount of water that may be contained in a defined volume of air.

$$H_{sat}=\text{High water volume/Air volume}[g/m^3] \quad (2)$$

Relative humidity - H_{rel} - represents the ratio of absolute humidity and saturation humidity.

$$Hrel = \frac{Habs}{Hsat} \quad (3)$$

Humidity represent the Interdependence between outdoor air and indoor air [1]-[3].

For weather data acquisition we using weather station shown in Figure 1, installed at the Faculty of Biotechnical Systems Engineering Bucharest, type AWS / EV made in Italy and purchasing data about: air temperature, wind speed, wind direction, atmospheric pressure, rainfall, humidity , solar radiation.

Data acquisition is done using GECO software, an operating system that runs under Microsoft Windows 95, 98, ME, Win NT, Windows 2000, XP. Meteorological data are measured, recorded and transmitted automatically in real time with specific systems and stored on computer databases [3]. Primary meteorological data was stored in databases and was and will be the subject to evaluation process, calculated and statistical analyzed.

Relative Humidity Sensor RH % is an electronic sensor, based on a thin film element (temperature compensated Capacitive Polymer) which capacity changes linearly with the air relative humidity.

It is an analogue sensor, with signal ranging linearly between o V and + 1 V.

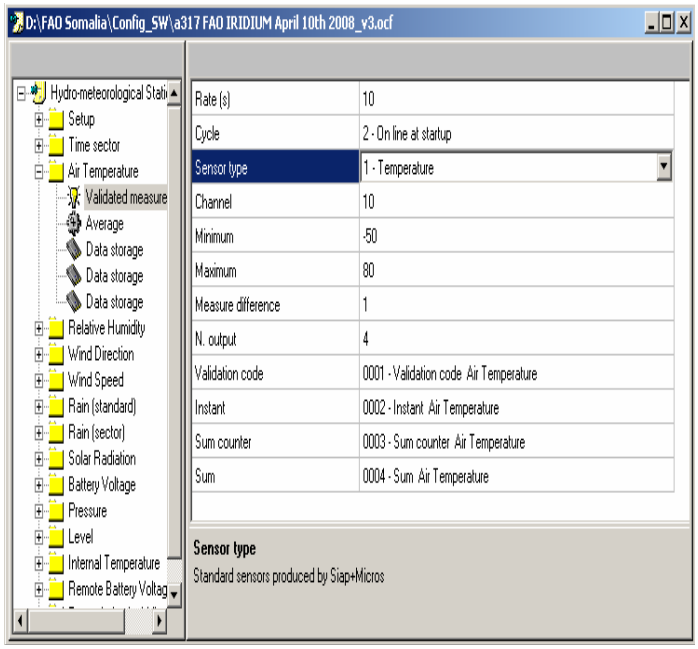
- Measuring range: 0 to 100 %
- Output signal: 0 to 1 VDC
- Sensitivity: +/- 2 % (full scale)
- Response time: < 15 s.

II PROBLEM FORMULATION

A. Materials Selection

In Table I are indicated the measured parameters like: relative humidity, wind direction, wind speed, Rain standard and in sector, solar radiation, battery voltage, pressure, level etc. , of the weather station, using the program GECO AWS station / EV) type AWS / EV from faculty Systems Engineering Biotechnical, "Politehnica" University of Bucharest. In Table I are presented measured parameters, using the program GECO AWS station/ EV) type AWS / EV.

Table I



B. Experimental Procedure

In Figure 1a it is presented environmental monitoring system with all sensors where is analyzed weather station.

The System for environmental and metrology monitoring is presented in Figure 1 b.

In Figure 2a is presented in which the box is the modem station. In Figure 2 b are presented the modem of the station.

In Figure 2 c are presented the sensor of temperature and relative humidity of the meteor station.

Figure 2 is shown the stop transmission of data recorded at the point of working at a computer and graphics software made automatic weather station. Note that the modem is installed up online with another modem installed on your PC from your point of work.

III PROBLEM SOLUTION

Next, we present statistical analysis of relative humidity variation in the months September to December and each week of the month.

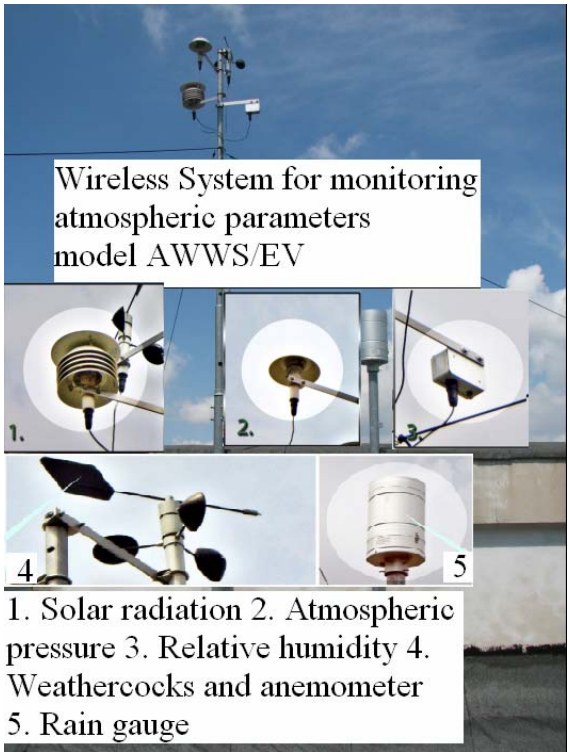


Fig. 1a Environmental monitoring system with all sensors described.

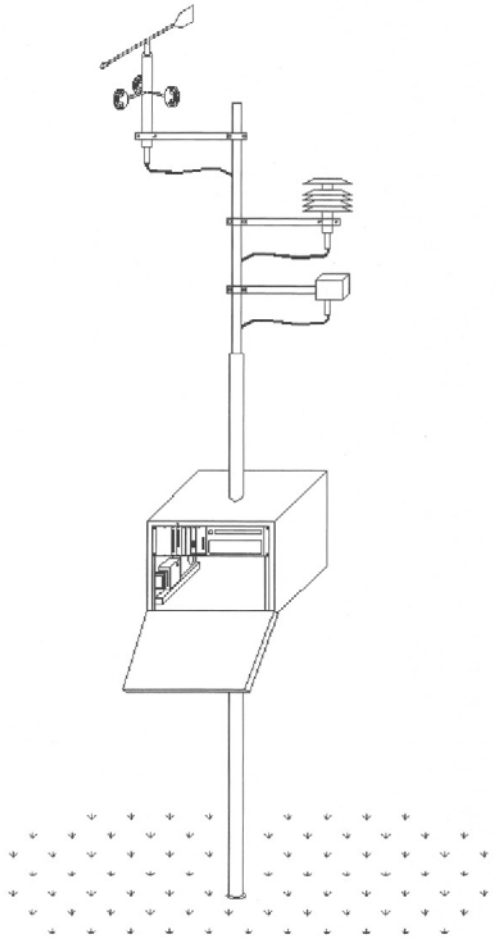


Fig. 1b System for environmental and metrology monitoring

Fig. 2 a The box which is modem station

Fig. 2b The modem of the station

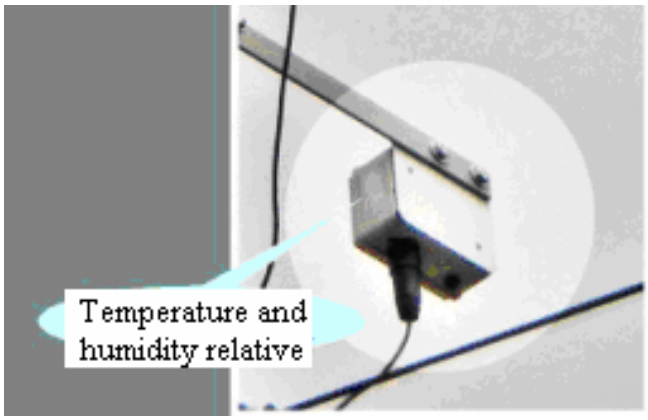


Fig. 2 c The sensor of temperature and relative humidity

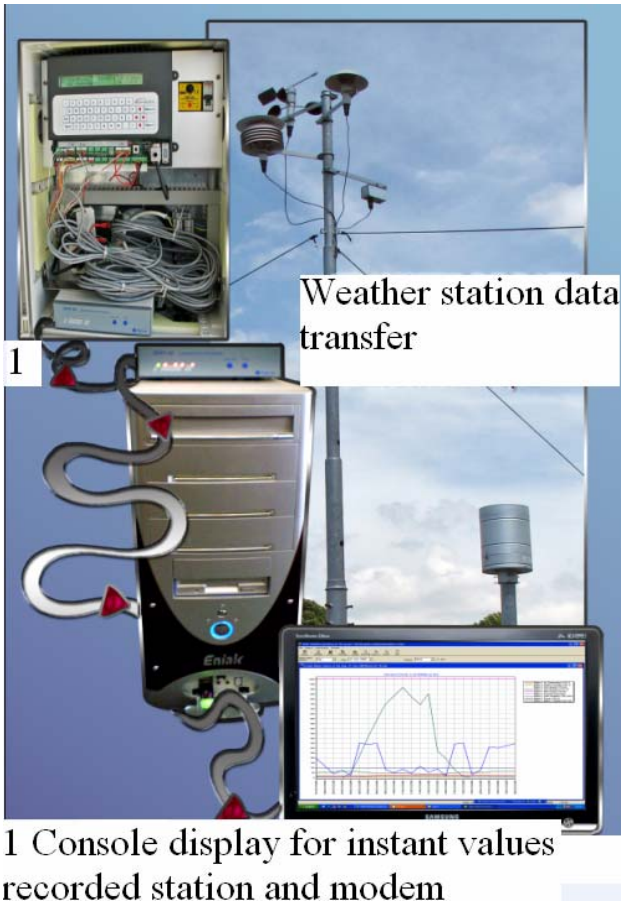


Fig. 2 d Transmission of data recorded at the point of this station.

In Figure 3a is presented relative humidity variation on September. Relative humidity was monitored 24 hours from 24 hours.

In Figure 3b we notice that the minimum value relative humidity in week from 1st to 7th September 2009 recorded in four days, September 5th at 17th and has a value of 28%. The maximum value of relative humidity this week was recorded in September 7th, 2009 at 2nd day.

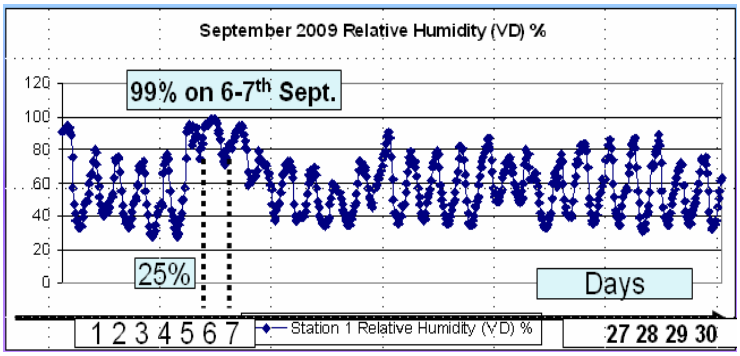


Fig. 3 a Relative humidity on September 2009

In Figure 3c is observed that the minimum value of relative humidity in the week 8 to 15 September 2009 was recorded on September 11 at 17 with a value of 34%. Maximum value was recorded in 5-8 hours on September 8 with a value of 94%.

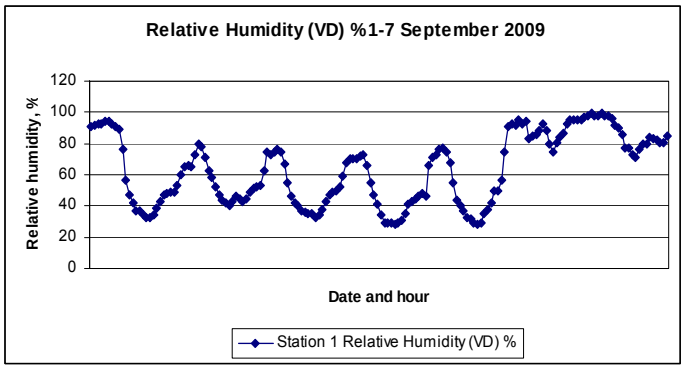


Fig. 3 b Relative humidity 1-7 September 2009

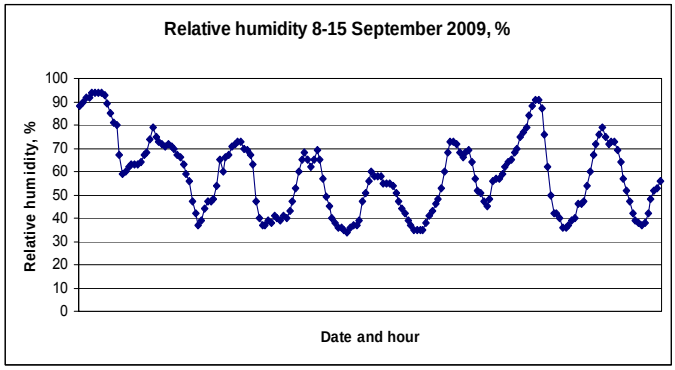


Figure 3 c Relative humidity 8-15 September 2009

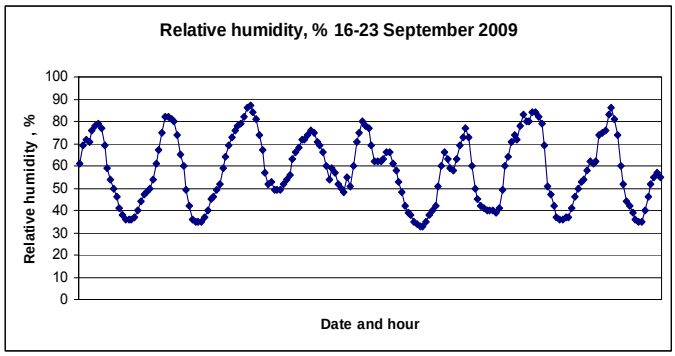


Figure 3 d Relative humidity 16-23 September 2009

In Figure 3d is seen as the minimum value of relative humidity in the week 16 to 23 September 2009 was recorded on September 20 with 17 to 18 times the amount of 33%. Maximum value was recorded in September 18th at 9:00 with a value of 87%.

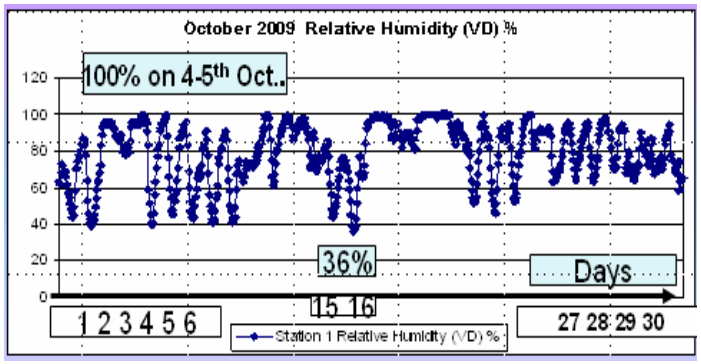


Fig. 4a Relative humidity on October 2009

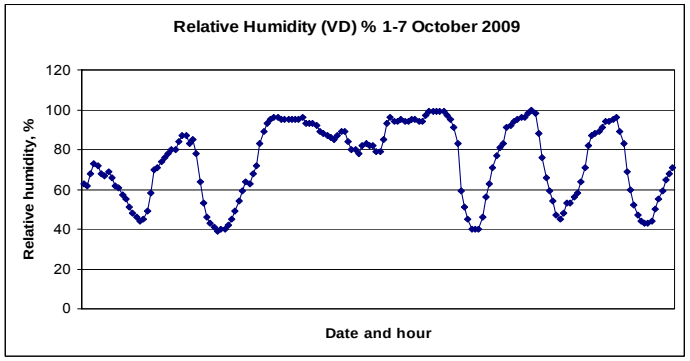


Fig. 4b Relative humidity 1-7 October 2009

Figure 4b we observed that the minimum value of relative humidity in week 1 to 7 October 2009 was registered on October 2 at 15:00 with a value of 39%. Maximum value was registered on October 6th at 8:00 with a value of 100%.

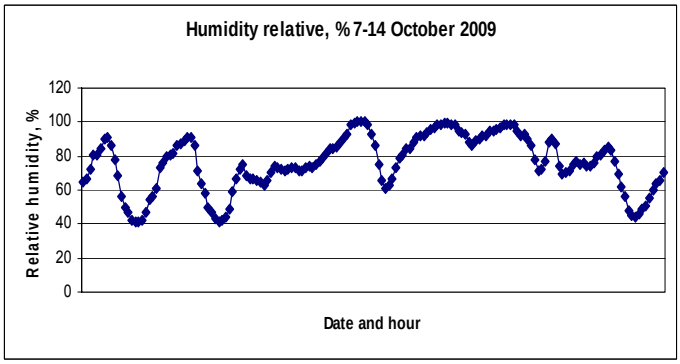


Fig. 4c Relative humidity 7-14 October 2009

In Figure 4c we notice that the minimum value of relative humidity in week 7 to 14 October 2009 was recorded on October 8th at 4:00 P.M. until 5:00 PM on October 9th at 4:00 PM with a value of 41%. Maximum value was recorded in October 11th at 8:00 to 10:00AM with an RH value of 100%.

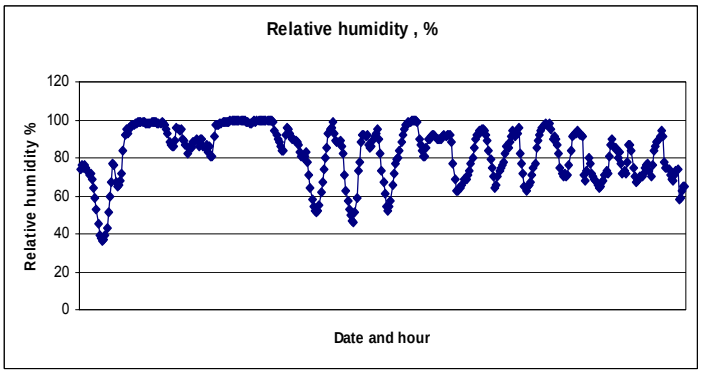


Fig. 4d Relative humidity 15-31 October 2009

Figure 4d is seen as the minimum value of relative humidity in the week 15 to 31 October 2009 was registered on October 15 at 4:00 PM with 36% value. Maximum value was recorded in 16 at 6 PM on October 19th , and on October 20th at 1:00PM to 10:00 PM and for October 24th the RH (%) was recorded with a value of 100%.

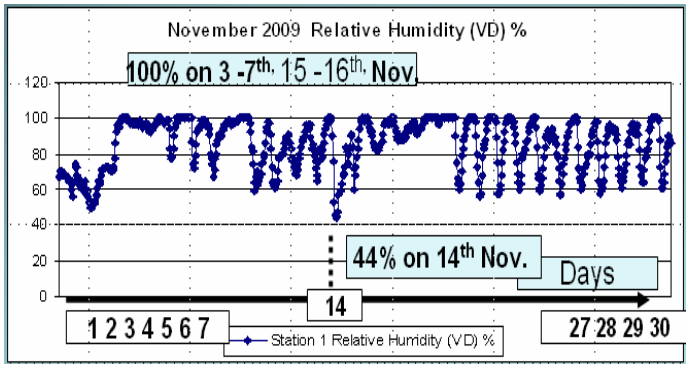


Fig. 5 a Relative humidity November 2009

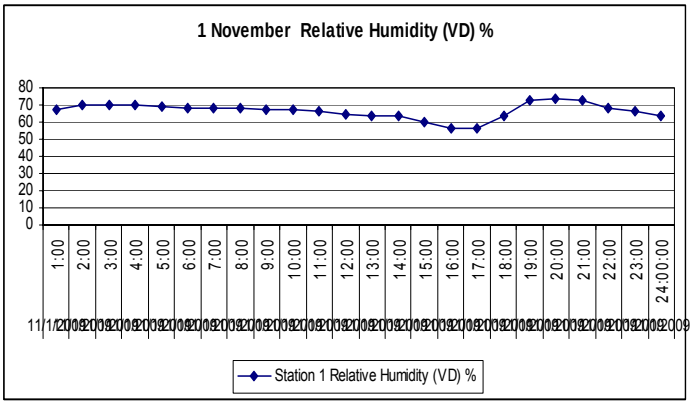


Fig. 5 e Relative humidity at 1st November 2009

The greatest value of relative humidity is 74% on 1st November at 8:00 PM, 56% lower value on 1st day at 4:00 PM and 5:00PM, in the analyzed period of time from 1 to 7 November during all day 24 hours from 24.

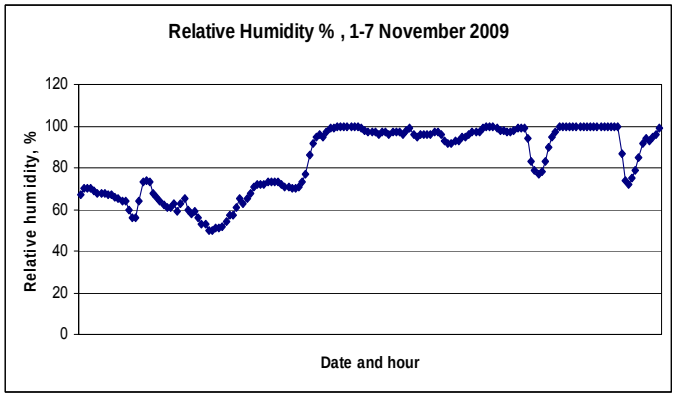


Fig. 5 c Relative humidity 1-7 November 2009

The greatest value of relative humidity was registered in the week 1 to 7 November 2009 is 100% on 4th November at hours 4-10, in November 5th at 11:00-12:00 PM, and at 7th November at 1PM.The lower values of 2 5% was at 3:00-4:00 PM.

In the second week of November (8 to 15 days of November) the minimum value of relative humidity was 44% on November 14th at 2:00 PM. The maximum relative humidity was 100% on 9th November at 10:00-12:00PM.

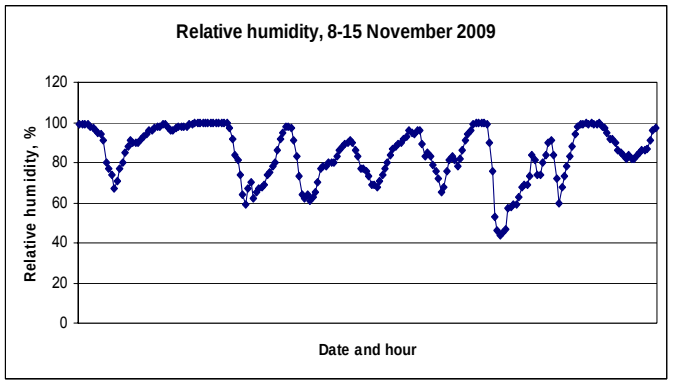


Fig. 5 d Relative humidity 8-15 November 2009

On 14th November the maximum RH % was at 10:00-11:00 AM.

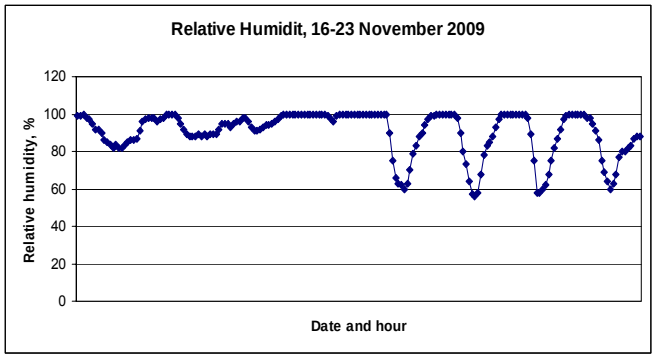


Fig. 5 e Relative humidity 16-23 November 2009

In week 16 to 23 November 2009 for 24 hours of measurement on day, the minimum value of relative humidity of 56% was recorded in November 21st at 6:00 AM and a maximum of 100% was recorded on 15th November at 10:00 to 12:00 PM , and also in the 16th day of November at 3:00AM, and on 17th Novermber at 7:00-10:00am .On November 19th, between 1:00am-1:00 pm, on November 22nd between 1-9 PM.

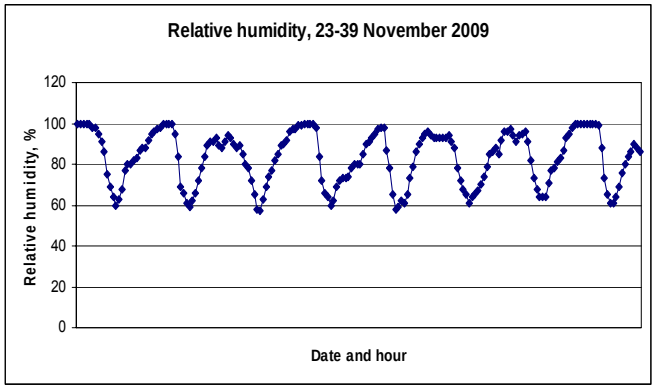


Fig. 5 f Relative humidity 23-30 November 2009

Week 23 to 30 November 2009, for 1-24 hours, the minimum value of relative humidity was 57% and was recorded in November 25th at 3:00 PM.

And a maximum of 100% was recorded on November 24th 6:00-9:00 PM and on 26th day of November 6:00-9:00PMand at 1:00-9:00 PM on 30 November.

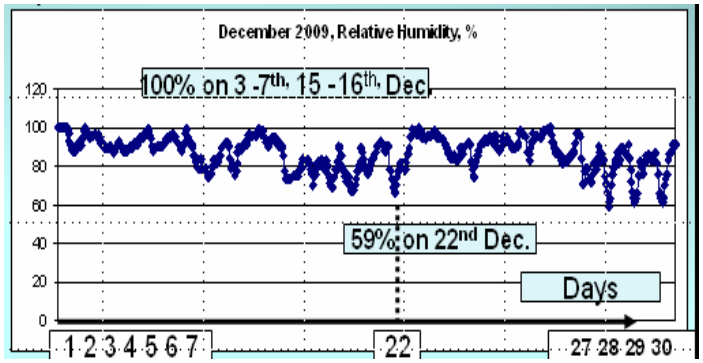


Fig. 6 a Relative humidity on December 2009

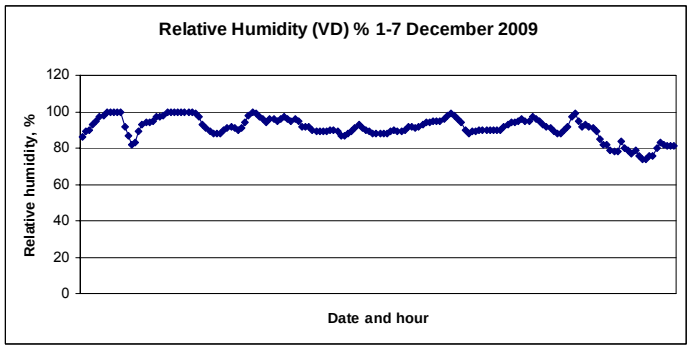


Fig. 6 b Relative humidity 1-7 December 2009

Figure 6 b, based on statistical analysis see that the minimum value of relative humidity of 74% was recorded on December 7 at 15-16. The maximum value of 100% relative humidity, was recorded in the December 1, 2009 on 8-12 in 1-8 hours December 2, December 3 at 1.

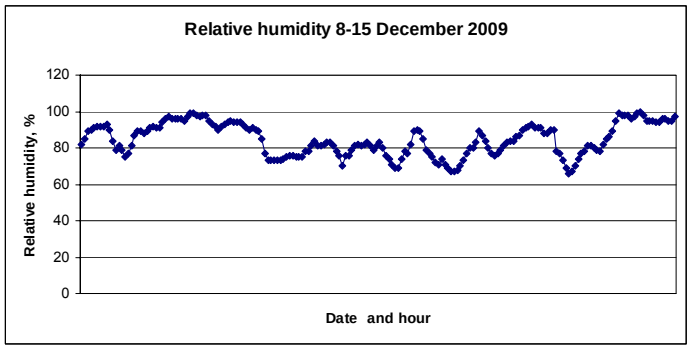


Fig. 6 c Relative humidity 1-7 December 2009

Figure 6 c, based on statistical analysis see that the minimum value of relative humidity of 66% was recorded in December 14 at 2:00PM. The maximum value of 100% relative humidity was recorded the day of December 15th, 2009 at 1:00 PM.

Figure 6 d, based on statistical analysis see that the minimum value of relative humidity of 59% was recorded in December 22nd at 3:00 PM.

The maximum value of 100% relative humidity, was recorded in the December 20th, 2009 on 9-10 hours.

The values tables are recorded by weather station on November 12th , 2009, 1:00-12:00 PM for atmospheric temperature and relative humidity.

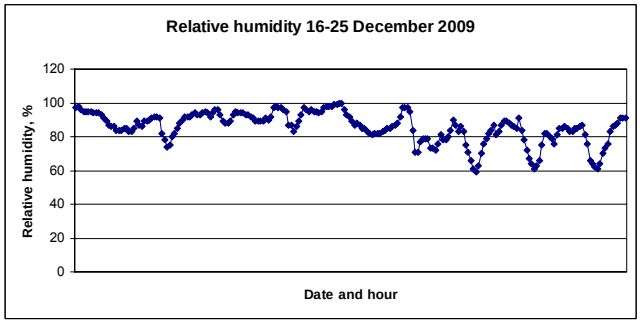


Fig. 6 d Relative humidity 1-7 December 2009

In Table II are indicated the air temperature, indoor air temperature, indoor relative humidity, outside relative humidity.

Table II

The hours on 12th Nov. when was recorded data	Outside air temperature (0C)	Indoor air temperature (0C)	Indoor relative humidity %	Outside relative humidity (%)
1:00 PM	6,6	22	40	83
2:00 PM	6,1	22	43	86
3:00 PM	5,7	22	45	88
4:00 PM	5,5	22	44	89
5:00 PM	5	22	53	90
6:00 PM	4,8	22	56	91
7:00 PM	5,2	22	47	86
8:00 PM	6	22	46	83
9:00 PM	7,1	22	36	77
10:00 PM	7,9	22	34	77
11:00 PM	8,1	22	37	76
12:00 PM	8,5	22	33	75

So, at temperature of 6,6˚C, the air can absorb 10g water vapor /m^3 and relative humidity was 83%. If the air is heated, relative humidity is halved. The same effect is observed in winter, when windows are open.

We observed the lowest relative humidity in October, November and December taking account outside temperature, indoor air temperature, indoor and outside relative humidity.

In Figures 3 to 6 are presented the relative humidity in September to December 2009. From the chart on September see that relative humidity has values between 25 and 99 % , in the days with rain reaching 99 % higher humidity values were recorded in October, November, December, where they recorded days with values of 100 % humidity.

In Table III are presented statistical analysis of relative humidity measured with the weather station on October, November, and December 2009.

From statistical analysis we see that in September 2009 was the minimum value on days 4 and 5 September at 17 with a value of 28 % and a maximum of 99 % in day on 7th September at 2:00 and 5:00.

In October is observed as the minimum value of relative humidity was recorded on the day on October 15, 2009 at 16, with 36% value, maximum value of 100% on the 6th October, 8 a.m. 11 Oct. 8 o'clock, 9 o'clock, 10 o'clock, on October 19th . at hours 6:00- 16:00, 22:00 and on 24th October, for 20 hours 1at 8:00, 9:00, 10:00, and 11:00 o'clock (time).

In November the minimum value was recorded in November 14 at day 14 with a value of 44% maximum relative humidity value of 100% was recorded in days: November 4th at hours 3:00-9:00, , on 5th November during the time 22:00-24:00, on 6th November between 20:00-24:00, 7th November at 2:00-12:00; on 9th November at 20:00-24:00, 10th November at 1:00 8:00 PM and on November 14th, November 15th and at 22:00-24:00 PM. November 16th at 3:00 PM.

Table III

Oct-2009	Air Temp. (VD) °C	Relative Humidity (VD) %	Wind Speed (VD) m/s	Wind Direction (VD) °N	Rain Gauge (VD) mm	Pressure (VD) mbar	Solar Radiation (VD) W/m2
Mean	13.1	79.2	1.5	79.8		1006.5	85.7
Min.	2.9	36	0			983	0
Max.	27.9	100	4.4			1018	687
Std. deviation	5.3	16.3	1			5.5	168.4
Nov-2009							
Mean	8.6	85.3	1.4	29		1006.6	51
Min.	-0.4	44	0			990	0
Max.	20	100	4.2			1019	469
Std. deviation	4	14.1	0.9			6.8	105.2
Dec-2009							
N° data	578	578	578	576	578	578	578
Mean	1.4	87	1.9	77.8		1003.8	15.8
Min.	-10.7	59	0.1			988	0
Max.	14.3	100	6.5			1013	296
Std. deviation	5.8	8.7	1.3			5.8	44.5

On 17th November at hours 8,9,10, Nov. 18th at times 23,and 24, November 19th at followings hours: 1:00, 2:00, 3:00, 4:00, 5:00, 6:00, 7:00, 8:00 ,9:00, 10:00 and also between 11:00 to 24:00. On November 20th at hours : 1:00, 2:00, 3:00, 4:00, 5:00, 6:00, 7:00, 8:00 ,9:00, 10:00, on 21st November at hours 3:00, 4:00, 5:00, 6:00, 7:00, 8:00 ,9:00, at November 22nd hours 1:00, 2:00, 3:00, 4:00, 5:00, 6:00, 7:00, 8:00 ,9:00 and on 23rd November between 1:00-9:00PM, on Nov. 26th 6:00-9:00PM, Nov. 30th 2:00-9:00PM.

In December 2009 the minimum value of 59% on 22nd December at 15, the maximum value of 100% in 8-12 days from December 1st , December 2nd 1-8 pm, Dec. 3rd at 1, December 15 at 13; December 20th from 9, and 10;

In Figure 7 are graphic representations of the relative humidity on September to December 2009(statistical analysis).

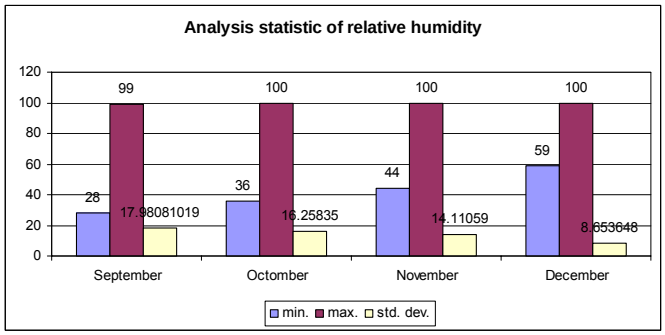


Fig. 7 Statistical analysis of relative humidity September-December 2009

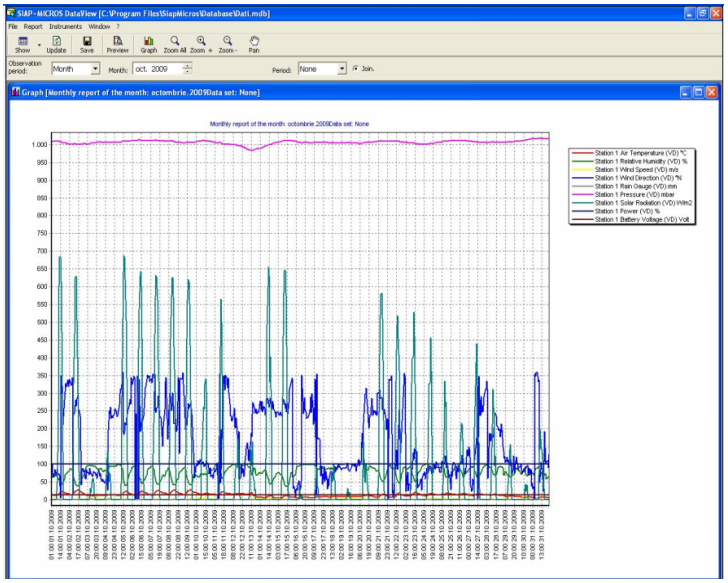


Fig. 8 a)

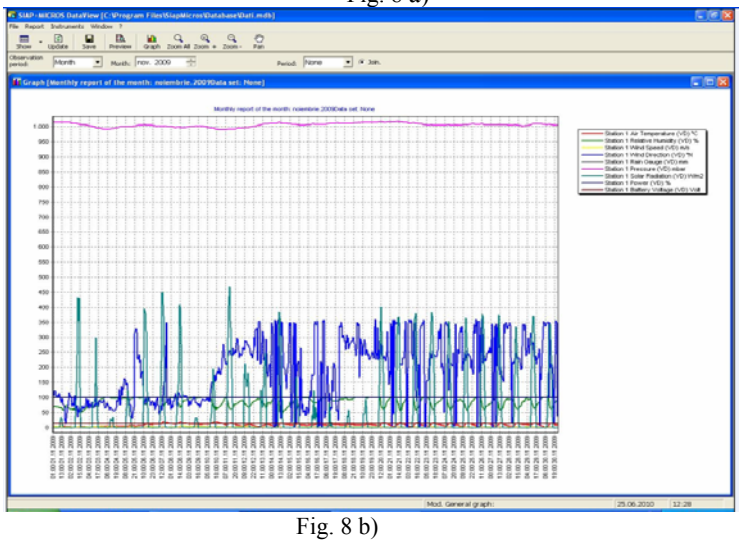


Fig. 8 b)

In Figure 8 are graphic report representation of the atmospheric weather station variation made on soft station in October (a), November (b) and December (c) 2009.

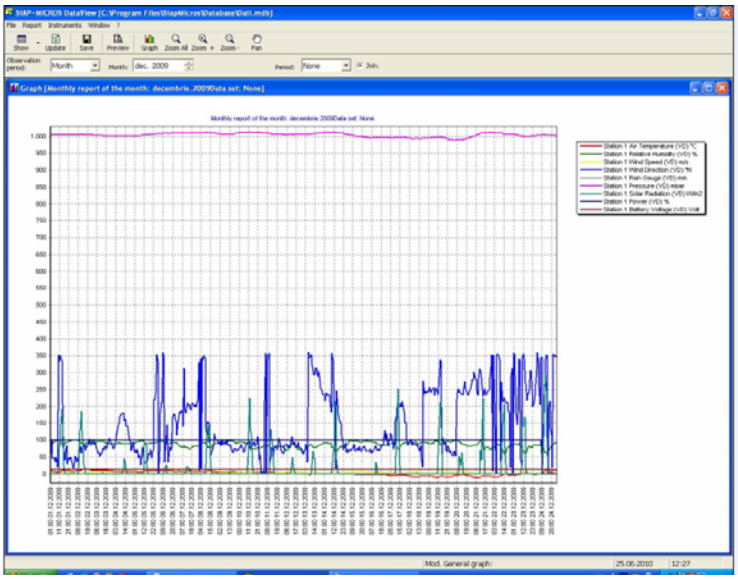


Fig. 8 c)

Fig. 8 Graph Report of the month a) October 2009; b) November 2009; c) December 2009

IV. Conclusion

It is very important to monitor relative humidity; excessive moisture is known to generate the appearance of mold. Dew point is in case the air with a certain temperature and relative humidity can not absorb an additional amount of vapour. Air in a chamber with a temperature of 20° C and relative humidity of 50% may still absorb half the maximum amount possible. If there is air cooled to 9.3 ° C, relative humidity increases to 100%. The air is so completely saturated with vapor and reaches the dew point. Cooling above this level (9.3 ° C) will result in condensation, so that air can not absorb water. Air temperature 20° C, 17.3 g saturated vapor / cm, by cooling to 10 ° C (maximum amount absorbed being 9.4 g vapor / m), determine the appearance of 7.9 g of condensate / mc. In a standard interior space (area of 15 sq m, 2.5 m height, volume of 37.5 cubic meters), air with a temperature of 20 ° C and a relative humidity of 100% contains 750 g of water vapor form . If the temperature drops to 10° C, the amount absorbed being 352.5 g 397.5 g is a difference of vapor that will condense on cold surfaces (glass, frame, frame, walls) where the temperature is below 20 ° C .

Relative humidity was monitored, values obtained were plotted, statistical analysis was performed. The lowest humidity in September was recorded on September 04, 05 September 2009 at 17:00 worth 28 % and the highest value on September 6, 7 2009 at 5:00 in the amount of 99 %.

The lowest relative humidity in October (October 15 at 16:00) was 36 % and the highest value (on October 6th , and 10th October between 8:00 and 10:00) was 100%.

The lowest humidity in November was 44 % (on November 14th at 14:00) and the highest value (on November 6th , 7th between 24: 00 and 8:00, 9th November hour 20: 00 at 24:00) was 100% when it was cold and blow the wind.

The lowest relative humidity in December (on December 10th at 12:00) was 77% and the highest (on December 3rd at 1:00) was 100% when it snowed and was cold.

Based on outside air temperature where the weather station is located and on the air temperature in the room where the computer processes the recorded data, was calculated outdoor and indoor relative humidity, we could see that the relative humidity inside is half of the relative humidity outside, at a temperature of about 22 ^{0}C and the same effect we could see it in winter when windows are open.

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