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The importance of the Open Air Factor

Study to determine the effectiveness of the WELLISAIR Device in a Secondary Education Center (IES CASTELLAR)

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1. INTRODUCTION

In the current situation, and at a global level, there is a concern to contain the pandemic of viruses and pathogens that surround us, which makes it necessary to sanitize spaces and especially those that are public. For this reason, personal protection and sanitation protocols are used such as masks, gloves and hand gels (mostly hydro-alcoholic). Likewise, in public spaces, disinfection is extreme with different types of detergents with disinfectants for floors, walls, objects and utensils, etc.

As for the devices that "purify" the air, they are not a novelty and, with the pandemic, a multitude of devices has increased on the market that also seek a biocidal action by viruses and bacteria. These teams contemplate different types of technologies, which can be grouped into two main categories: **active technologies and passive technologies**. The passive ones require the air in the room to pass through the equipment to "purify" it, while the active ones exert an action directly in the air. The most prominent technologies (active and / or passive) are HEPA filtration, Photocatalysis, Ionization (ionizing plasma), ozonation, Ultraviolet and the generation of Hydroxile Radicals.

All these products and sanitizing devices have advantages and disadvantages, some are not compatible with public attendance and must be applied in the absence of people, others only filter the air without biocidal action, others can only sanitize the air that passes through the device, others leave chemical traces, some even release unwanted reactions, etc.

For example, disinfection of land and other surfaces in industries or in supermarkets that are carried out with a series of chemical products, these in the end would evaporate and would be in the environment and deposited on surfaces even in exposed foods such as bread, fruits , meat, fish, etc.

In the case of the public concurrence, such as an Educational Community, it is necessary to search a balance between the disinfectant actions of air and surfaces, compatible with the presence of people, that are sufficiently effective against pollutants and at the same time innocuous for the people.

The ideal thing for the sanitization of the air in public spaces is a correct and adequate ventilation, and if there is also the opportunity to have these ventilation in a Natural environment that comes from nature's detergents such as Hydroxyl Radicals, it will contribute in a generous and healthy sanitize the air and surfaces to be treated.

2. OBJECTIVE

The objective of this study is to determine the effectiveness and importance of the Open Air Factor (OAF) in a Natural environment, compared with the suitability in this sense that the WELLISAIR device can offer, for the elimination of pathogens and environmental pollutants and surface in a Secondary Education Center.

3. BACKGROUND

For the educational community that has been studied, a previous selection of devices on the market was made that could offer this Natural and balanced way of contributing to disinfect not only the air of the entire School, but also the surfaces during the presence of the people who live together , interact and move around it (a total of 880 people among students, teachers, administrative and service personnel), through the corridors and between the classrooms, every day and practically every hour during class days.

A major challenge is presented: being able to sanitize air and surfaces and find the **Natural** balance between the presence of people and the disinfectant and biocidal purifying effectiveness of the WELLISAIR **active** technology device without unnecessary, harmful and exaggerated chemicals, for this great **Educational Community.**

The surroundings of this Educational Center (in a pre-Natural Park environment) make it highly suitable for the evaluation of this OAF. Specifically, the institute is located at Calle Carrasco y Formiguera, 6, 08211 Castellar del Vallès, Barcelona.

Figure 1 *INS Castellar location*

Logically, and as already mentioned, the recommendations to periodically ventilate the classrooms are essential to maintain acceptable levels of both air and surface pollutants (bio-aerosols) and volatile organic components and the same CO_2 indoors, but with the arrival In winter and especially in big cities, it will not always be possible to ventilate everything that should be, and it can even be a source of entry for new pollutants in classrooms and other interior rooms.

The advantage of having a Natural environment around a school is the benefit that nature itself offers with its sanitization system through Advanced Oxidation Processes (AOP) provided by hydroxyl radicals OH·.

According to the manufacturer's specifications, the WELLISAIR device generates and uses hydroxyl radicals OH · to inactivate microorganisms, eliminate odors and reduce Volatile Organic Compounds (VOCs) as well as PM particles in suspension.

All and that it has already been verified, with the certificates and tests offered by the manufacturer of the WELLISAIR device, that this active technology based on Advanced Oxidation Processes (AOP) is safe and effective for certain viruses and bacteria, it is necessary to review which are the most prevalent pathogens in educational centers to define the effectiveness of WELLISAIR in these spaces.

The most common infectious diseases among school-age boys and girls mostly affect the upper respiratory or gastrointestinal tract [1 2 3].

Among the pathogens that affect the respiratory tract, we find the viruses that give rise to the common cold (the most prevalent causative agent is the Rhinovirus, although the Respiratory Syncytial Virus, the Parainfluenza viruses and the viruses of the Adenoviridae and Coronaviridae families are also frequent), the Influença virus responsible for the flu, those that cause neck pain (although it is usually a symptom of the common cold or flu, in 1 out of 3 cases in children it is due to Streptococcus pyogenes -or also called Streptococcus group A, which can also cause conjunctivitis-), the bacterium Bordetella pertussis that causes whooping cough, and the bacteria that cause meningitis (the most typical causative agent is Neisseria meningitidis although Streptococcus pneumoniae and Haemophilus influenzae are also relevant). The common cold and flu viruses and bacteria that cause meningitis can cause ear infections. All these are transmitted through the respiratory tract through drops and microdroplets released when speaking, breathing, coughing, etc. So they are susceptible to being attacked by hydroxyl radicals when they are in the air.

The most common microorganisms causing gastroenteritis in child care centers are Norovirus, Rotavirus, and Hepatitis A virus; the bacteria Salmonella, Escherichia Coli and Shigella; as well as the parasites Cryptosporidium, Cyclospora and Giardia. Gastrointestinal diseases are mainly transmitted by the enteric route, although, like respiratory diseases, they can remain in fomites (surfaces and objects) for a while.

The importance of *Staphylococcus aureus* (which causes impetigo and is highly prevalent in classrooms –corresponding to 41% of the total microorganism detected[4]-), the *Coxsackievirus* virus (which causes hand, foot and mouth disease), the *Hepatitis B Virus y* and *Human Immunodeficiency Virus*, all of them transmitted by direct contact with fluids or the skin.

The transfer of pathogens from hands to fomites and vice versa has been proven in a large number of studies[5]. Depending on the characteristics of each microorganism (such as its external structure) and the environment (such as humidity or exposure to Hydroxyl Radicals), the time they hold on a surface can be extended or closer. As a general rule, the enveloped *Influença* virus resists 48 hours on a dry surface but the non-enveloped SARS-CoV virus survives up to 96 hours, for example.

In a classroom, keyboards, taps, school supplies, towel dispensers and desks act as fomites, in which there is a high general presence of viruses and bacteria[5]

Airway (air and fomites)	***Rhinovirus***	Common cold Bad neck Ear infections
	Respiratori Syncytial Virus	Common cold Bad neck Ear infections

[1] *Churchill RB, Pickering LK. Infection control challenges in child-care centers. Infect Dis Clin North Am. 1997;11(2):347-365. doi:10.1016/s0891-5520(05)70360-3*
[2] *CDC, Children's diseases and conditions. https://www.cdc.gov/parents/children/diseases_conditions.html*
[3] *Mink CM, Yeh S. Infections in child-care facilities and schools. Pediatr Rev. 2009;30(7):259-269. doi:10.1542/pir.30-7-259*
[4] *Wang Z. (2007). Potential pathogens in the school environment.*
[5] *Bright KR, Boone SA, Gerba CP. Occurrence of bacteria and viruses on elementary classroom surfaces and the potential role of classroom hygiene in the spread of infectious diseases. J Sch Nurs. 2010;26(1):33-41. doi:10.1177/1059840509354383.*

	Parainfluenza	Common cold Bad neck Ear infections
	Adenoviridae	Common cold Bad neck Ear infections
	Coronaviridae	Common cold Bad neck Ear infections
	Influenza	Flu Bad neck Ear infections
	Streptococcus pyogenes	Bad neck Conjunctivitis
	Bordetella pertussis	whooping cough
	Neisseria meningitidis	Meningitis Ear infections
	Streptococcus pneumoniae	Meningitis Ear infections
	Haemophilus influenzae	Meningitis Ear infections
Entericway (fomites)	***Norovirus***	stomach flu
	Rotavirus	stomach flu
	Hepatitis Virus A	stomach flu
	Salmonella	stomach flu
	Escherichia Coli	stomach flu
	Shigella	stomach flu
Direct contact (fluids in fomites)	***Hepatitis Virus B***	Fever, jaundice, coluria ...
	Coxsackievirus	Hands-feet-mouth
	VIH	High fever, respiratory problems ...
	Staphylococcus aureus	Impetigo
	***Staphylococcus aureus* resistant to Methicillin**	

Table 1 *Prevalent pathogens in school-age children, method of transmission and general symptoms*

The effectiveness of the WELLISAIR purifier on seven of the mentioned pathogens has already been tested in different laboratories (see Table 2) and justified in the article Vimbert et al.[6].

[6] *Martínez Vimbert R, Arañó Loyo M, Custodio Sánchez D, Garcia Raurich J, Monagas Aasensio P. Evidence of OH· radicals disinfecting indoor air and surfaces in a harmless for humans method. International Journal of Engineering Research & Science. 2020 April; Vol 6, Issue 4.*

According to the sampling (air or surface), the humidity conditions, the exposure time and the characteristics of each microorganism, the reports show reduction rates of between 99.9% and 37%; results that allow us to conclude that WELLISAIR is effective in the disinfection and purification of educational spaces, protecting our children and the teaching staff.

Virus	***Respiratori Syncytial Virus***	- Humid environment, 2 hours of exposure: reduction of 99%.Universitat de Barcelona, 2019. Test report nº 20191212-3 - Dry environment, 2 hours of exposure: reduction of 92%. Universitat de Barcelona, 2019. Test report nº 20191212-4
	Influenza	- Humid environment, 30 minuts of exposure: reduction of 86%. Universitat de Barcelona, 2020. Test report nº 20200228 - Dry environment, 30 minuts of exposure: reduction of del 38%. Universitat de Barcelona, 2020. Test report nº 20200228
	Coxsackievirus	- Humid environment, 2 hours of exposure: reduction of 99,99%. Universitat de Barcelona, 2018. Test report nº 20180711 - Dry environment, 4 hours of exposure: reduction of 99,42%. Universitat de Barcelona, 2018. Test report nº 20180711
	Rotavirus	- Humid environment, 2 hours of exposure: reduction of 48%. Universitat de Barcelona, 2019. Test report nº 20191212-1 - Dry environment, 2 hours of exposure: reduction of 99 %. Universitat de Barcelona, 2019. Test report nº 20191212-2
Bacterias	***Salmonella***	- Surface, 4 hours of exposure: reduction of 99,9%. Korea Conformity Laboratories, 2016. Test report nº 027129
	Escherichia Coli	- Surface, 1 hours of exposure: reduction of 99,9%. Kangwon National University, 2015. Test report nº EM20150002 - Surface, 4 hours of exposure: reduction of 99,9%. Korea Conformity Laboratories, 2016. Test report nº 027128 - Air, 20 minute exposure: reduction of 99,9%. Kangwon National University, 2015. Test report nº EM20150002 - Air, 2 hours exposure: reduction of 99,9%. Universitat Politécnica de Catalunya, 2012. Test report nº 080612
	Staphylococcus aureus	- Surface, 1 hours of exposure: reduction of 52,3%. Kangwon National University, 2015. Test report nº EM20150002 - Surface, 4 hours of exposure: reduction of 99,9%. Korea Conformity Laboratories, 2016. Test report nº 027128 - Air, 20 minute exposure: reduction of del 99,9%. Kangwon National University, 2015. Test report nº EM20150002 - Air, 2 hours exposure: reduction of 94,5%. Universitat Politécnica de Catalunya, 2012. Test report nº 080612
	***Staphylococcus aureus* resistant to Methicillin**	- Surface, 4 hours of exposure: reduction of 99,9%. Korea Conformity Laboratories, 2016. Test report nº 027129 - Air, 4 hours exposure: reduction of 99,9%. Korea Conformity Laboratories, 2016. Test report nº 027131

***Table 2** Results of the tests to determine the efficacy of WELLISAIR on some of the most common pathogens at school.*

4. SCOPE

As indicated above, the study was carried out at the IES Castellar Institute, located at Carrasco y Formiguera, 6 in Castellar del Vallès, with the presence of people who live together, interact and move through corridors and between classrooms, every day and practically every hour during class days (a total of 880 people including students, teachers, administrative and service person).

The building, located on 11,000 m^2 of land, has two floors and the different spaces are distributed through a central corridor that communicates with the different classrooms, library, laboratories, audiovisual rooms, classrooms-workshops, computer rooms , etc.

For the study, samples of three classrooms were taken, with the following characteristics:

	CLASSROOM 1 (E3F)	CLASSROOM 2 (E4C)	CLASSROOM 3 (E4D)
State of doors and windows	Fully open	Partially open + Vents	Partially open + Vents
Sanitizing element	Open Air Factor (Without WELLISAIR)	WELLISAIR	WELLISAIR
Space dimensions	167 m^3		
Sampling time	2 h (in 30 minutes intervals)		
Sampled items	**Enviromental study:** Formaldehydes, TCOVs, PMs, CO_2, O_3, ions **Microbiological study:** Bacteria, Fungi		

Table 3 Description of stdudy classroom

Taking as control data those obtained in Classroom 1 (WITHOUT WELLISAIR), a study of the effectiveness of the device has been carried out, taking as reference values the median between the data obtained in Classrooms 2 and 3 (WITH WELLISAIR) . Two corridors have also been sampled to monitor external conditions at all times.

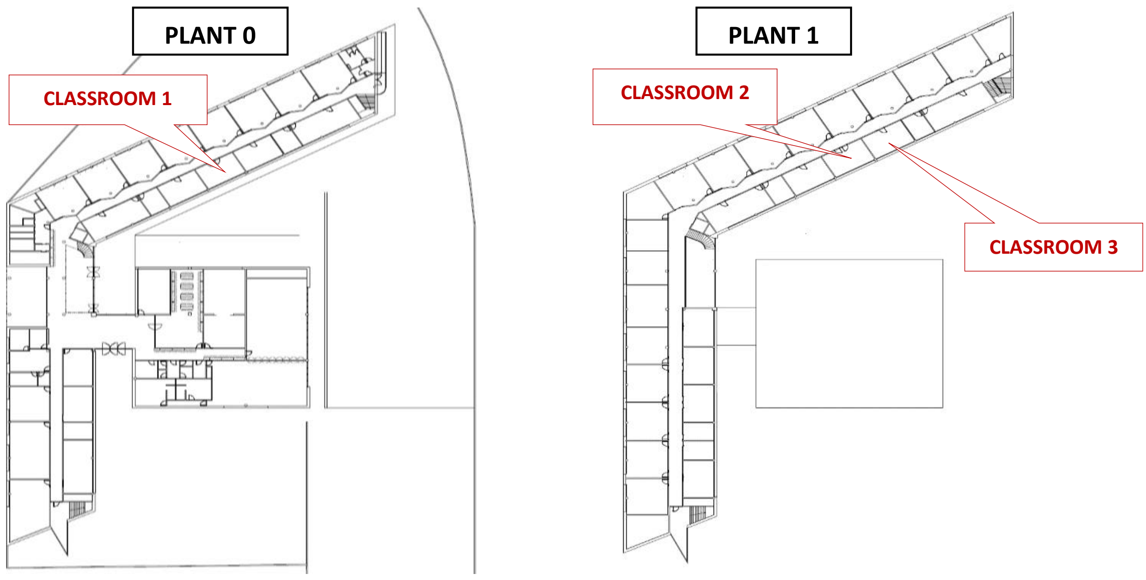


Figure 2 Institute plan

To study all the effects of the Open Air Factor (either naturally or through the use of the WELLISAIR device) in air and surfaces, **the study has been carried out in two clearly differentiated parts: the study of environmental quality and the microbiological study.**

5. ESTUDY OF ENVIROMENTAL QUALITY

5.1. Description of the work carried out

Last Friday 10/23/2020 and 10/30/2020, Ms. Esther Montesinos, laboratory technician, visited the IES Castellar facilities located at Carrasco y Formiguera, 6 in Castellar del Vallès, to take the relevant readings for the environmental quality study of the center, before and after installing the WELLISAIR devices.

5.2. Methodology and reference criteria

5.2.1. Methodology

For the environmental quality study, readings were made to the different classrooms and hallways. The first readings were taken at 10:00 a.m. Once the initial readings were made, the WELLISAIRs were turned on and the test strips were placed to analyze the Open Air Factor (OAF). The measurements were repeated every half hour until a time of two hours from the first reading.

Figure 3 IGERESS WP6930S

To make the **quantitative evaluations** of the pollutants under study, such as **dust, suspended particles, organic contamination in suspension and odors,** the IGERESS environmental quality meter (model WP6930S) was used, which indicates the real values of **Formaldehyde** in mg / m^3 , **VOCs** (Volatile Organic Components) also in mg / m^3, and **PM1, PM2.5** and **PM10** in µg / m^3.

Ozone, CO_2 and ions concentration readings were also taken in the air to better assess the environmental quality of the environment and the operation of the device, to verify that it does not expel ions in the air or ozone, and also decreases the concentration of CO2. The devices used in this case have been: TROTEC Oz-One (Ozone), MAX FOR model 3.7_IAQM1 (CO2) and AlphaLab, Inc Air Ion Counter Model IC-1000-W (ions).

5.2.2. Reference criteria

The air quality in IGERESS equipment is determined by aldehydes (HCHO) and by particles (PM 2.5), as indicated in the following table:

HCHO	PM2.5	LEVEL	
<0.061	<35	0-15	Fresh
<0.100	<75	16-30	Normal
<0.370	<115	31-50	Poor
<0.775	<150	51-60	Harmful
<1.181	<250	61-99	Serious
≥1.181	≥250	100	Danger

***Table 4** Enviromental quality levels*

Regarding Ozone, the regulation of Professional Exposure Limits for Chemical Agents in Spain, 2019, of the National Institute of Safety and Health at Work (INSST) stipulates the following reference values:

Nº CE	Nº CAS	CHEMICAL AGENT	LIMITE VALUES VLA-ED	
			ppm	mg/m^3
233-069-2	10028-15-6	Ozone: Heavy work	0,05	0,1
		Ozone: Moderate work	0,08	0,16
		Ozone: light work	0,1	0,2
		Ozone: heavy, moderate or light work (≤2 hours)	0,2	0,4

***Table 5** Ozone Exposure Limit Values*

Finally, the admissible CO_2 levels are regulated by the World Health Organization (WHO) regulations and the regulation "NTP 549: Carbon dioxide in the evaluation of indoor air quality" of the National Institute of Safety and Security. Occupational Health (INSST)[7], as follows:

ENVIRONMENT	CO_2 (ppm)
Outside (clean air)	300 - 400
Healthy environment	≥ 1000
Recovered ventilation	1000 - 1500
Urgent ventilation	≥ 1500

***Table 6** CO_2 levels in the air*

5.3. DATA COLLECT

Before beginning to take the readings in the classrooms and corridors of the center, an initial reading was made in the street and the hall of the institute, to determine the starting environmental conditions.

The values obtained are collected in the following table:

	23/10/2020						30/10/2020		
	LEVEL	HCHO (mg/m^3)	TVOC (mg/m^3)	PM ($\mu g/m^3$) PM 2,5	PM 1,0	PM 10	CO_2 (ppm)	OZONE (ppm)	IONS (cm^3)
STREET	**4**	0,031	0,128	008	006	009	**431**	000	000
HALL	**35**	0,239	1,092	006	004	006	**479**	000	000

***Table 7** Enviromental data collect Street and Hall*

[7] https://www.insst.es/documents/94886/188493/L%C3%ADmites+de+exposici%C3%B3n+profesional+para+agentes+qu%C3%ADmicos+2019/7b0b9079-d6b5-4a66-9fac-5ebf4e4d83d1

__Figure 4__ Data collection on the street

__Figura 5__ Data collection on the Hall

We can determine that the air outside the building is in perfect condition. On the other hand, environmental contamination at the entrance of the institute as soon as we arrive, at 10:00 a.m., is high since at the entrance there is a pot of hydroalcoholic gel to disinfect our hands on arrival and departure, and each time it is used releases aldehydes in the environment. This reading is when there is movement at the entrance of the Institute, at any time of the day. A high value of aldehydes (HCHO) and total volatile organic components (TVOCs) can be observed, as well as an increase in suspended particles (PMs). The CO_2 level, on the other hand, is at normal values in all two cases.

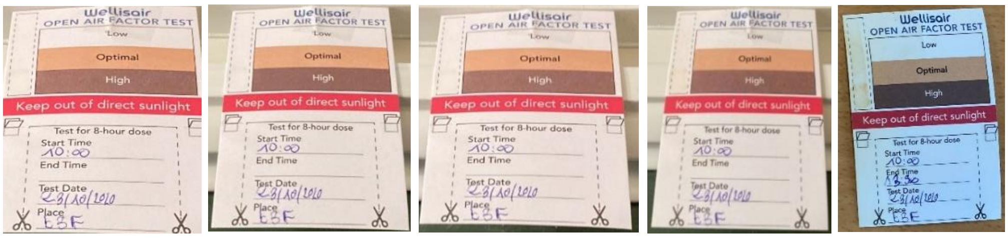
5.3.1. Classroom E3F (Without WELLISAIR)

This classroom is the classroom without WELLISAIR with children inside, yes, windows were wide open and we could see that just below the window there was a small garden with plants. The values obtained are collected in the following table:

	23/10/2020						30/10/2020		
	LEVEL	HCHO (mg/m^3)	TVOC (mg/m^3)	PM (µg/m^3)			CO_2 (ppm)	OZONE (ppm)	IONS (cm^3)
				PM 2,5	PM 1,0	PM 10			
0H	**31**	0,129	0,543	006	004	006	**1470**	000	000
0,5H	**30**	0,109	0,451	007	005	008	**1494**	000	000
1H	**28**	0,098	0,409	004	003	004	**1507**	000	000
1,5H	**21**	0,077	0,333	003	002	003	**1217**	000	001
2H	**25**	0,090	0,389	003	002	003	**1147**	000	000

Table 8 Collection of environmental Classroom E3F (without WELLISAIR)

On the other hand, the evolution of the test strips placed to evaluate the Open Air Factor (OAF) is monitored:



T0 T30 T60 T90 T120

After 2 hours of experiment, a small twist can be observed in the strip. This variation verifies the Open Air Factor (OAF), it must be remembered that this classroom had the windows open to a small garden.

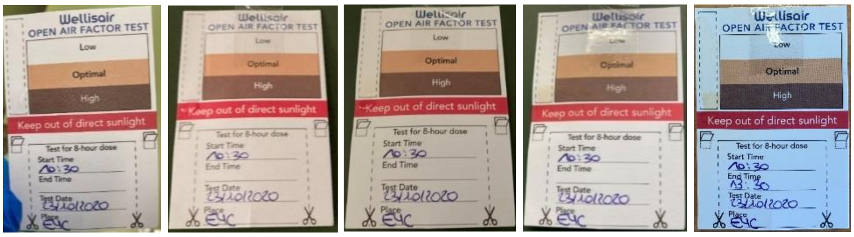
5.3.2. Classroom E4C (WELLISAIR Hour 0)

This classroom the first reading is without Wellisair but from this we turn on the device. It does not have the windows open or the door initially, then from the time of the experiment they open. The values obtained are collected in the following table:

	23/10/2020						30/10/2020		
	LEVEL	HCHO (mg/m^3)	TVOC (mg/m^3)	PM (µg/m^3)			CO_2 (ppm)	OZONE (ppm)	IONS (cm^3)
				PM 2,5	PM 1,0	PM 10			
0H	**35**	0,241	1,408	006	004	006	**748**	000	000
0,5H	**34**	0,232	1,037	004	003	004	**819**	000	000
1H	**34**	0,229	1,012	005	003	005	**592**	000	001
1,5H	**31**	0,142	0,586	005	003	005	**659**	000	001
2H	**19**	0,074	0,316	003	002	003	**1142**	000	001

Table 9 Collection of environmental Classroom E4C (with WELLISAIR)

On the other hand, the evolution of the test strips placed to evaluate the Open Air Factor (OAF) is monitored:



T0 T30 T60 T90 T120

At the time of the experiment, we can begin to see how the test strip turns in the box, at the bottom. At two hours it has a more brownish color and the remainder of the box has also turned a bit. The fact that at the end of the box it is more skewed is because the reagent has spread.

5.3.3. Classroom E4D (WELLISAIR -16H)

The WELLISAIR was placed in this classroom the day before (Thursday 10/22/2020). The first measurement at time 0 and with children was already the WELLISAIR. The door was closed and the window was half open. After the 30-minute reading, the windows were fully opened. The values obtained are collected in the following table:

	23/10/2020						30/10/2020		
	LEVEL	HCHO (mg/m^3)	TVOC (mg/m^3)	PM ($\mu g/m^3$)			CO_2 (ppm)	OZONE (ppm)	IONS (cm^3)
				PM 2,5	PM 1,0	PM 10			
0H	**32**	0,155	0,663	006	004	006	**743**	000	000
0,5H	**31**	0,150	0,649	004	003	004	**722**	000	001
1H	**30**	0,125	0,528	003	002	003	**776**	000	000
1,5H	**9**	0,046	0,192	005	003	005	**871**	000	000
2H	**12**	0,055	0,227	005	003	005	**858**	000	000

Tabla 10 *Collection of environmental Classroom E4D (with WELLISAIR)*

On the other hand, the evolution of the test strips placed to evaluate the Open Air Factor (OAF) is monitored:

T0 T30 T60 T90 T120

From the hour the test strip begins to change color. The color obtained at the end of the experiment is very significant since the device had been in operation since the previous day.

5.3.4. Hallway with WELLISAIR

The hallway initially had the WELLISAIR standing still but the door at the end was open and there was a lot of draft. After the first reading we start the WELLISAIR. The values obtained are collected in the following table:

	23/10/2020						30/10/2020		
	LEVEL	HCHO (mg/m^3)	TVOC (mg/m^3)	PM ($\mu g/m^3$) PM 2,5	PM 1,0	PM 10	CO_2 (ppm)	OZONE (ppm)	IONS (cm^3)
0H	**27**	0,093	0,384	004	003	004	**703**	000	000
0,5H	**42**	0,440	2,116	005	003	005	**669**	000	000
1H	**30**	0,115	0,486	004	003	004	**658**	000	002
1,5H	**22**	0,080	0,342	004	003	004	**783**	000	000
2H	**16**	0,065	0,274	003	002	003	**707**	000	000

Table 11 *Collection of environmental Hallway (with WELLISAIR)*

On the other hand, the evolution of the test strips placed to evaluate the Open Air Factor (OAF) is monitored:

T0 T30 T60 T90 T120

In this case we can observe the rotation in the first 30 minutes of the experiment. In this case it is so fast due to the short distance with the wellis.

5.3.5. Hallway without WELLISAIR

	23/10/2020						30/10/2020		
	LEVEL	HCHO (mg/m^3)	TVOC (mg/m^3)	PM ($\mu g/m^3$) PM 2,5	PM 1,0	PM 10	CO_2 (ppm)	OZONE (ppm)	IONS (cm^3)
0H	**39**	0,362	1,705	005	003	005	**1527**	000	000
0,5H	**35**	0,241	1,048	006	004	006	**765**	000	002
1H	**40**	0,390	1,793	005	003	005	**1150**	000	000
1,5H	**36**	0,275	1,215	002	001	002	**814**	000	000
2H	**38**	0,322	1,516	003	002	003	**1147**	000	000

Table 12 *Collection of environmental Hallway (without WELLISAIR)*

5.4. INTERPRETATION OF RESULTS

In order to interpret the results obtained, the results obtained in the two classrooms were first compared with the WELLISAIR device installed.

	ENVIROMENTAL POLLUTION LEVEL		
	CLASSROOM E4C	CLASSROOM E4D	MIDDLE VALUE
0h	35	32	**33,5**
1h	34	30	**32**
2h	19	12	**15,5**
REDUCTION (2h)	**46%**	**63%**	**54%**

	CO_2 LEVEL(ppm)		
	CLASSROOM E4C	CLASSROOM E4D	MIDDLE VALUE
0H	748	743	745,5
1H	592	776	684
2H	1142	858	1000
MIDDLE VALUE	**792**	**794**	**793**

Table 13 *Classroom comparison with WELLISAIR (Enviromental quality)*

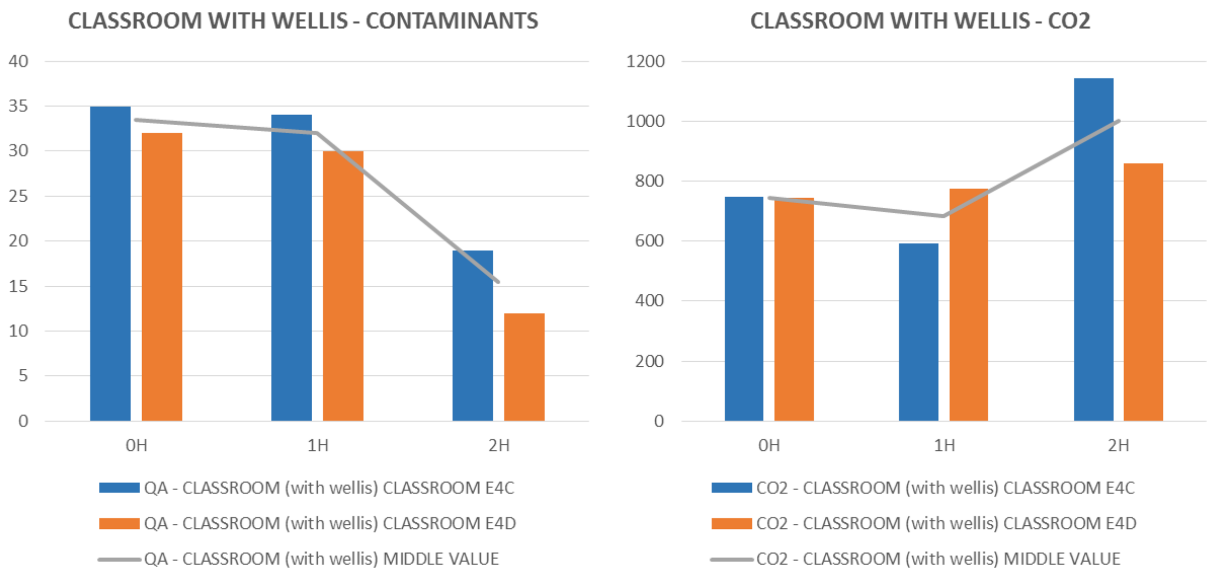


Figure 6 *Classroom comparison with WELLISAIR (Enviromental quality)*

As can be seen, the values obtained, as well as the trends, can be considered equivalent in the two classrooms. Therefore, the median values between the two classrooms are taken as classroom values with installed WELLISAIR device.

Taking this into account, the values obtained in the classroom are compared with WELLISAIR installed in verse to the classroom without WELLISAIR and with the windows open.

	ENVIRONMENTAL POLLUTION LEVEL - CLASSROOM	
	WITHOUT WELLISAIR	WITH WELLISAIR
0h	31	33,5
1h	28	32
2h	25	15,5
REDUCTION (2h)	**19%**	**54%**

	CO_2 LEVEL (ppm) - CLASSROOM	
	WITHOUT WELLISAIR	WITH WELLISAIR
0h	1470	745,5
1h	1507	684
2h	1147	1000
MIDDLE VALUE (2h)	**1367**	**793**

Table 14 *Comparison WITH WELLISAIR vs WITHOUT WELLISAIR – CLASSROOMS (Enviromental quality)*

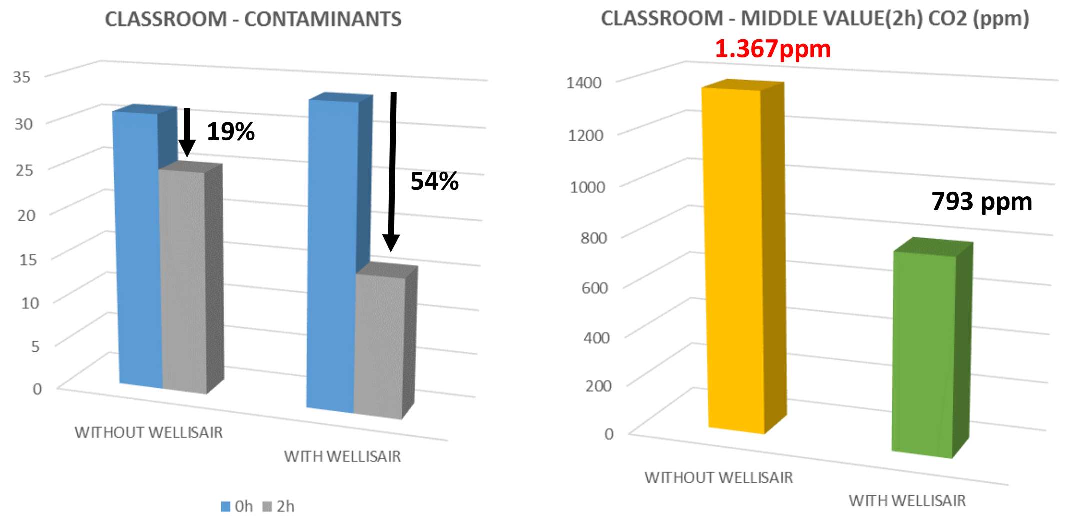


Figure 7 Comparison WITH WELLISAIR vs WITHOUT WELLISAIR – CLASSROOMS (Enviromental qualityl)

As can be seen, everything and that in the classroom without the WELLISAIR device the Open Air Factor improves air quality after 2 hours, in the classrooms with the WELLISAIR device installed the reduction of pollutants is much more remarkable (54 % against 19%).

On the other hand, in the classroom without a WELLISAIR device, the air quality (at the level of pollutants and CO_2) is at harmful values (all and with the doors and windows wide open), while in classrooms with the WELLISAIR device installed, the measurements are at healthy values.

Regarding the hallway, the results obtained are shown below.

	ENVIRONMENTAL POLLUTION LEVEL - HALLWAY	
	WITHOUT WELLISAIR	WITH WELLISAIR
0h	39	27
1h	40	30
2h	38	16
REDUCTION (2h)	**3%**	**41%**

	CO_2 LEVEL(ppm) - HALLWAY	
	WITH WELLISAIR	WITHOUT WELLISAIR
0h	1527	703
1h	1150	658
2h	1147	707
MIDDLE VALUE	**1081**	**704**

Table 15 Comparison WITH WELLISAIR vs WITHOUT WELLISAIR – HALLWAY (Enviromental quality)

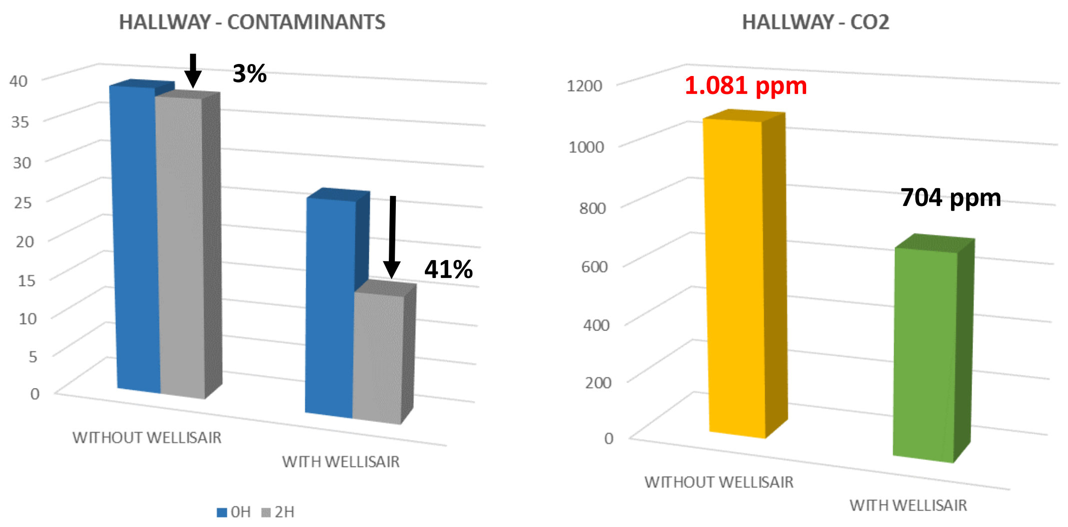


Figure 8 Comparison WITH WELLISAIR vs WITHOUT WELLISAIR – HALLWAY (Enviromental quality)

As can be seen, in the same way that happens in classrooms, in the corridor without the WELLISAIR device the Open Air Factor slightly improves the air quality after 2 hours, while in the classrooms with the WELLISAIR device installed the reduction of pollutants is much more remarkable (41% against 3%).

On the other hand, in the corridor without the WELLISAIR device, the air quality (at the level of pollutants and CO_2) is at harmful values (everything and having doors and windows wide open), while in the corridor with the device WELLISAIR installed, the measurements are at healthy values.

6. MICROBIOLOGIAL STUDY

6.1. DESCRIPTION OF THE WORK CARRIED OUT

Last Friday 10/23/2020, Mr. Rubén Plaza and Mr. Sergi Diaz, microbiology laboratory technicians, visited the IES Castellar facilities located on Carrasco y Formiguera, 6 in Castellar del Vallès, to take the relevant samples for the microbiology study of the center, before and after installing the WELLISAIR devices.

6.2. METHODOLOGY AND REFERENCE CRITERIA

6.2.1. Methodology

Air sampling tests

__Figure 9__ Photograph of one of the HUMIDIFIER air samplers used to measure samples during aerosol tests.

For the air sampling inside the classroom or corridors, 90 mm Petri dishes were used, collecting 100 L with an air sampler (own design and produced by 3D printer) in a total time of 1 min.

To carry out these tests, air samples are taken in the classrooms and corridors (with and without Wellisair) to quantify the amount of bacteria in the air at minute 0 and every 30 minutes until the 2-hour experiment. All air samples were taken in duplicate.

Finally, the plates were incubated 24 hours at 37ºC to visualize the results the next day.

Surface disinfection tests

As for the air sampling tests, for these tests the classrooms and corridors discussed above (WELLISAIR and CONTROL) were used and surface samples were taken in duplicate. After this, samples were taken at time 0 to determine the bacterial load and every 30 minutes for 2 hours to evaluate the disinfection of surfaces by the device. RODAC (Replicate Organism Detection and Counting) plates were used for sampling. The use of these plates is a simple and quick method to check surfaces for microbiological contamination and provides the hygienic state of the surface.

Finally, the plates were incubated 24 hours at 37ºC to visualize the results the next day.

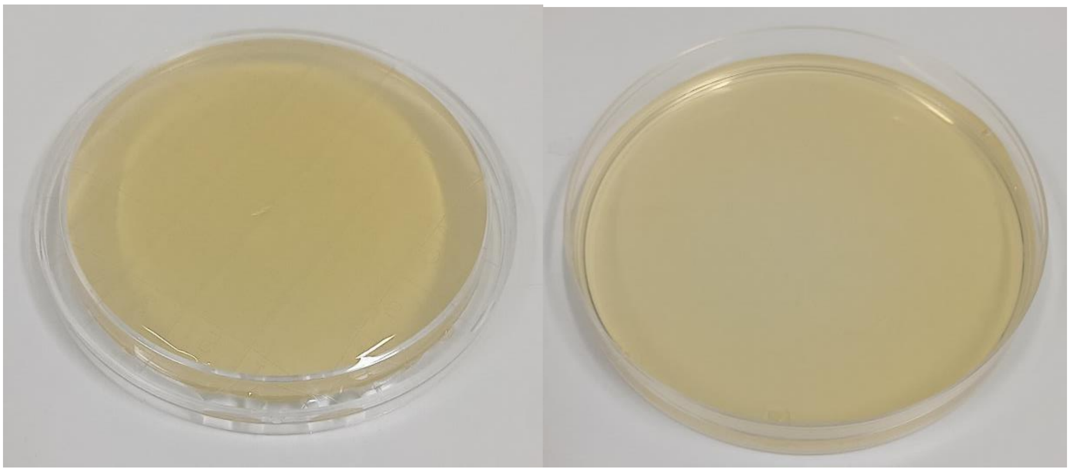


Figure 10 *Photographs of the plates with the culture medium used in the tests. On the left, a RODAC plate used for surface sampling, and on the right, a 90mm diameter Petri dish used for measuring air samples.*

6.2.2. Reference criteria

According to *standard NTP 409: Biological Contaminants: Endpoints.* There are no numerical endpoints. But the ACGIH (American Conference of Governmental Industrial Hygienists) commission for bioaerosols explains the reasons why these criteria cannot be determined:

- Bioaerosols are complex mixtures of different kinds of particles.
- Human responses to bioaerosols range from harmless to serious disease, depending on the specific agent and individual susceptibility factors.
- The measured concentrations of the cultivable and countable bioaerosols depend on the method of the sample measurement and analysis. It is not possible to collect and evaluate all components of bioaerosols using a single sampling method.

CATEGORY	DEFINICIÓN	EXAMPLES
Group 1	Biological agent that is unlikely to cause illness in the person.	The community classification does not include group 1 biological agents.
Group 2	Pathogenic agent that can cause illness in the person and can pose a danger to workers; it is unlikely to spread. There are generally effective treatments.	Bacteria: Legionella pneumophila. Viruses: influenza. Fungi: Penicillium sp.
Group 3	Pathogenic agent that can cause illness in person and present a hazard to workers; there is a risk of it spreading. There are generally effective treatments.	Bacteria: Mycobacterium tuberculosis. Viruses: Hepatitis B virus. Fungi: Histoplasma capsulatum.
Group 4	Pathogenic agent that can cause serious illness in person and poses a danger to workers; chances are high that it will spread. There are generally no effective treatments.	Bacteria: There are none classified. Virus: Ebola virus. Fungi: There are none classified.

Table 16 *Classification of biological agents according to the risk of infection.*

ACGIH's commission for bioaerosols has developed guidelines for the assessment of exposure to biological contaminants indoors.

VIRUSES	The number of particles necessary to cause an infection in a susceptible individual is not known. Factors such as increased occupancy or poor air renewal can contribute to an increase in the contagion rate.
BACTERIA	Some authors have suggested 4,500 ufc/m^3 of air as the upper limit for the concentration of total bacteria for indoor use.
ENDOTOXINS	Some authors suggest levels 100-1000 times higher than the levels measured in control environments.
FUNGI	The origin of fungi (which are usually found in indoor environments) is mostly outdoor, therefore, it will preferably be used as a control environment.
MYCOTOXINS	Exposure to these is related, basically, to an agricultural environment and grain storage.
PROTOZOUS	The size of these microorganisms makes their presence in bioaerosols less frequent, since they tend to settle rapidly.
ANTIGENS	A concentration <2 µg of dust has a low risk level. A concentration of 2-10 µg of dust has a significant level of risk. A concentration> 10 µg of dust has a high risk level.

Table 17 *Exposure to biological contaminants indoors.*

6.3. Data collention

6.3.1. Classroom E3F (Without WELLISAIR)

	FUNGI				BACTERIA			
	AIR (Ufc/100 l)	SURFACE (Ufc/cm2)			AIRE (Ufc/100 l)	SURFACE (Ufc/cm2)		
		TABLE	DOOR	AVERAGE		TABLE	DOOR	AVERAGE
0H	0	0,0	0,1	0,0	59	0,1	3,0	1,6
0,5H	6	0,0	0,0	0,0	95	1,5	4,1	2,8
1H	9	0,0	0,0	0,0	10	1,3	6,0	3,7
1,5H	4	0,0	0,0	0,0	56	1,7	9,0	5,4
2H	1	0,0	0,0	0,0	68	1,2	3,0	2,1

Table 18 *Microbiology data collection classroom E3F (without WELLISAIR)*

6.3.2. Classroom E4C (WELLISAIR Hour 0)

	FUNGI				BACTERIA			
	AIR (Ufc/100 l)	SURFACE (Ufc/cm2)			AIRE (Ufc/100 l)	SURFACE (Ufc/cm2)		
		TABLE	DOOR	AVERAGE		TABLE	DOOR	AVERAGE
0H	5	0,0	0,0	0,0	65	7,8	9,0	8,4
0,5H	22	0,0	0,1	0,0	49	3,6	3,0	3,3
1H	10	0,0	0,0	0,0	66	0,4	1,6	1,0
1,5H	19	0,0	0,0	0,0	53	1,5	1,9	1,7
2H	8	0,0	0,0	0,0	31	2,6	3,9	3,3

Table 19 *Microbiology data collection classroom E4C (with WELLISAIR)*

6.3.3. Classroom E4D (WELLISAIR -16H)

	FUNGI				BACTERIA			
	AIR (Ufc/100 l)	SURFACE (Ufc/cm2)			AIR (Ufc/100 l)	SURFACE (Ufc/cm2)		
		TABLE	DOOR	AVERAGE		TABLE	DOOR	AVERAGE
0H	3	0,00	0,00	0,00	90	2,7	3,0	2,8
0,5H	13	0,00	0,03	0,02	100	0,7	3,6	2,1
1H	33	0,09	0,00	0,05	55	1,0	3,3	2,1
1,5H	7	0,00	0,00	0,00	19	3,0	3,0	3,0
2H	13	0,12	0,00	0,06	46	0,9	3,0	2,0

***Table 20** Microbiology data collection classroom E4D (with WELLISAIR)*

6.3.4. Corridor (WELLISAIR Hour 0)

	FUNGI				BACTERIA			
	AIR (Ufc/100 l)	SURFACE (Ufc/cm2)			AIRE (Ufc/100 l)	SUPERFICIE (Ufc/cm2)		
		TABLE	DOOR	AVERAGE		TABLE	DOOR	AVERAGE
0H	3	0,0	0,1	0,0	27	1,2	5,1	3,2
0,5H	6	0,1	0,0	0,1	22	0,8	1,7	1,3
1H	0	0,0	0,1	0,0	39	0,8	1,5	1,2
1,5H	0	0,0	0,1	0,1	100	0,9	2,2	1,6
2H	8	0,1	0,0	0,0	100	0,5	2,2	1,3

***Table 21** Microbiology data collection corridor (with WELLISAIR)*

6.4. INTERPRETATION OF RESULTS

To interpret the results of the microbiological part of this study, it was necessary to take into account only the results obtained in the sampling of bacteria, everything and have also taken samples of the fungi.

Fungi are microorganisms without chlorophyll, provided with thalli, generally filamentous and branched, by means of which they absorb the organic nutritive principles of the environment, of a very varied measure and preferably asexual reproduction (by spores); they live in parasites or on decomposing organic matter or parasites of plants or animals. As explained in table 17 and the proper definition of fungi, they come from an outdoor environment and are accompanied by the movement of people. So, we cannot extract concluent results since it is not about a classroom with wellis or without wellis, but that the people are not the same and the movement of people entering and leaving each classroom is not either.

First, the results obtained in the two classrooms with the WELLISAIR device installed were compared, both in aerosols and on surfaces.

	BACTERIA					
	CLASSROOM E4C		CLASSROOM E4D		MIDDLE VALUE	
	AIR	SURFACE	AIR	SURFACE	AIR	SURFACE
0H	65	8,44	90	2,85	77,5	5,65
1H	66	0,99	55	2,14	60,5	1,57
2H	31	3,27	46	1,98	38,5	2,62
REDUCTION (2H)	**52%**	**61%**	**49%**	**31%**	**50%**	**54%**
REDUCTION MAX.	**53%**	**88%**	**81%**	**35%**	**54%**	**72%**

Table 22 *Comparison of classroom with and without WELLISAIR bacteria in air and on the surface (Microbiology)*

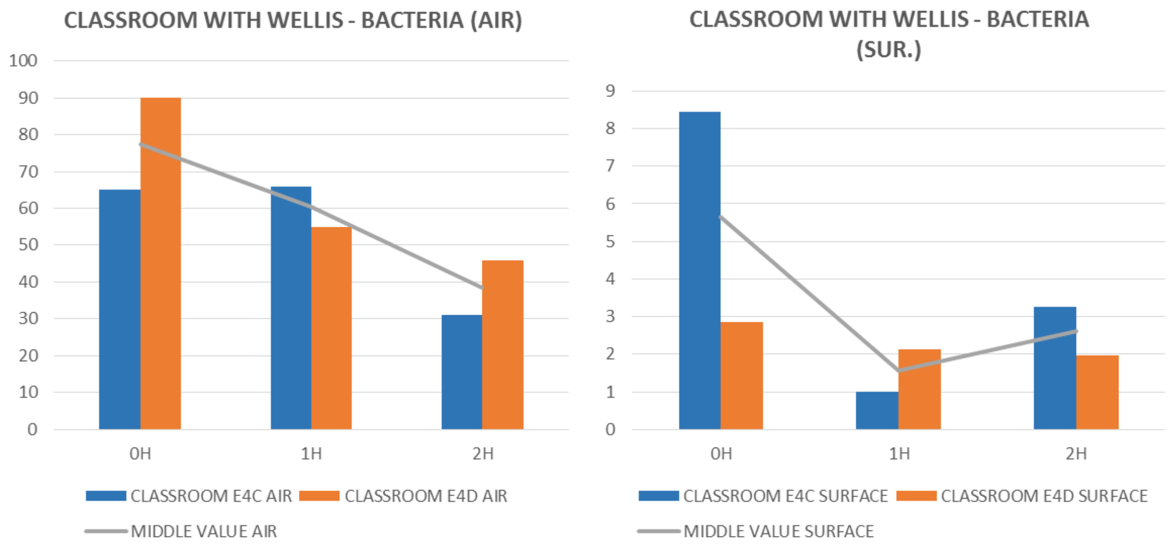


Figure 11 *Comparison of classroom with and without WELLISAIR bacteria in air and on the surface (Microbiology)*

As can be seen, the values obtained, as well as the trends, can be considered equivalent in the two classrooms. Therefore, the median values between the two classrooms are taken as classroom values with installed WELLISAIR device.

Taking this into account, the values obtained in the classroom with WELLISAIR installed are compared against the classroom without WELLISAIR.

	BACTERIA IN AEROSOLS - CLASSROOM	
	WITHOUT WELLISAIR	WITH WELLISAIR
0h	59	77,5
1h	10	60,5
2h	68	38,5
REDUCTION (2h)	**-15%**	**50%**

Table 23 *Comparison of classrooms with and without WELLISAIR bacteria in aerosols (Microbiology)*

	BACTERIA IN SURFACE - CLASSROOM	
	WITHOUT WELLISAIR	WITH WELLISAIR
0h	1,6	5,6
1h	1,2	1,6
2h	2,1	2,6
REDUCTION (2h)	**-36%**	**54%**

Table 24 *Comparison of classrooms with and without WELLISAIR bacteria in surface (Microbiology)*

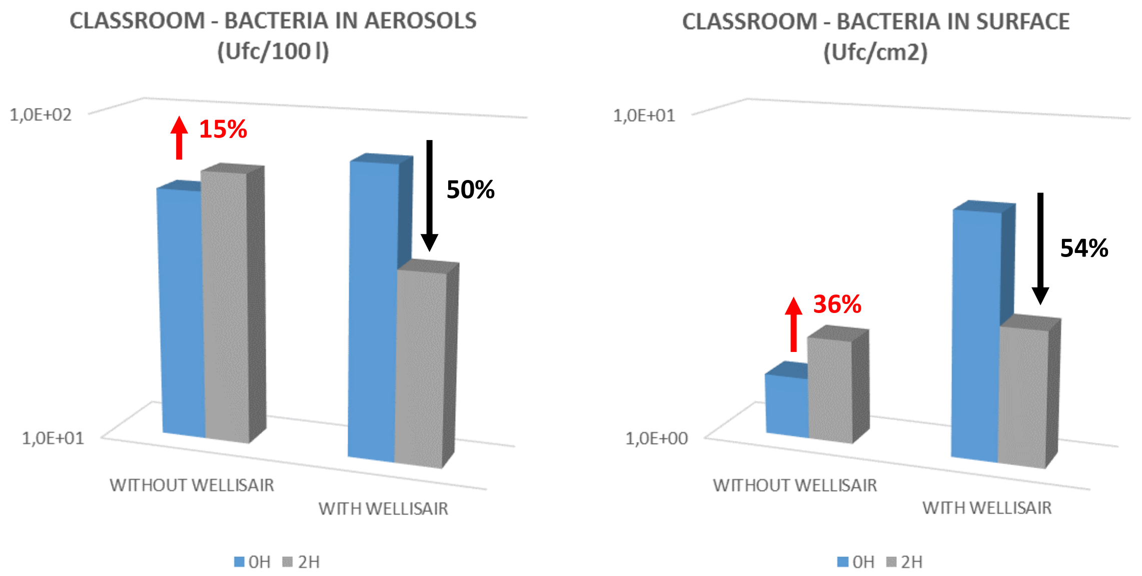


Figure 12 *Comparison WITH WELLISAIR vs WITHOUT WELLISAIR – BACTERIA in aerosols and surface (Microbiology)*

As can be seen, with WELLISAIR there is a decrease in bacterial colonies both in aerosol and on surfaces, while without WELLISAIR the bacteria proliferate. The increase in bacteria on surfaces is much more noticeable than in aerosols (36% against 15%) in the classroom without WELLISAIR, while the decrease with WELLISAIR is very similar in aerosols and on surfaces (50% and a 54%, respectively).

7. CONCLUSIONS

The conclusions that we can obtain, after conducting a whole series of tests in the experiment, is that we have reached our objective, which is to determine the effectiveness and importance of the Open Air Factor (OAF) in a Natural environment, compared with the WELLISAIR device, for the elimination of pathogens and environmental and surface pollutants in a Secondary Education Center. The conclusions are as follows:

- Although in the classroom without the WELLISAIR device the Open Air Factor improves the environmental quality after 2 hours, in the classrooms with the WELLISAIR device installed the reduction of pollutants is much more significant (54% instead of 19%).
- In the classroom without the WELLISAIR device, the air quality (at the level of pollutants and CO_2 is at harmful levels (although the doors and windows are open), while in the classrooms with the WELLISAIR device installed, at 2 hours the medians are within healthy values.
- Using test strips it has been possible to verify the importance of the Open Air Factor (OAF) and the correct functioning of the device, since in both cases they have turned correctly and this indicates a level of oxidation in the environment.
- The bacterial load in aerosols shows a slight increase in the classroom without WELLISAIR (+15%), while in the classrooms with the purifying device installed there is a reduction of 50%.
- Bacterial load on surfaces shows a significant increase in the classroom without WELLISAIR (+36%), while it is significantly reduce (by 54%) in classrooms with a purifier.

Thus, the use of the **WELLISAIR device in classrooms can significantly improve air quality, reducing the bacterial load**, limiting the opening of windows in ventilation operations stipulated by the Ministry of Education and **improving the comfort of students and teachers in the classroom, especially in the winter months.**