IEQ IN DOMESTIC WORKSPACES: Indicators and perceptions in Spanish homes

Principal Researcher (PI): *Teresa Cuerdo Vilches (IETcc-CSIC)*

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21-22 April 2026, Workshop, Madrid:
"Climate Change, Ventilation and Resilience"

CHARACTERIZATION OF ENVIRONMENTAL CONDITIONS FOR DOMESTIC WORKSPACES IN SPAIN

Principal Researcher (PI): *Teresa Cuerdo Vilches (IETcc-CSIC)*
Research Team-Buildings: *Ignacio Oteiza, Juan Queipo, Elena Frías, Pilar Linares, Sonia García, Amelia Romero, Belén Casla, Teresa Carrascal, Enrique Larrumbide (IETcc-CSIC)*
Research Team-Sociology: *Pablo Meseguer (UCM, Coordinador); Miguel Ángel Navas (ISCIII); Irene Lebrusán (UC3M);*
(International): *Sergio Torrejón (JRC-EC).*
Technical Staff: *Julián Martín (IETcc-CSIC)*

MINISTRY of SCIENCE and INNOVATION
GENERATION OF KNOWLEDGE CALL 2022
Ref: PID2022-142864NA-I00

HYPOTHESES-STARTING POINTS

1) There is no representative sample at national level of telework households, in regard to housing and environmental conditions.

2) The domestic worspace has not been yet characterized for Spanish households, nor the adequacy of those spaces for such domestic task.

OBJECTIVES

Main objective: Characterize the Spanish domestic workspace.

Specific objectives (Phases):

SO1. Inventory and assess the environmental conditions for the domestic workspaces

SO2. Evaluate in an integrated way, the environmental attributes of domestic workspaces

SO3. Implement improvement solutions

SO4. Analyse multicriteria the feasibility of solutions. Conclusions. lizar con multicriterio la viabilidad de soluciones. Conclusiones

Telework definition

"Such remote work that is carried out from the worker's home through the predominant use of computer and telecommunications systems and means".

Ad-hoc survey generation

11 ARCHITECTS/ENGINEERS (8)+(3)
(IETcc-CSIC, US)

Hygrothermal Comfort/Energy:
T. Cuerdo; I. Oteiza
Acoustics:
A. Romero, T. Carrascal, B. Casla
Lighting/Ergonomy-Accesibility:
J. Queipo, E. Frías
I. Acosta
Idooor Air Quality/Hygiene:
P. Linares, S. García
Sostenibility:
E. Larrumbide

+

6 SOCIOLOGISTS
(ISCIII, UCM, UAM, UC3M, JRC-EC)

Sociololgy of professions and health:
P. Meseguer
Urban Environment/Health/Telework-Digital:
M. A. Navas
Urban Sociology /Ageing/Housing:
I. Lebrusán
Employment, society-territory/Policy and Internationalization:
S. Torrejón
A. Viera, J. V. Castellanos

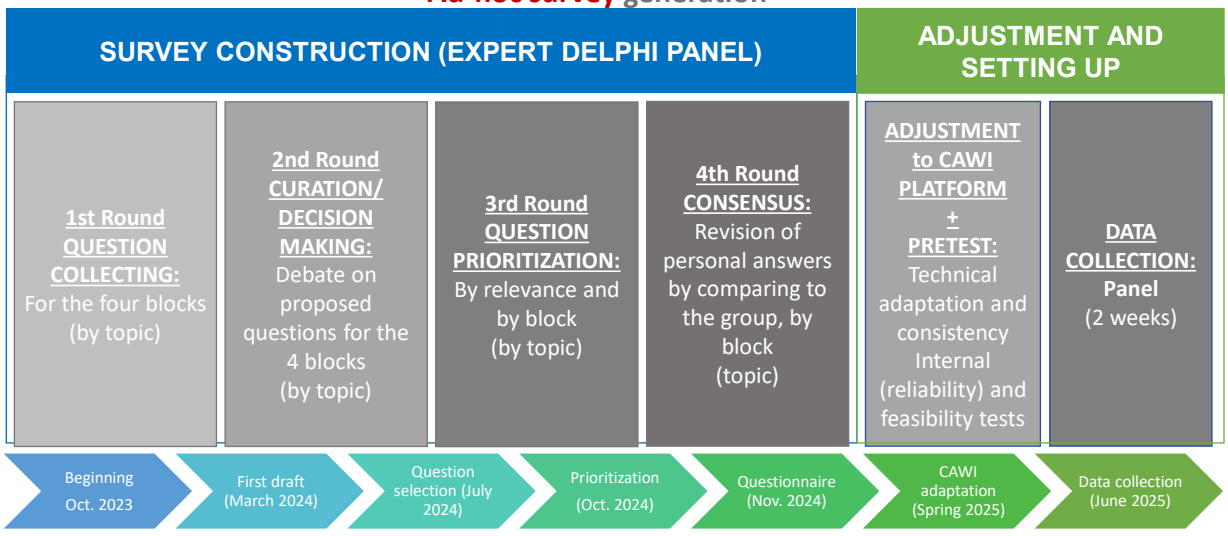
Also: Julián Martín (Technical Staff), SGAI (CSIC), and Aplica Coop.

Ad-hoc survey generation

QUESTION SECTIONS
BLOCK 1: Sociodemographic and economy variables on the participant and their household
BLOCK 2: General variables on housing and urban surroundings
BLOCK 3: General variables on the telework performance
BLOCK 4: Variables on the indoor environmental conditions and the use of energy inside the workspace

Sociology questions, from official sources (INE, CIS, other surveys)
Technical questions, from scientific literature and existing regulation

Ad-hoc survey generation



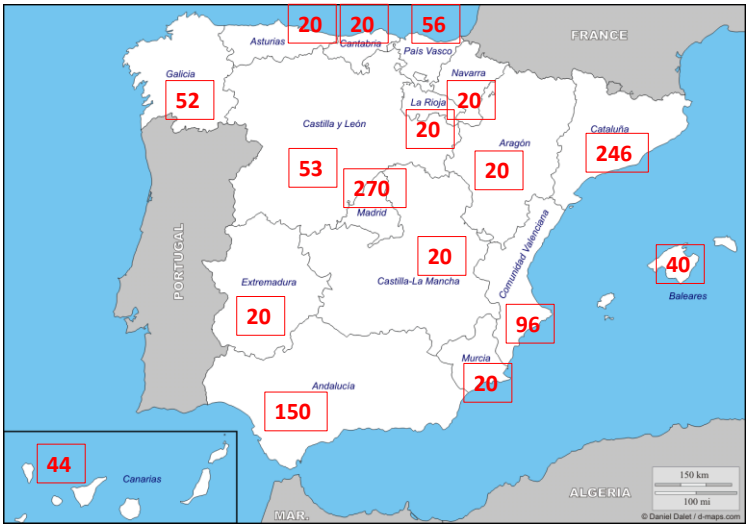
National Representative Survey Distribution

Survey distribution:

- By sex:
  - **Women**
  - **Men**
- By age (six segments):
  - **16 to 24**
  - **25 to 34**
  - **35 to 44**
  - **45 to 54**
  - **55 to 64**
  - **65 to 74**
- By Autonomous Communities

*Autonomous cities - Ceuta and Melilla - not included.

- Guaranteeing a sampling error margin of +/- 3 for p=q=50%, and a significance level of 95% for the entire sample
- Using Software JASP and R.



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National Representative Survey Distribution

Variable
Sex
Age
Minor presence
% TT time
Part time/Full time

Dependent variable: TT space adequacy

Variable	Category	P*
Qualification	Higher	0,000
Household incomes	High	0,000
Current position	Directors, managers Intellectual professionals, Intermediate vocational training	0,003
TT time	>1 year	0,000
TT preference	At least 20%	0,000
TT experience	Good/very good	0,000
More than 1 TT	Yes	0,028
Digital means adequation for TT	Yes	0,000

National Representative Survey Distribution

Variable
Dwelling and building type (rural, single/multifamily house…)

Variable	Category	P*
Construction date	From 1951	0,000
Dwelling maintenance	Good/Excelent	0,000
Tenancy	Owned	0,010
Dwelling useful surface	> 90 m2	0,000
Dwelling surroundings	External (rural, to Parks, to boulevards, …)	0,002
Connection element to the exterior	Yes	0,012
Dwelling heating system	Yes	0,000

Dependent variable: TT space adequacy

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National Representative Survey Distribution

Variable
Dwelling and building type (rural, single/multifamily huse…)

Variable	Category	P*
Room size	Adequate	0,000
Room temperature	Adequate	0,000
Artificial lighting	Adequate	0,000
Noise insulation	Adequate	0,000
External views from openings	Adequate /Indifferent	0,000
Carpentries	Adequate	0,000
Solar control devices	Adequate	0,000
Surface finishings	Adequate	0,000

Dependent variable: TT space adequacy

Telework Space Adequacy Index (TSAI) – coming soon for regular conditions

Table 4. Telework Space Adequacy Index (TSAI) ranked (1–10).

	Education Level			Tenure Regime		Dwelling Useful Surface (m²)				Dwelling Type		Telework Space Adequacy		Usual Work Activity		
	U.G.	G.	P.G.	O	R	0–60	61–90	91–120	>120	H	F	NA/LA	A/VA/TA	P.S.	E.J.	S-E.J.
TSAI (11 telework space aspects)	4.26	5.04	5.23	5.28	4.36	4.22	4.97	5.08	5.67	5.31	4.92	3.42	5.53	5.27	4.73	5.00
TSAIe (5 essential aspects)	5.40	6.17	6.32	6.46	5.32	5.18	6.00	6.25	7.04	6.53	6.01	4.27	6.73	6.45	5.81	6.01
TSAIne (6 non essential aspects)	3.31	4.09	4.32	4.29	3.56	3.42	4.11	4.10	4.52	4.30	4.01	2.72	4.52	4.29	3.83	4.17
Score ranges:		2–3		3–4		4–5		5–6		6–7		7–8				

Table colors represent the TSAI score ranges, as showed caption added above. Acronyms: U.G.: Undergraduate; G: Graduate; P.G.: Postgraduate. O: Owned; R: Rented. H: House; F: Flat. NA: non adequate; LA: little adequate; A: Adequate; VA: very adequate; TA: totally adequate. P.S.: Public Servant; E.J.: Employed job; S-E.J.: Self-employed job. TSAIe: TSAI based on essential categories; TSAIne: TSAI based on non-essential categories.

Working from Home: Is Our Housing Ready?

by Teresa Cuerdo-Vilches [1,*], Miguel Ángel Navas-Martín [2] and Ignacio Oteiza [1]

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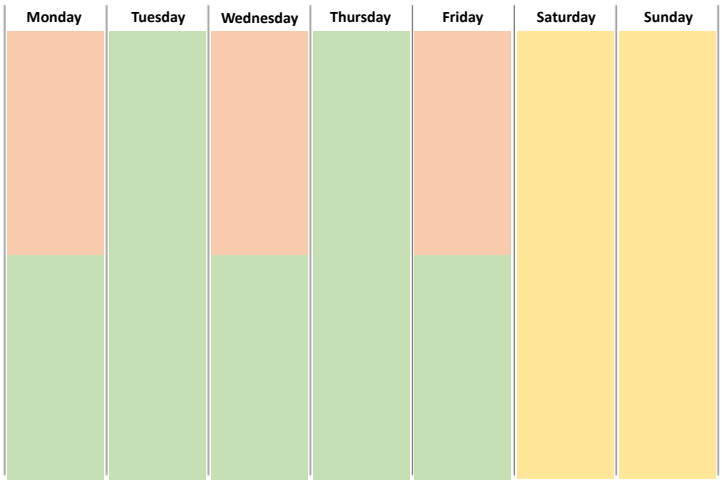
Monitoring Campaign

Main features for monitoring:

- Hybrid domestic teleworking (2-3 days/week)
- From Autonomous Community of Madrid
- From March 2026 (in progress)
- Minimum 8 cases (expected 15-20)
- 1 type-week per worker, distinguishing:
  - Teleworking time (2-3 days)
  - Non-telework time (2-3 days)
  - Week-end (2 days)



Indoor Environmental Quality: SENSORS

Air Quality

Sound levels

Intensity of light

Energy Consumption

Envelope airtightness/ thermal bridges

Indoor Air Quality: SENSORS

Temperature
Sensor: Silicon bandgap / Unit: ºC
Range: -40 - 125 ºC / Resolution: 0,1 ºC
Accuracy: ± 0,5 ºC
Lifespan[1]: >10 years

Relative Humidity
Sensor: Capacitive / Unit: %RH
Range: 0 - 100 %RH / Resolution: 1 %RH
Accuracy: ± 2 %RH
Lifespan: >10 years

CO_2
Sensor: NDIR / Unit: ppm
Range: 400 - 10.000 ppm / Resolution: 1ppm
Accuracy: ±(30 + 3% m.v.) ppm
Lifespan: >10 years

TVOC
Sensor: MOx / Unit: VOC Index Points (µg/m³ / ppb)*
Range: 0 - 500 VOC Index Points (0 - 1000 ppm) / Resolution: 1 VOC Index Points
Accuracy: ±15 VOC Index points or ±15% m.v., whichever is larger
Lifespan: >10 years

$PM_{2.5}$
Sensor: Particle laser / Unit: µg/m³
Range: 0 - 1.000 µg/m³ / Resolution: 1 µg/m³
Accuracy: ± (5 µg/m³ + 5% m.v.) (0 -100 µg/m³), ±10% m.v. (101-1000 µg/m³)
Lifespan: >10 years

PM_{10}
Sensor: Particle laser / Unit: µg/m³
Range: 0 - 1.000 µg/m³/ Resolution: 1 µg/m³
Accuracy: ±25 µg/m³ (0 -100 µg/m³), ±25% m.v. (101 - 1000 µg/m³)
Lifespan[1]: >10 years

$PM_{4.0}$
Sensor: Particle laser / Unit: µg/m3
Range: 0 - 1.000 µg/m3 / Resolution: 1 µg/m3
Accuracy: ±25 µg/m3 (0 -100 µg/m3), ±25% m.v. (101 - 1000 µg/m3)
Lifespan[1]: >10 years

$PM_{1.0}$
Sensor: Particle laser / Unit: µg/m3
Range: 0 - 1.000 µg/m3 / Resolution: 1 µg/m3
Accuracy: ± (5 µg/m3 + 5% m.v.) (0 -100 µg/m3), ±10% m.v. (101-1000 µg/m3)
Lifespan: >10 years

Formaldehyde
Sensor: Electrochemical / Unit: ppb
Range: 0 - 1000 ppb / Resolution: 1 ppb
Accuracy: ±20 ppb or ±20% m.v., whichever is larger
Lifespan: >6 years

CHAMBER

Indoor Air Quality: InBiot Dashboard

inBiot

25.7 °C — Temperatura	32 % — Humedad	406 ppm — CO_2	1 µg/m³ — Formaldehído
116 INDEX — TVOC	2 µg/m³ — PM1.0	2 µg/m³ — PM2.5	2 µg/m³ — PM4.0
2 µg/m³ — PM10			

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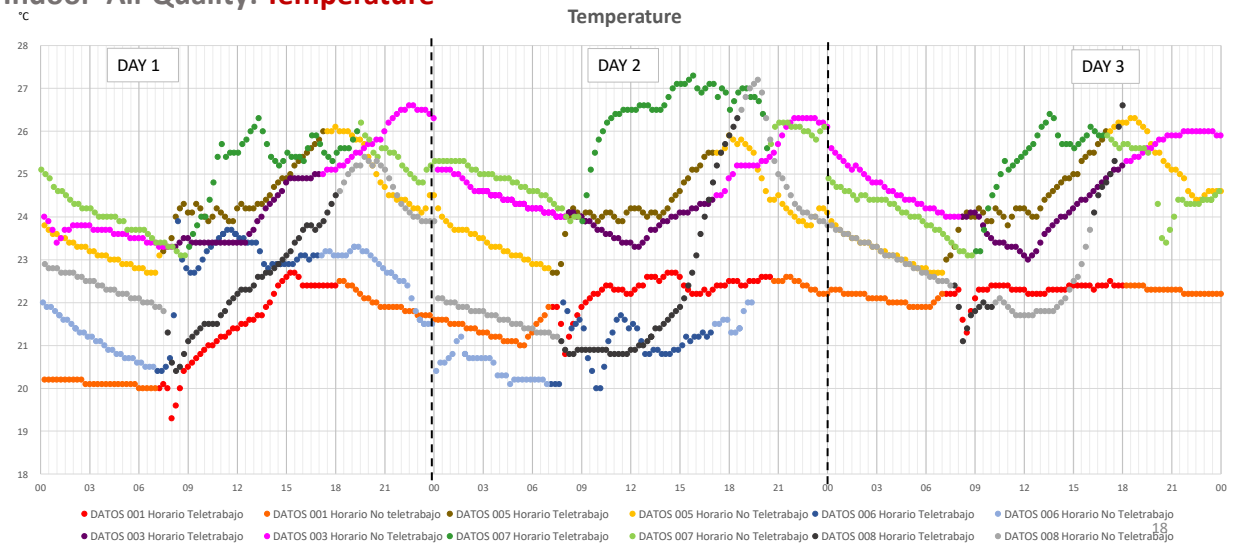
Indoor Air Quality: Temperature



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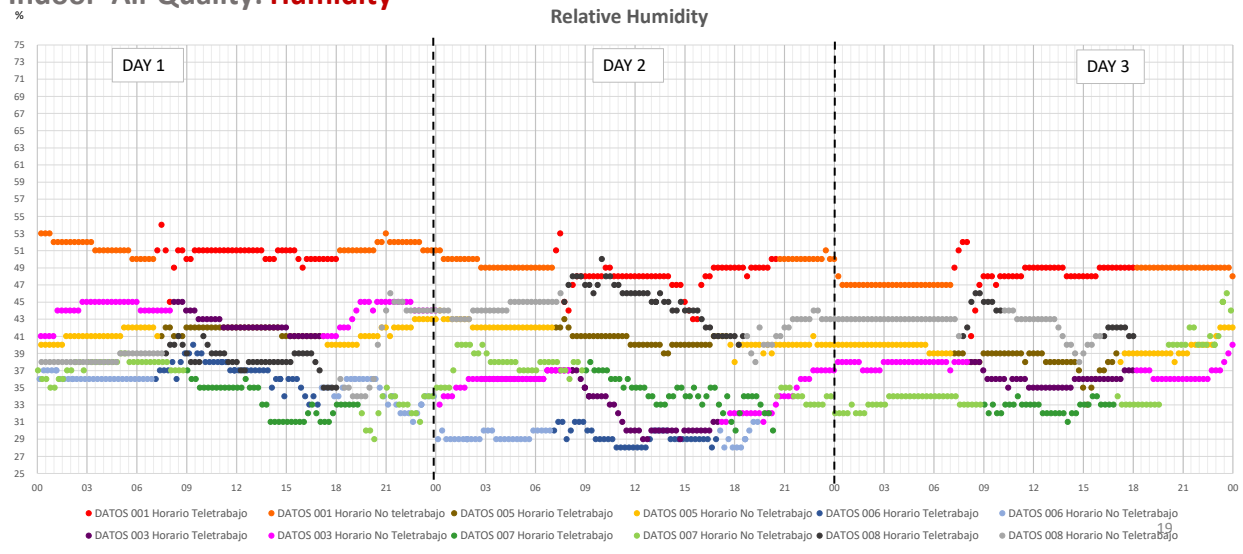
Indoor Air Quality: Humidity



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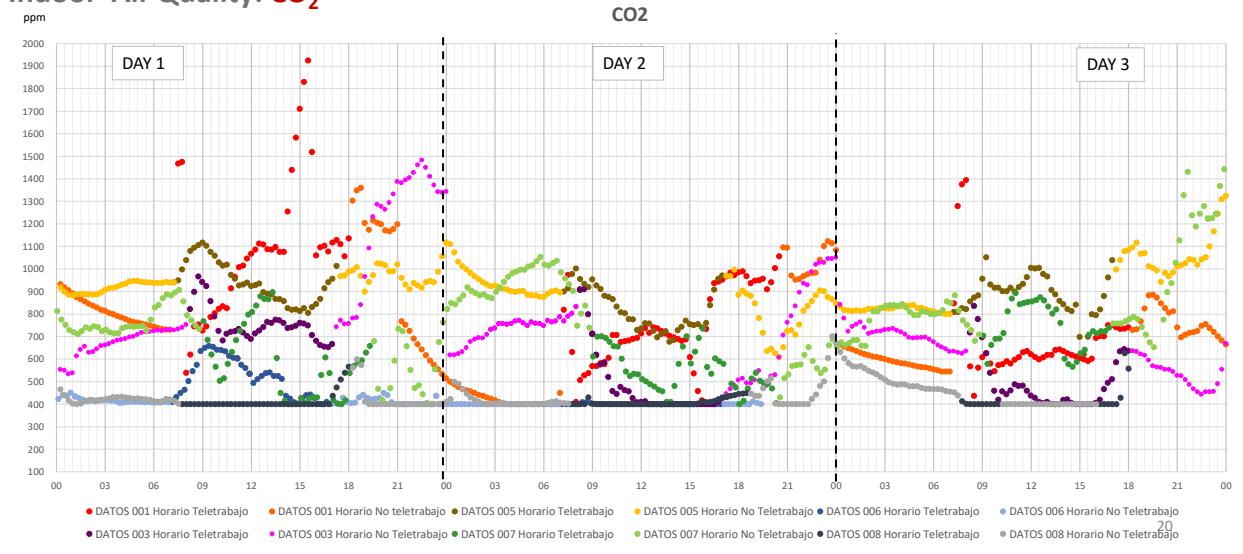
Indoor Air Quality: CO_2



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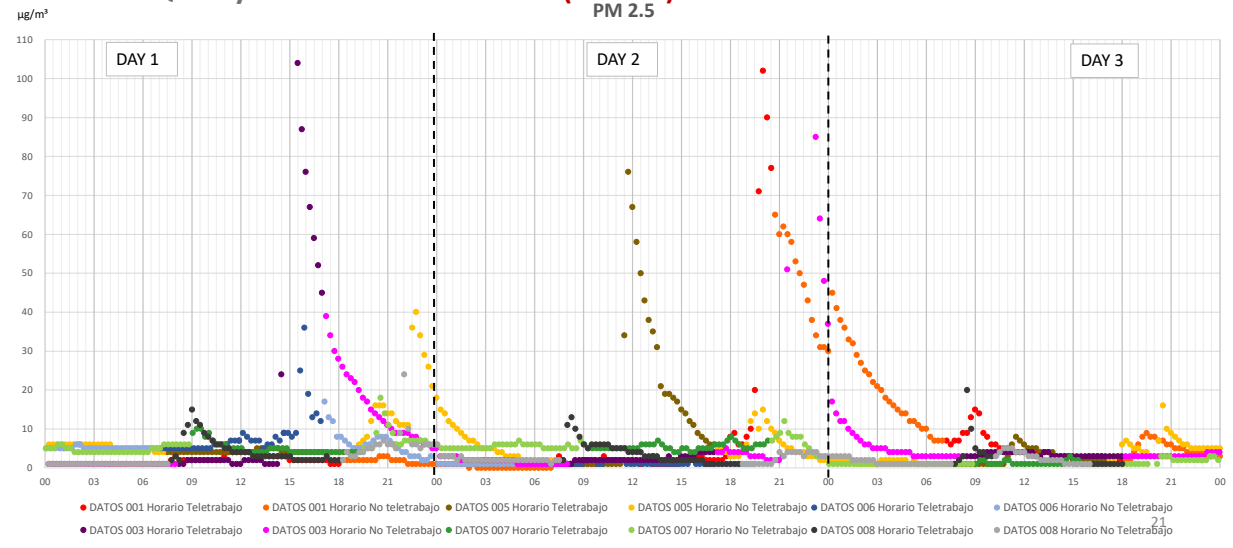
Indoor Air Quality: Particulate Matter 2.5 (PM 2.5)



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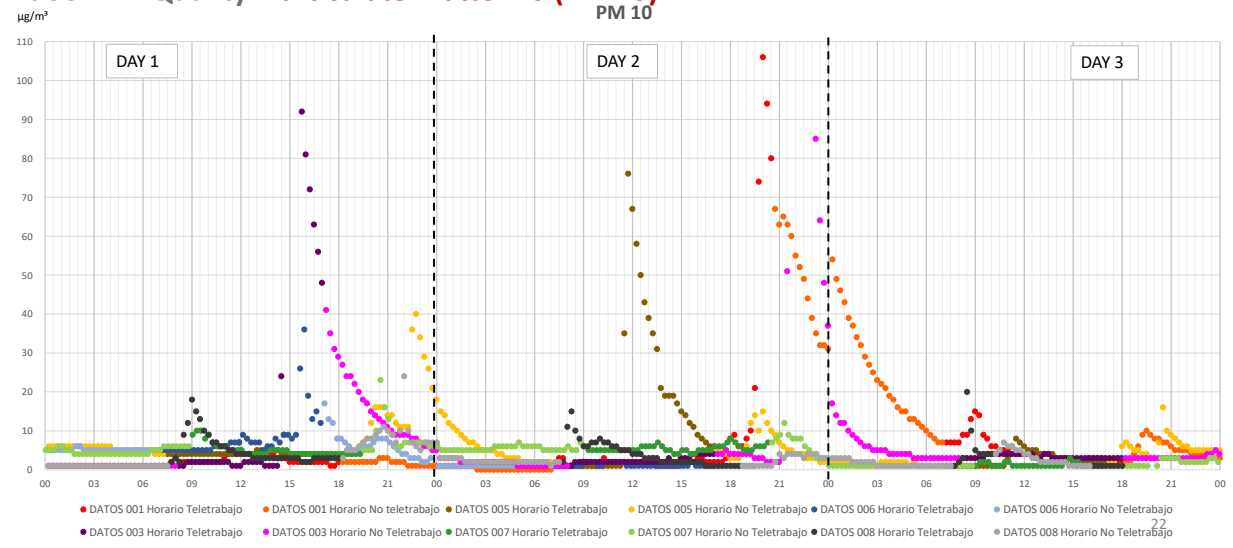
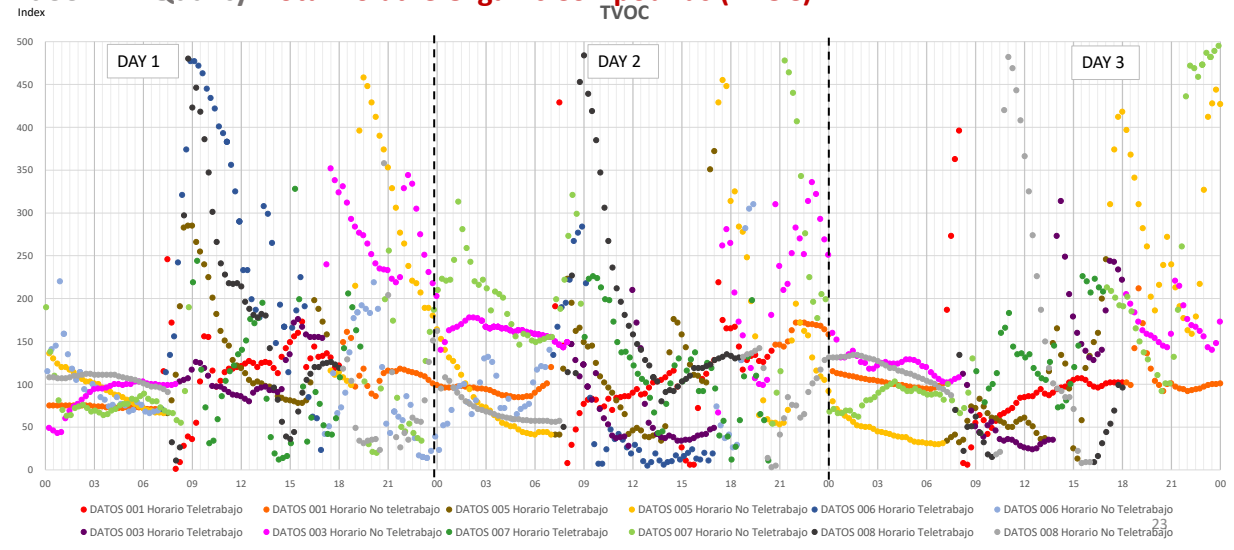
Indoor Air Quality: Particulate Matter 10 (PM 10)



Indoor Air Quality: Total Volatile Organic Compounds (TVOC)



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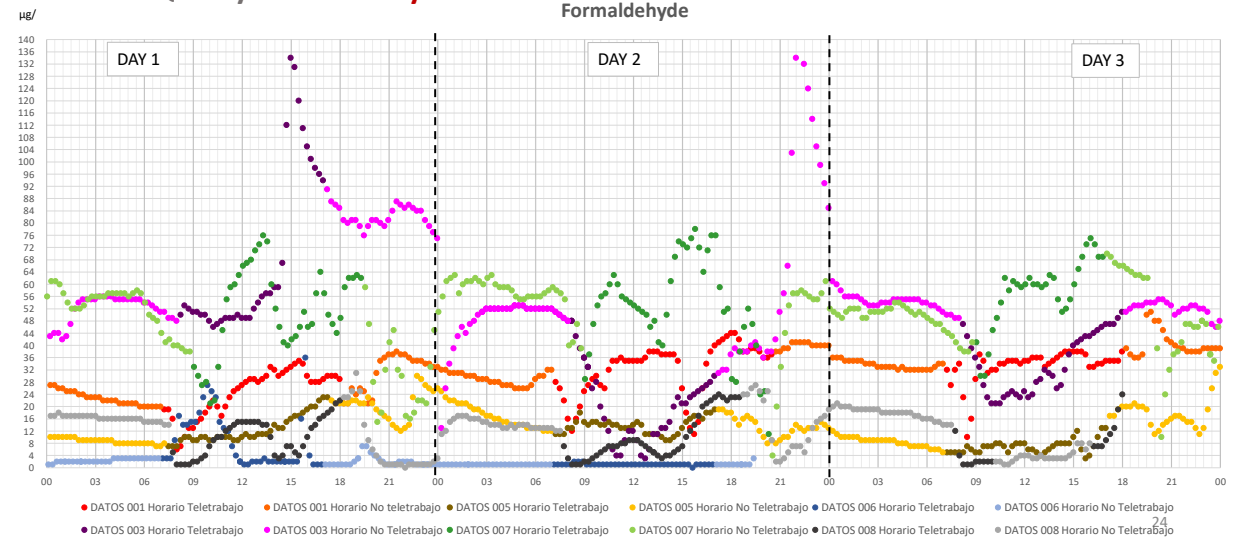
Indoor Air Quality: Formaldehyde



Initial takeaways from the results

- Diversity of spaces –and dwelling features- dificults the characterization,
- Also, heterogeneous extent of exclusiveness when using them as workspaces,
- Difference ventilation patterns (basically naturally ventilated, by window opening),
- A common time strip is found for teleworking (in the morning), but a difussed one by the afternoon/evening
- Family, personal and working times are diffused as well (additional difficulty for measuring)
- Also, different habits whilst teleworking, or even living (cleaning; cooking; hygiene, self-care and well-being)
- Since we are in-progress on the measurement campaign, let's see what else… (amazing, btw!)

THANK YOU!

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