hackAIR

COLLECTIVE AWARENESS
FOR AIR QUALITY

# D7.4: Intermediate pilot implementation and evaluation report

WP7 – Pilot operation and evaluation

## Document Information

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|---|---|---|---|
| Grant Agreement Number | 688363 | Acronym | hackAIR |
| Full Title | Collective awareness platform for outdoor air pollution | | |
| Start Date | 1st January 2016 | Duration | 36 months |
| Project URL | www.hackAIR.eu | | |
| Deliverable | D 7.4 – Intermediate pilot implementation and evaluation report | | |
| Work Package | WP 7 – Pilot operation and evaluation | | |
| Date of Delivery | Contractual | 28 February 2018 | Actual | 22 May 2018 |
| Nature | Report | Dissemination Level | Public |
| Lead Beneficiary | NILU | | |
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## Document History

| Version | Issue Date | Stage | Description | Contributor |
|---|---|---|---|---|
| 1.0 | 13.04.2018 | Draft | First version, structure | NILU, BUND |
| 2.0 | 02.05.2018 | Draft | Second version, content partly filled | NILU |
| 3.0 | 07.05.2018 | Draft | Third version, integrated input for the pilot implementation in Germany, Brussels and privacy impact assessment | BUND, VUB, NILU |
| 4.0 | 08.05.2018 | Draft | Fourth version, integrated input from VUB and CREVIS | VUB, CREVIS, NILU |
| 5.0 | 11.05.2018 | Draft | Fifth version, revised it based upon first round of internal review | DRAXIS, NILU |
| 6.0 | 21.05.2018 | Draft | Six version, revised it based second round of internal review | NILU, VUB |
| 7.0 | 22.05.2018 | Final | Final | NILU, VUB |

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# Table of Abbreviations

| Abbreviation | Description |
|---|---|
| AQ | Air Quality |
| DoA | Documentation of Action |
| GDPR | General Data Protection Regulation |
| KPIs | Key Performance Indicators |
| M | Mean |
| N | Number |
| NGO | Non-Governmental Organization |
| PIA | Privacy Impact Assessment |
| PM | Particulate matter |
| SD | Standard-deviation |

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# 1 Executive summary

This deliverable includes the report on the hackAIR intermediate pilot implementation and evaluation in Norway and Germany. In the deliverable, we also include the progress of extended pilot activities in Belgium and Greece. These are not official pilot cases and the hackAIR activities there are not evaluated, but we just monitor their progress.

The first part of the current document summarizes the activities in each pilot country. The second part describes the results of a performance assessment of the SDS011 sensors under real-world conditions. It is completed by evaluation results of Key Performance Indicators (KPIs) of the hackAIR platform by the project consortium. Further aspects that have been evaluated were participation and privacy aspects of the platform.

We conclude that 1) the pilot activities are running well as planned in both Germany and Norway; 2) the extended pilot activities in Belgium and Greece are also running well; 3) the performance assessment results indicated the hackAIR home V2 sensor is quite reliable for $PM_{2.5}$ measurement, and it has a great potential to be implemented in larger number under real world conditions in terms of data accuracy, size and cost; 4) KPIs evaluation of the hackAIR platform indicated that the hackAIR platform reached quite good levels of success towards its planned objectives according to the DoA (Documentation of Action) and the consortium is in a continually process improving it; 5) feedback from the workshop participants have been positive; 6) user evaluation survey in phase I indicated that some improvements are needed in order for the platform and its related devices to be optimum; 7) regarding the privacy impact assessment specific arrangements and mitigation measures were taken to be in line with the GDPR (General Data Protection Regulation) specifications, as well as to protect the users' privacy and the collected citizen science data.

# 2 Introduction

According to the pilot plan (D7.1, Liu et al., 2017), the pilot activities are going to be implemented through five phases:

- Phase I – Pre-test (Nov 16 – Aug 17)
- Phase II – Platform launch and test (Sep – Oct 17)
- Phase III – Full pilot (Nov 17 – Mar 18)
- Phase IV – Full pilot expansion (Apr – Oct 18)
- Phase V – Evaluation and integration (Nov – Dec 18)

In this deliverable, we included the pilot activities implemented and evaluated in phase II, III and partly in phase IV. We had to work on some unexpected technological advancements, which resulted in a postponement of the public launch of the hackAIR platform (phase II). This was nothing to worry about, as we already had pilot tested the solution with consortium internal users (until January 2018).

The official launch of the hackAIR platform in the beginning of February 2018 was the starting shot for the pilot activities in Norway and Germany, and further extended to Belgium and Greece.

During the preparation phase both NILU in Norway and BUND in Germany have been identifying potential user groups that might be interested in the different activities. While BUND was preparing a large campaign amongst members of BUND and people interested in their activities, NILU has been focusing on the population of Oslo to find volunteers to join the hackAIR activities. Further, a policy maker and a NGO (Non-Government Organization) in the city of Bergen, and an environmental engineer in the city of Stavanger are discussing with NILU to explore the possibilities to involve volunteers from Bergen and Stavanger to join the hackAIR activities as well. In addition, Skedsmo high school in Lillestrøm (a town located some 18 km east-northeast of Oslo) is preparing with NILU to involve 30 high school students in autumn to test hackAIR home v2 sensors and mobile sensors.

Whilst focus was put on the pilot activities in Norway and Germany, engagement activities have also been planned and carried out in Athens and Brussels. This document is an intermediate report about the first months of the pilot implementation and their evaluation.

# 3 Intermediate pilot implementation

## 3.1 Pilot implementation in Norway

NILU has held two workshops in Oslo to engage advanced hackAIR users to build their own hackAIR home sensor and test it in their surroundings. The participants had to sign the consent forms to join the workshop and completed an evaluation form after the workshop (see chapter 4.3). They also had to sign a form about borrowing of the sensor equipment where they agreed to return the sensors to NILU at the end of 2018.

In addition, NILU held a lunch seminar at the Agency for Urban Environment of the Municipality of Oslo for interested employees and distributed 20 hackAIR home v2 sensors to the seminar participants. Here, the volunteers borrowing a hackAIR sensor had to sign a form about borrowing the sensor equipment where they agreed to return the sensors to NILU at the end of 2018. Since NILU had to create user profiles for each of the volunteers to get an access key to complete the flashing of the sensors, the volunteers also had to sign the hackAIR terms of service.

Further, NILU held a breakfast seminar at the Oslo Science Park aimed to disseminate the hackAIR platform within the scientific research field in Oslo.

Currently, NILU are planning two more workshops and other activities outside Oslo, in the town of Lillestrøm, the cities of Bergen and Stavanger, respectively.

### 3.1.1 Workshop I "Measuring the air quality yourself - build your own air measurement sensor"

NILU held the first hackAIR workshop at the Oslo Science Park on 01.03.2018. NILU spread the workshop invitation through the following channels: NILU's homepage (www.nilu.no), information on NILU's Twitter and Facebook account, information through the Facebook account of Oslo Citizens' Observatory which is community of members from Oslo who are interested in air quality and health issues. 20 people registered to attend the workshop, of whom 16 showed up. The participants had a very diverse background, such as high school students, interested scientists, interested individuals, people from the Agency for Urban Environment at the Oslo municipality, etc.

The first 20 minutes of the workshop were used for an introductory presentation about air quality (AQ), AQ measurements and hackAIR. Since only limited time was available, NILU assembled the sensors beforehand and used the workshop to flash the software on the sensor with the participants (Figure 1). They had to complete the last part (i.e., connecting the sensor to their WIFI-network) at home. The participants got the offer to contact us in case they might experience any problems. The workshop lasted for 2 hours and the participants expressed their appreciation for the workshop through the evaluation forms (see chapter 4.3).

*Figure 1 - Pictures from workshop I*

After the workshop, the interest of participants to the hackAIR activities was high. Several participants managed to connect their sensor to their home WIFI-network and obtained sensor measurements by themselves. NILU received positive feedback from them about the sensors' functionality and suggestions about improving measurement visualization. However, a few participants had challenges to make their sensor work at home, and had many questions. Every request has been replied to by NILU. Several participants did not set up their sensor yet.

### 3.1.2 Breakfast seminar "Measuring air quality – why and how?"

NILU held a breakfast seminar at the Oslo Science Park on 25.04.2018. The 45 attendees were university students, researchers, people from public administration, policy-makers (e.g., The Bergen Green Party), entrepreneurs, etc. (Figure 2). NILU presented the hackAIR project by focusing on its platform, particularly the tools and technologies that hackAIR has developed and the results of the PM sensors performance assessment in Oslo. The seminar was perceived as very interesting, and NILU received many questions. The participants seemed very engaged, and many of them expressed their willingness to contribute to the hackAIR pilot in Norway via taking pictures of the sky through the hackAIR mobile app, and the portable or static sensors. NILU used this seminar also to advertise workshop II (see below).


*Figure 2 - Pictures from the breakfast seminar*

### 3.1.3 Lunch seminar - air quality, pollution and measurement methods

NILU was also asked to hold a lunch seminar at the Agency for Urban Environment of the Municipality of Oslo on 27.04.2018 (Figure 3). The participants were employees of the agency. NILU gave a presentation about air quality, AQ measurements, micro sensors and hackAIR. The announcement of the seminar said that it was possible to borrow a hackAIR home sensor after the seminar. 20 people asked for such a sensor. Due to time constraints (the seminar was scheduled for 30 minutes only), NILU assembled all sensors and also flashed the software in advance. The participants only had to connect the sensors with their WIFI-network at home. For this, NILU provided them with a manual and offered to take contact any time.

*Figure 3 - Lunch seminar at the Urban Environmental Agency of the Oslo municipality*

After the seminar, NILU got several questions about challenges to set up the sensor, to get measurement, etc., and provided help needed. One sensor holder decided to return the sensor due to security considerations after realizing the sensor had to be connected to the home WIFI-network.

### 3.1.4 Workshop II "Measuring the air quality yourself - build your own air measurement sensor"

The second workshop "Measuring the air quality yourself – build your own air measurement sensor" has been held on 03.05.2018 at the Oslo Science Park. 19 People registered and 16 showed up (Figure 4). The participants had a very diverse background, such as university students, environmental scientists, interested private persons, people from the municipality and Norwegian Environmental Agency, etc.

As Workshop I, this workshop aimed to engage with advanced hackAIR users to build a hackAIR home sensor and test it at home. The participants received pre-assembled sensors from NILU and after a short presentation about AQ and introduction to hackAIR, the participants were taught how to flash the software on the sensors. Most participants liked the workshop (see chapter 4.3). After the workshop, NILU provided technical support whenever needed.

*Figure 4 - Pictures from workshop II*

### 3.1.5 Sensor distribution and deployment in Oslo

Until now, NILU has distributed 56 hackAIR home sensors to volunteers in total, including workshop participants (33), NILU colleagues and family members (3), and employees from the Agency for Urban Environment of the Municipality

of Oslo (20). Currently, 17 of them have been set up and are functioning and can be visualized on the hackAIR platform (Figure 5). The sensor measurement results from these advanced users will be used for generating real time street level air quality map in Oslo.

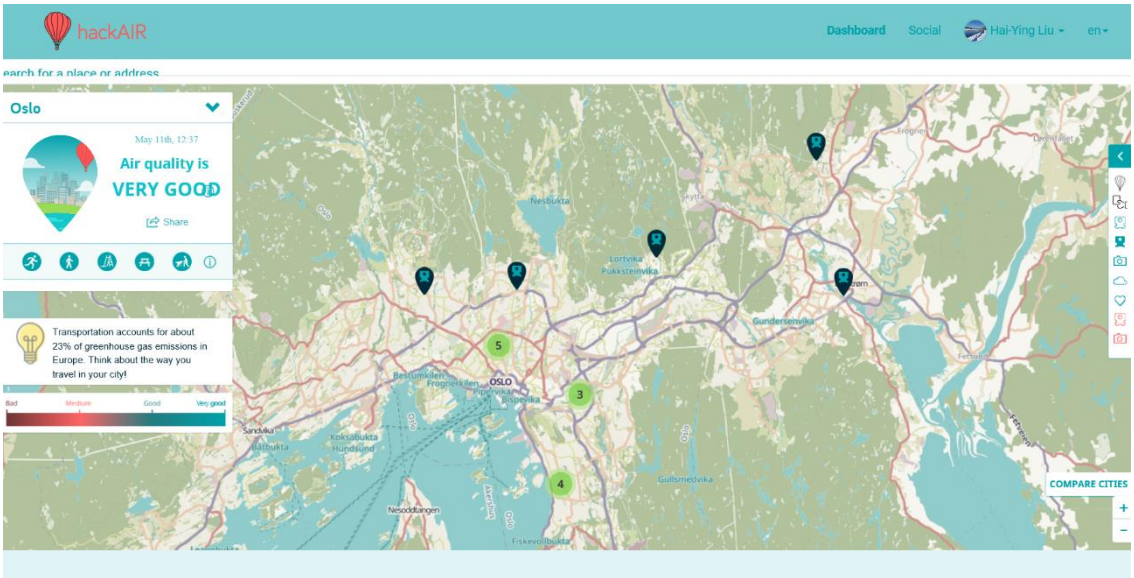



*Figure 5 - Screenshot of up-and-running hackAIR sensors in Oslo*

## 3.1.6 Other pilot related activities

NILU has been approached by a policy maker from The Bergen Green Party. He is very much interested in the topic of air quality and is planning to organize a workshop where NILU can give a presentation about AQ and distribute hackAIR sensors to interested users in Bergen. However, specific plans have not been made yet. He is one of the volunteers that built his own hackAIR home v1 sensor (static) and made his own sensor casing (Figure 6). Currently, he is in the process of building his own hackAIR mobile sensor.

*Figure 6 - hackAIR home sensor built by a volunteer*

In addition, an environmental engineer from the city of Stavanger contacted NILU for technical support to build up his own hackAIR home v2 sensor.

Currently, NILU and the NGO Friskby (Fresh city) in Bergen (http://www.friskby.no) are planning to co-organize a workshop in Bergen in midterm of June to engage with members of Friskby in Bergen to build up hackAIR home v2 sensor and test sensors in Bergen. Furthermore, NILU and Skedsmo high school in Lillestrøm are planning to co-

organize a workshop in Lillestrøm in autumn to involve 30 high school students to build up hackAIR home v2 and mobile sensors and test them in Lillestrøm.

## 3.2 Pilot implementation in Germany

Already in the preparation of the pilot phase, BUND in Germany has liaised with its regional and federal offices. By the time of the launch of the platform in Germany on the 13th of February, 2018, the organization was already aware of the project. BUND's first part of the strategy was to focus on the hardware Wemos (home v2) sensors.

On the launch day, next to BUNDs official launch press release and social media posts, BUND also sent out an activist newsletter to >4,800 addresses, covering the launch of the platform. One week later, BUND sent out its large newsletter to >180,000 addresses. In subsequent weeks, several social media posts and newsletters covered elements of the platform.

Already before the launch, BUND cooperated with the student support programme of the German business Foundation SDW and undertook a prelaunch workshop with 23 students on the 15th of January 2018 (Figure 7). This workshop was used to both present the topic of air pollution, discuss the influence of transport policies and current trends like electro mobility and to introduce the students to hackAIR and let them assemble sensor kits and connect them to the internet.

*Figure 7 - SDW student hackAIR workshop 15th of January, Berlin*

After the launch, the next phase was to cooperate with local groups in order to organize workshops that will attract more users and will help them to better understand hackAIR and the problem of air pollution. Workshops were planned in March and April and led to the following series:

- Frankfurt, 16th of May 2018
- Munich, 14th of June 2018
- Chemnitz, 19th of June 2018
- Dresden, 20th of June 2018
- An additional workshop is expected to take place in Leipzig in June

All workshops are designed to last between two and three hours and will feature both theoretical and sensor building elements.

In order to facilitate the pilots, BUND created leaflets, little flyers and stickers as well as a series of 4 printed tutorials on software installation (See Annex), sensor assembly, case building and data handling, that came with every sensor package and also are distributed on workshops and events (Figure 8).


*Figure 8 - Overview of sensor kit in online order form*

## 3.2.1 Citizen participation

In total, BUND reached out members and interested people by several of its large newsletters and was able to send out 290 sensor kit packages to users of hackAIR, the first 150 in February, the next 140 sensors in April. Via the newsletters, which had a combined audience of over 190,000, BUND spread the launch of the platform very broadly. In consequence, the organization also had a wide range of support and interest requests.

Much of BUND's work after the sensor kit distribution was handling support requests of users not being able to assemble and program the sensors. They faced a variety of issues mostly related to different hardware combinations of their computers. Many users also remarked further improvements and submitted usability requests.

From 150 sensor kits sent out already in February, BUND currently counts 40 as active on average, which is a number BUND will aim to increase in the next coming months.

## 3.2.2 Sensor distribution and deployment

In order to achieve a widespread uptake of sensor measurement activities in Germany, BUND set up a simple online shop system, where BUND members and other interested users were able to 'buy' a sensor kit (Table 1). This share, at 12,50 € for BUND members and 17,50€ for non-members. People had the option to order a sensor kit with or without a micro-USB cable and plug. This option was used to reduce the amount of necessary hardware. Often users already have a spare USB cable, which they could use for this purpose. Without this USB-option, a sensor kit costed for BUND a little under 20€ with a USB-option around 27€. The costs per sensor in the second hardware ordering are summarized here.

*Table 1 Sensor components and cost by BUND*

| Article | Costs per Sensor Kit |
|---|---|
| Nova PM sensor SDS011 | 14,13 € |
| Sensor DHT22 | 2,05 € |
| WEMOS D1 mini | 2,58 € |
| AZDelivery DHT 22 / AM2302 | 0,51 € |
| SAMSUNG MICRO-USB 2A | 7,20 € |
| Jumper Wires 1, 8 "(200mm) | 0,17 € |
| Jumper Wires 2 | 0,07 € |
| Polyamid Tube | 0,38 € |
| SUM OF SENSOR KIT COSTS | 27,09 € |

These figures match the approximated unit costs of the second batch, but due to differences in prices and varying order volumes they do not resemble the overall costs per unit and are included to give a realistic estimate of the unit costs.

With the launch of the platform in Germany on the 13th of February, non-member users were able to order a first batch of the sensor kits. BUND members were able to order them already two days before the official launch. The first order was limited in numbers as the initial hardware purchase included hardware for only 200 kits (Figure 9). The first number of 150 sensors was sold out after less than 10 days.

*Figure 9 - Distribution of sensor kits in mailing department*

Consequentially, BUND decided to order more kits in order to have a second order period and distribute additional sensors. Those kits were limited in quantity again and were sent out finally in the third week of April.

In total, in the first phase of orders 150 sensor kits were sent out and in the second phase additional 140 sensors were distributed. BUND kept around 60 sensors in stock that will be distributed in workshops and used for activities and actions in the last months of the project.

### 3.2.3 Other pilot related activities

In addition to administering the launch of the platform in Germany and distributing the sensors, BUND also received a lot of feedback from members and other users about hackAIR's relationship with the citizen science project Luftdaten.info. Consequentially, after the launch BUND intensified its communication with the project and also visited two workshops of two different OKlabs in Stuttgart in Frankfurt on the OpenDataday 2018 on the 3rd of March.

## 3.3 Extended activities in Athens

DRAXIS put effort to engage other citizen communities besides the ones in Germany and Norway to pilot test the hackAIR solution and contribute with air quality measurements. From DRAXIS' communication activities one additional case study resulted in Athens. Specifically, some schools and communities of citizens who are interested in new technologies expressed their interest to be engaged in the hackAIR project and use the platform for their own purposes. In detail:

- Kantas School contacted us in summer 2017 to learn more about the hackAIR initiative and find out how they can raise the awareness of their students about the problem of air pollution. After a meeting with DRAXIS in autumn, the director of the Kantas School expressed their interest to connect the 2 webcams that are placed in the schoolyard and depict sky (for weather forecast purposes) with the hackAIR platform. Indeed these two webcams were integrated with the hackAIR platform where we provide estimations about the air quality from the depicted sky images. Furthermore, representatives from the Kantas School have already ordered a hackAIR home v1 sensor and they plan to organize a workshop with their students to present the sensor assembly and its installation to the schoolyard. These activities are planned for autumn 2018.
- DRAXIS also presented the hackAIR solution to the Greek-German school (Ellinogermaniki Agogi) in Athens who consider to include hackAIR activities in their programme. This is still under discussion.
- TEI and DRAXIS are in constant collaboration with the Athens Wireless Metropolitan Network who have already assembled and installed a hackAIR home v1 sensor in Athens. Their sensor is contributing with data to the hackAIR platform and they examine the possibility to connect other kind of air quality sensors with our system.
- Five hackAIR home v2 sensors were donated from DRAXIS to the LoRAthens community in Athens. The sensors were assembled and installed by volunteers, and they are sending data since February 2018. Volunteers from this community have also connected five additional sensors (three home v2 and two nodeMCU) with the hackAIR system and the current measurements can be reach through the platform.
- DRAXIS and TEI had also a meeting with the Hackerspace Athens community in autumn 2017. They were also interested to connect some already installed air quality sensors with the hackAIR platform but no progress have been performed yet.

Currently, 12 sensors have been installed in the greater Athens area sending data to the hackAIR system. It is expected that this network will be widened by the end of the project.

## 3.4 Extended activities in Brussels

Apart from the two pilot cases in Norway and Germany, a test case is also being deployed in Brussels (Belgium). The focus of the Brussels case is to establish collaborations with citizens' initiatives in order to test and evaluate the hackAIR platform, raise citizens' awareness on air pollution levels and map the local air quality.

The following list presents the main activities performed until April 2018:

- Building synergies with Brussel-based air quality initiatives - meeting organised and held at CREVIS premises (29th of June 2017). The meeting aimed at bringing different stakeholders together: CleanAirBXL, CivicLab, Greenpeace, Client Earth. These initiatives have an active role in raising awareness around air quality and have current measurement activities in Brussels. Further communications have taken place in order to plan and coordinate activities for the hackAIR Brussels test case.
- Participation at the meetup of CleanAirBxl (10/07/2017). During the meet up, a brief presentation of hackAIR and a discussion about participation in measurements and hackAIR activities (workshop; photo safari; bike tour/measurements) took place. Regular updates are taking place with the members of CleanAirBxl in order to coordinate activities for air-quality measurements in Brussels.
- Meeting with VRT (Belgian public broadcasting company) and VUB (03/11/2017). VRT is the Belgian public broadcasting company and has expressed interest in getting to know more about the hackAIR activities and air-quality measurements. There was a discussion about the use of the hackAIR platform; and participation in the hackAIR test case activities through media covering (workshop at schools; technology box of VRT with a hackAIR sensor to be provided to a technological school).
- Participation at researchers' meetings on Air Quality & Citizens Science at the VUB, Brussels (08/11/2017; 25/05/2018). The focus of these activities is to get informed about other ongoing air quality initiatives in Brussels, and also to stimulate collaboration among academic researchers in Brussels around air quality. hackAIR has been presented to the participants, reaching out a wider audience throughout the networks of other projects, groups and citizens initiatives. The focus of the discussions is to identify patterns of collaboration with the hackAIR platform, invite citizens and other groups to participate in air-quality measurements in Brussels and seek for further collaboration (e.g. the organization of a conference, or hackathon in April 2019).
- Organisation of workshops at schools in Brussels. Discussions with the CleanAirBXL citizens group are ongoing for the identification of schools within the region of Brussels, for the organisation of workshops and presentation of the hackAIR project. Follow up is expected in May 2018.
- Collaboration has been established with Open Knowledge Belgium. After the presentation of the hackAIR project by the VUB, during the international open data day in Brussels: «Towards clean air with open data» (05/03/2018 - https://www.openknowledge.be/2018/03/05/open-data-day-towards-clean-air-with-open-data/) further discussions took place for the co-organisation of activities. As a result, a first common activity is the co-organization of the event "build your air quality sensor". The event is taking place in Brussels on the 13th of June 2018 and aims at supporting citizens to build 100 air quality sensors. https://www.eventbrite.co.uk/e/build-your-air-quality-sensor-tickets-45510743860.
- Meeting with beweging.net and representatives from the political party «Groen» in Brussels (26 & 27/3/2018). Beweging.net is an overarching network of different organisations in Belgium, such as «Christelijke Mutualiteit» (catholic medical service), «Femma» (representative organisations for women) «okra» (representative organisation for elderly people), etc. These two contacts approached hackAIR during the open data day in Brussels aiming in developing synergies in awareness raising for air-quality. Beweging.net will also be a partner in the «Build you air quality sensor» event taking place in June 2018 in Brussels; as such it is aimed to recruit a more diverse profile of citizens non-aware of air quality.

The above-mentioned activities in Brussels are expected to contribute to further awareness raising in the general public as well as to widen the hackAIR's sensors network. Furthermore, the recruitment of participants for the behavior change experiment is planned to take place during the event in June.

# 4 Intermediate pilot evaluation

The intermediate pilot evaluation includes the following activities: 1) a performance assessment of the SDS011 sensors under real-world conditions; 2) Internal evaluation of Key Performance Indicators (KPIs) of the hackAIR platform by the project consortium; 3) Feedback from external participants to the hackAIR workshops; 4) Evaluation survey (Phase I) – measuring user experience, acceptance and usability of the hackAIR solution; and 5) Privacy aspects of the platform.

## 4.1 A performance assessment of SDS011 sensors under real-world conditions

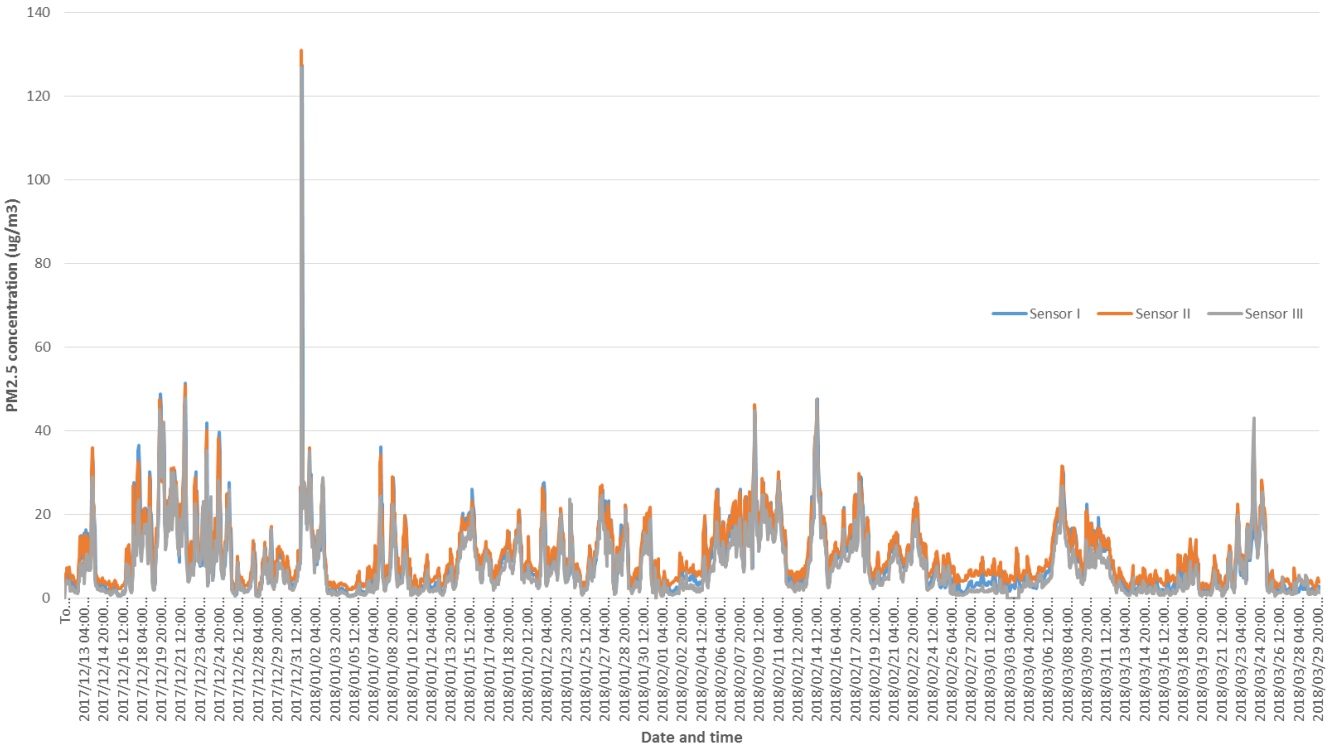
The consortium partners responsible for the pilot activities in Norway and Germany decided to choose the Nova PM sensor SDS011 to engage with volunteers. This choice had been made because this sensor was relatively easy to set up and previous usability tests had demonstrated that this sensor delivered best results from all those proposed by the technical hackAIR partners. As an internationally renowned research institute for air research, NILU tested the SDS011 sensor also on a scientific-technology base.

### 4.1.1 Methodology

Three SDS011 sensors were evaluated by co-locating them at an official air quality monitoring station equipped with reference instrumentation (Kirkeveien, Oslo, Norway). The sensors' measurement results were compared with official data generated from the air quality monitoring station over a three-month period (11-12-2017 to 31-03-2018). Five performance aspects were examined: inter-sensor variability, linearity of the response, precision of measurement, dependence on relative humidity and temperature, and calibration by using machine-learning methods.

### 4.1.2 Results

The performance results showed that (i) three sensors provided quite similar results and did not vary too much, with inter-sensor correlations exhibiting $R^2$ values higher than 0.95 for $PM_{2.5}$, and 0.65 for $PM_{10}$ (Figure 10); (ii) all three sensors demonstrated quite high linearity against official measured concentrations of $PM_{2.5}$, with $R^2$ value higher than 0.70 (Figure 11), however, for $PM_{10}$, $R^2$ is 0.37; (iii) humidity affected the sensor response, especially for PM10 measurement (Figures 12 and 13); and (iv) by data calibration, the $R^2$ value increased from 0.71 to 0.84 using only the internal sensor data without creating external dependencies (Figure 14).



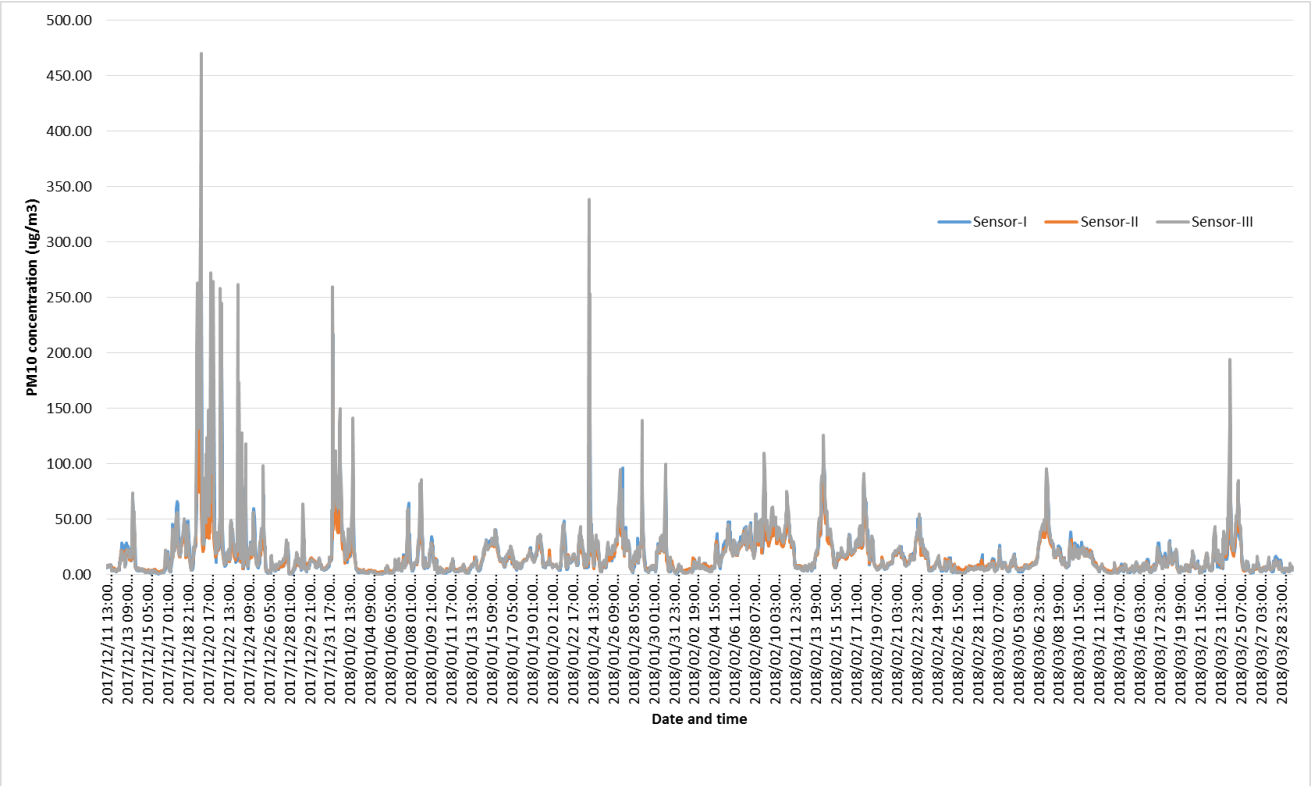
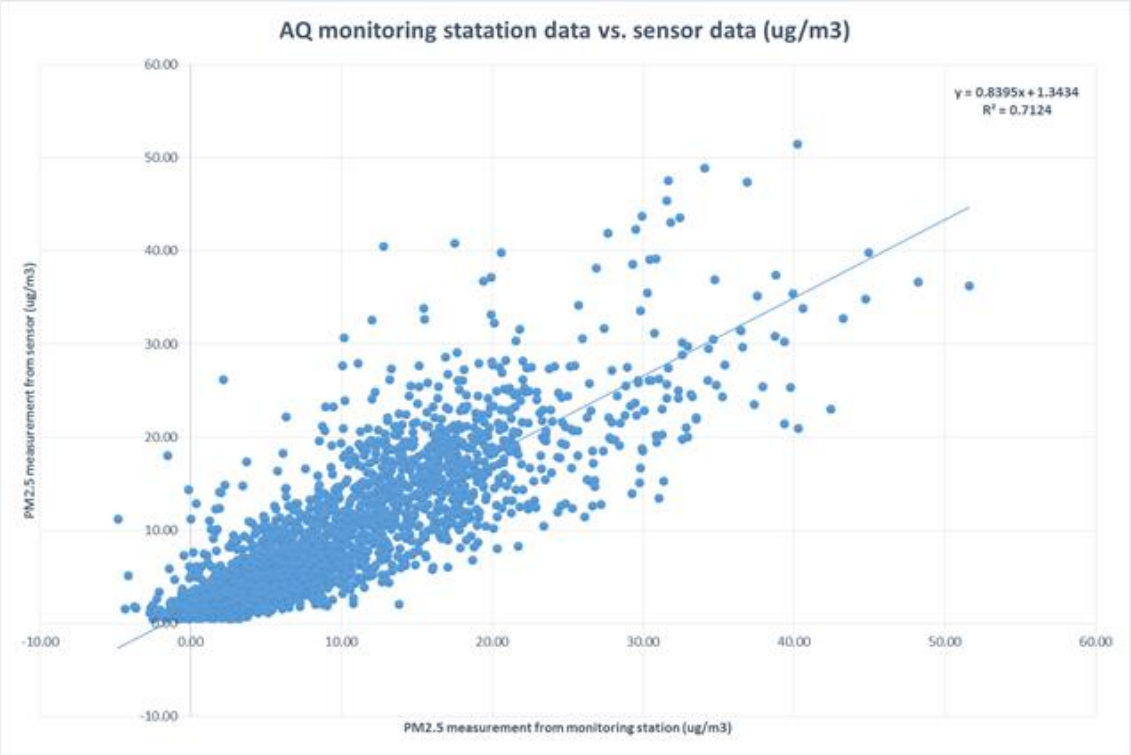




*Figure 10 - Results from inter-sensors variability over three months*



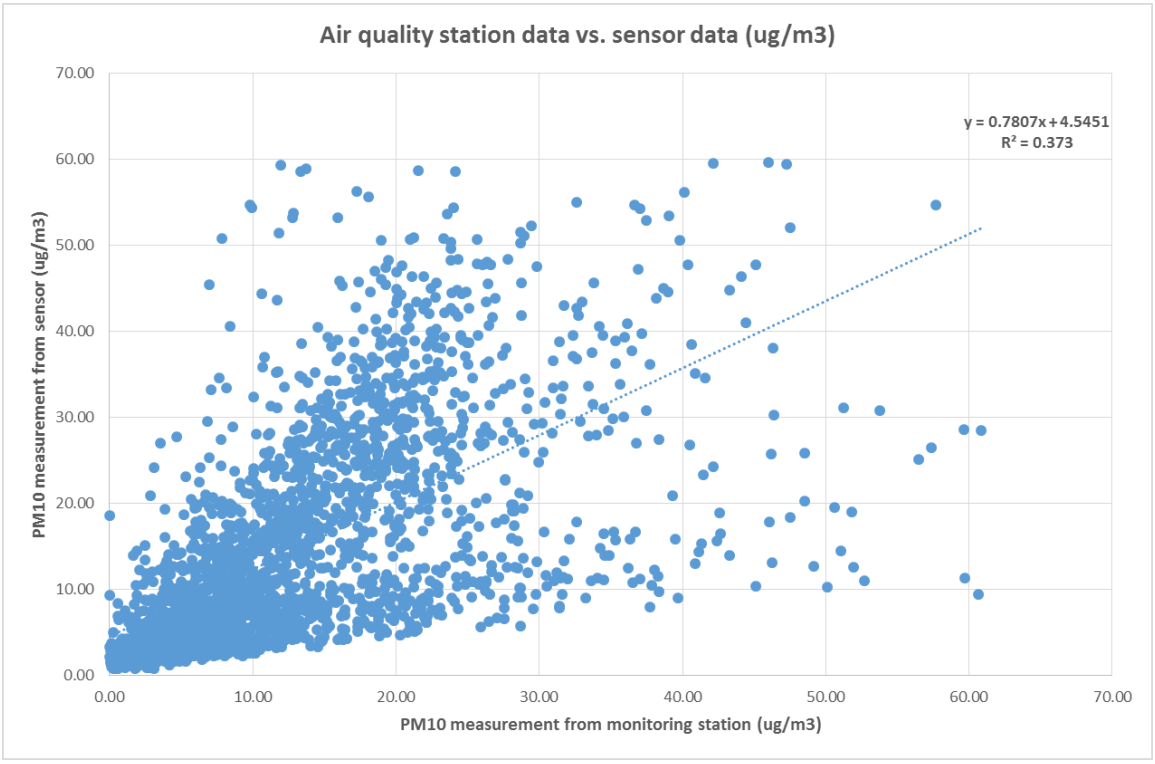




*Figure 11* - Sensor linearity of the response against air quality monitoring station

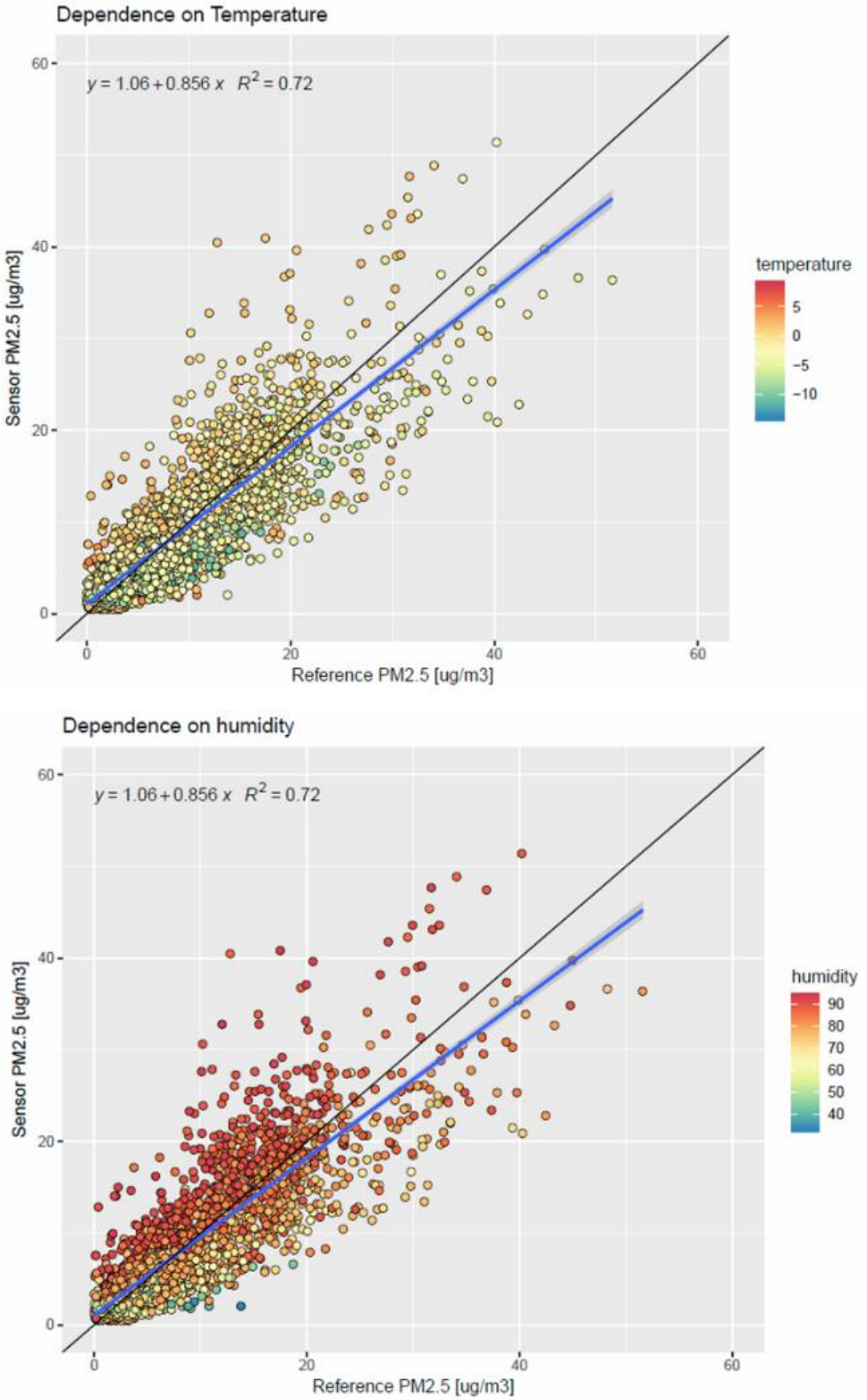
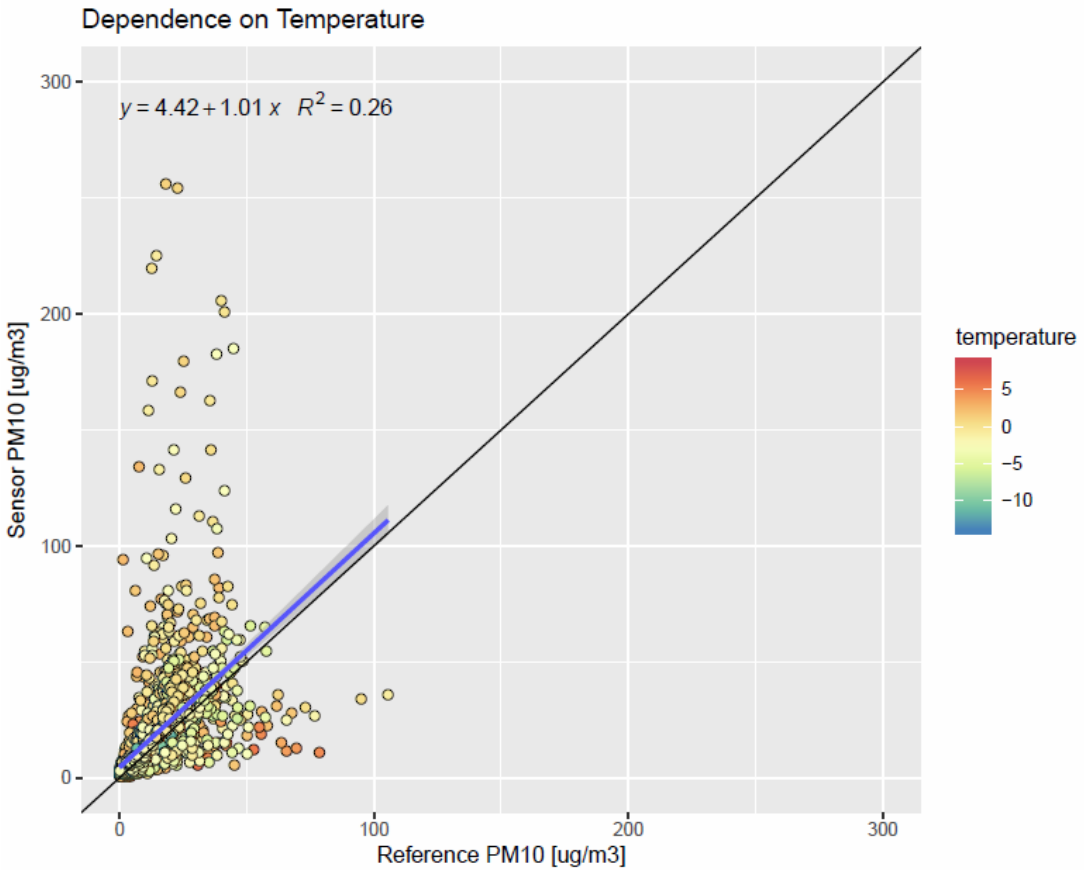



*Figure 12 - Dependence on humidity and temperature for PM2.5 measurement*



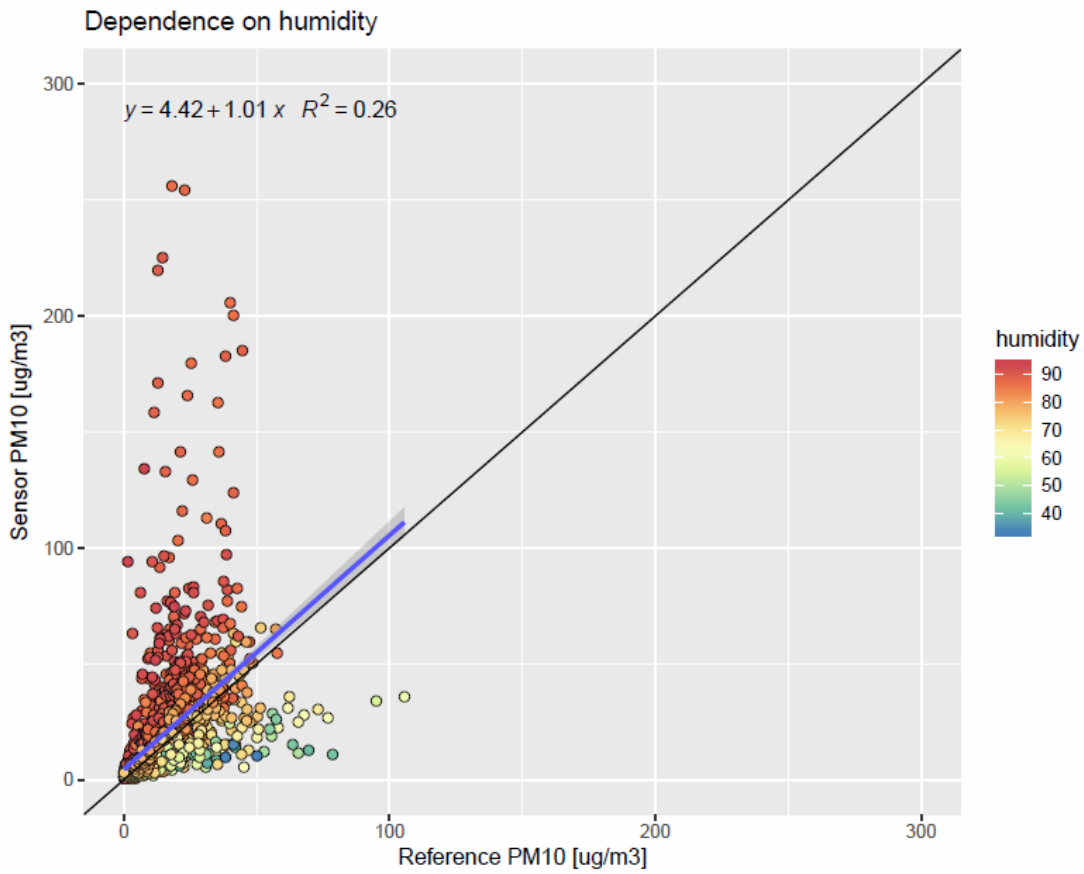




*Figure 13 - Dependence on humidity and temperature for PM10 measurement*

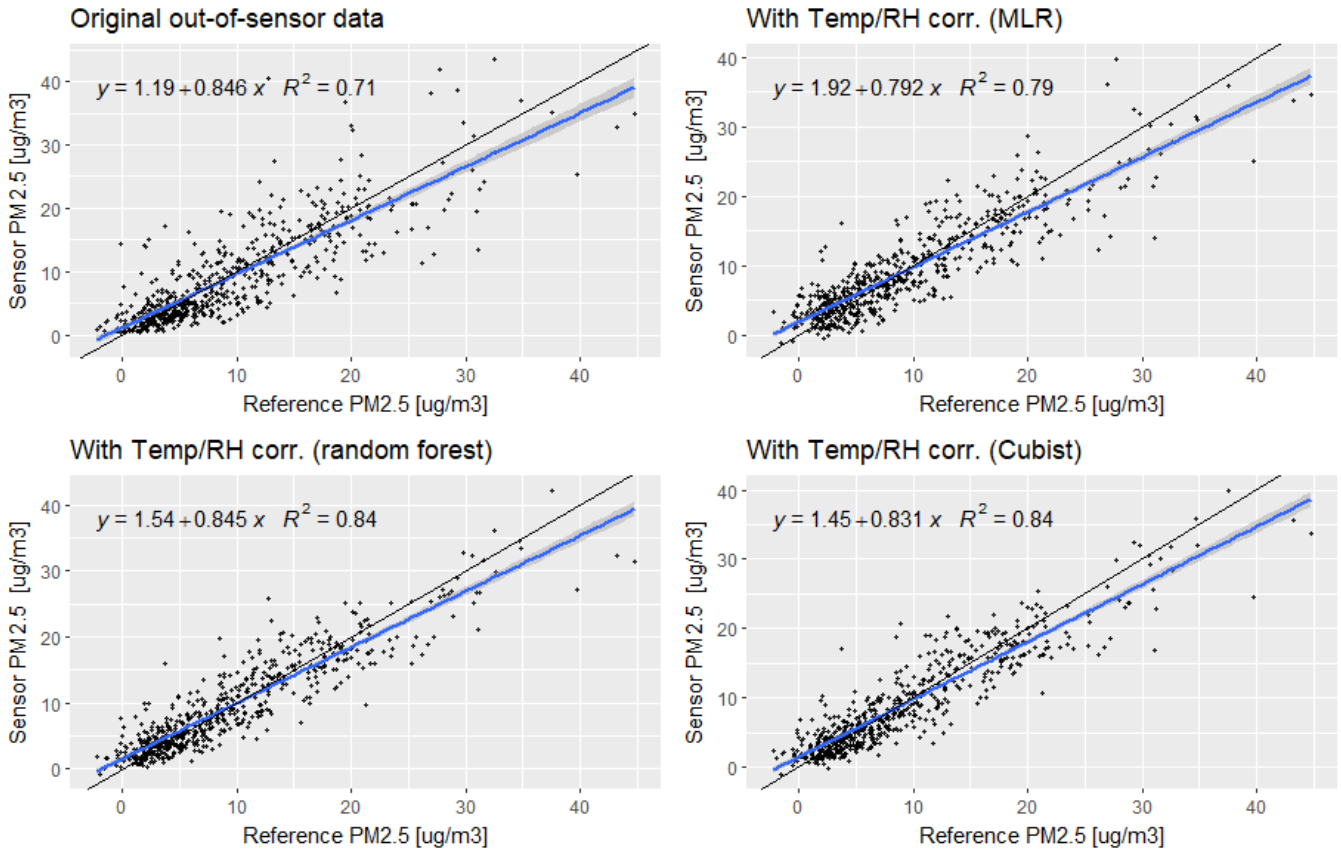



*Figure 14 - Potential accuracy improvement by talking into account the T and RH measurements recorded around sensors*

### 4.1.3 Conclusions and recommendations

The hackAIR home v2 sensors provided a consistent measurement response to measurements of the reference monitoring stations, with $R^2$ value higher than 0.70 for $PM_{2.5}$. Applying machine-learning techniques for potential accuracy improvement by taking into account the T and RH measurements recorded around sensors, the $R^2$ value increased from 0.71 to 0.84. For $PM_{2.5}$ measurement, the low cost (30 EUR) hackAIR home v2 sensors can be almost as good as the very high cost (100,000 EUR) reference monitoring stations. The performance assessment results indicate that the hackAIR home v2 sensor has a great potential for implementation in larger quantities under real world conditions for measuring particulate matter.

## 4.2 Key performance indicators for platform evaluation – consortium internal evaluation

### 4.2.1 Key performance indicators

WP7 has developed a set of KPIs (Key Performance Indicators) to evaluate the level of success for the hackAIR platform. This was an internal procedure aiming only at achieving to deliver high-quality services for the pilot activities. The KPIs were assessed only by those hackAIR consortium members that developed the tools (DRAXIS and CERTH) and those who have tested the tools in practice and used them in their pilot activities, e.g., NILU and BUND. The KPIs were not intended to be used by the external users.

The KPIs were evaluated after all the tools had been tested internally by the hackAIR consortium members and before they were used to engage citizens to contribute to the pilot in Norway and Germany. After the evaluation, the outcome

of the KPIs assessment has been used as feedback to the platform developers (DRAXIS, TEI and CERTH) to ensure necessary updates carried out so that all the tools would work in the pilot implementation as they were expected (see chapter 4.5).

In hackAIR, the following tools have been chosen to be evaluated:

1) Home v1 sensor
2) Home v2 sensor
3) Cardboard sensor
4) Mobile app
5) hackAIR platform

## 4.2.2 Evaluation methods

The KPI score includes five completion scales (Table 2), from 5 = excellent or complete success, to 1 = low or relatively poor achievement of the objectives defined. The total score for each tool is averaging up all completion scale values from each question for the tool.

*Table 2 KPIs evaluation scale for five hackAIR tools (1=low or relatively poor achievement of the objective defined; 5=excellent or complete success)*

| Level of success | Score (%) | Completion scale |
|---|---|---|
| Excellent or complete success | 90-100 | 5 |
| Very good or very effective success | 80-90 | 4 |
| Good or effective success | 70-80 | 3 |
| Fair or moderate achievement of goals defined | 60-70 | 2 |
| Low or relatively poor achievement of the objectives defined | <60 | 1 |

## 4.2.3 Evaluation results

NILU received 27 replies (it was possible to complete the questionnaire for different tool) from the consortium members, among them, 6 were platform developers and users, 21 were platform users. The group "developers and users" concluded that the consortium was very much involved in the development of both hackAIR mobile app and hackAIR platform, whereas they think the consortium was not much involved in the development of the cardboard sensor. The group believes that both cardboard sensor and mobile app were not working as expected. The group "users" was less positive towards the involvement of the consortium in the development and towards the performance of the tools (Table 3).

*Table 3 Average KPI results of the KPI questionnaire to the hackAIR consortium*

| Tool | Consortium members' involvement into development | Tool performance | Consortium members' involvement into development | Tool performance |
|---|---|---|---|---|
| | Developer and user | | User | |
| Home v2 sensor | - | - | 2 | 4 |
| Home v1 sensor | - | - | 2 | 2 |
| Cardboard sensor | 2 | 2 | 2 | 2 |
| Mobile app | 5 | 3 | 3 | 2 |
| hackAIR platform | 5 | 4 | 3 | 3 |
| Mobile sensor | - | - | 2 | 4 |

Most responses about the usability of the tools were related to the design, interface and the easiness of setting up the tools (Cardboard sensor, Home v2 sensor). Feedback regarding the most disappointing aspect of the tools were the difficulty to set-up the Arduino based sensors, the malfunctioning mobile sensor and bugs and display issues of the

data at both mobile app and platform. All of the latter issues however have been taken up at the last consortium meeting in March 2018, resulting in a priority list, which has been working on continuously until now (May 2018) to improve the user experience for the pilot participants.

## 4.3 Feedback from the hackAIR workshops

After the organization of each workshop module (i.e., co-creation workshop, build your own air quality sensor workshop) with external users, participants are invited to share their feedback with the hackAIR partners through a feedback form. This feedback form was developed by VUB and ON:SUB, and is part of the workshop toolkit and downloadable at: http://www.hackair.eu/hackair-workshop-toolkit/. The feedback form relies on the stipulated evaluation framework in D7.2, and has the objective to measure usability, user experience and acceptance of the hackAIR tools through a formalized methodology. The milestones to be reached during this period for user performance, user acceptance and user satisfaction should averagely be between **50%-70%.**

Pilot coordinators are requested to print out this feedback form, hand it out on paper to each workshop participant, and send the answers back (in an anonymous way) to VUB. The feedback form consists out of the following questions:

- General profile questions: gender, age, former experience with monitoring air quality, former experience in assembling DIY sensors
- General satisfaction about the workshop (learning new things, feeling empowered by hackAIR, the workshop was enjoyable and valuable)
- Specific questions about the hackAIR platform, hackAIR mobile application and sensors – these questions are not applicable to every workshop module, and only need to be completed if applicable to the content and activities of the workshop.
- A general satisfaction score on 10 for the platform, mobile application and sensors, and other specific aspects: Satisfaction score on 10 for the ease of use, overall look and feel, ease of learning, processing speed and usefulness of included features
- User satisfaction questions for the sensors (adding a new sensor to the profile, sending data, and checking the PM value on the map)

In total, 25 participants answered the survey: 12 male, 12 female and one other, representing nearly 80% of the workshops' attendees, hence providing us with representative results for those workshops. Until now, workshops have only been organised in Norway (workshop module 3), thus the questionnaires represent only the participants from the Norwegian workshops. It has to be noted that, because those survey were handed in paper form and respondents did not have to answer each question to finish the questionnaire, not all participants filled in the survey entirely, most likely because respondents did not know how to answer it. Those missing values are indicated in the tables underneath the column "missing". Lastly, the questions for rating the mobile application are not applicable for this workshop module since that device was not reviewed.

Most of the workshop participants ($N$ = 19) were aged between 21 and 50 years old, with 7 participants between 31-40 years old, and 6 between 21-30 years old and 41-50 years old. Only 5 of them had a former experience in monitoring air quality, and 8 had a former experience in assembling DIY sensors (and only 1 participant had both skills).

Regarding the obtained results, it is obvious that the organised workshops were really well received by the participants (See Table 4). As a matter of fact, participants reported that using hackAIR is a pleasant experience for them ($M$= 4.37, $SD$= 0.68)[1], and that the workshop they attended was really enjoyable and valuable ($M$ = 4.16, $SD$ = 0.85). Participants also felt empowered to use the hackAIR platform and the related sensors ($M$ = 3.64, $SD$ = 0.99), and state to have learnt new things ($M$ = 3.80, $SD$ = 0.91).

[1] Abbreviations : M is the abbreviate for mean; SD is the abbreviate for standard deviation

As final outcomes, participants have the intention to use the hackAIR platform frequently (*M* = 4.33, *SD* = 0.57), and also confirm that they now better understand how the air quality is in their neighbourhood (*M* = 3.94, *SD* = 1.11).

*Table 4 General satisfaction about the hackAIR workshops – Norway (5 point Likert scales, 1= strongly disagree, 5=strongly agree)*

| Questions | Valid | Missing | Mean | SD | Min | Max |
|---|---|---|---|---|---|---|
| I learned new things about air quality (measurements) | 25 | 0 | 3.80 | .91 | 2 | 5 |
| I feel empowered to use the hackAIR platform/sensor | 25 | 0 | 3.64 | .99 | 2 | 5 |
| The workshop was enjoyable and valuable for me | 25 | 0 | 4.16 | .85 | 1 | 5 |
| Overall using hackAIR is a pleasant experience | 19 | 6 | 4.37 | .68 | 3 | 5 |
| I intend to use hackAIR frequently to monitor air quality | 21 | 4 | 4.33 | .57 | 3 | 5 |
| I understand better how good/bad air quality is in my neighbourhood | 18 | 7 | 3.94 | 1.11 | 1 | 5 |

Regarding the web platform (Table 5), participants reported to be very satisfied (*M* = 8.21, *SD* = 1.42). They were pleased by the overall look and feel (*M* = 7.56 *SD* = 1.46) and the ease of use (*M* = 7.11, *SD* = 1.84). The ease of learning (*M* = 6.71, *SD* = 1.26), the processing speed (*M* = 6.82, *SD* = 1.13) as well as the usefulness of the included features (*M* = 6.81, *SD* = 1.51) were perceived as good to moderate. Further, it has to be noted that ease of use obtains a high standard deviation, meaning that the opinions of participants are quite opposing on this aspect.

Regarding the sensors (Table 5), respondents reported being quite satisfied by them (*M* = 7.60, *SD* = 1.43). Participants seemed to be satisfied about adding a new sensor to their profile (*M* = 8.31, *SD* = 1.25), while fewer participants were satisfied about sending the data from their sensors to the platform (*M* = 6.70, *SD* = 2.16), as well as to check the PM value of their own sensors on the map (*M* = 6.00, *SD* = 2.55). Seen more participants were less satisfied about several tasks with the hackAIR sensors, the overall satisfaction score for the sensors is lower than for the web platform:

*Table 5 User satisfaction regarding the web platform and the sensors (Ten-point Likert scale: 1 = extremely dissatisfied, 10 = extremely satisfied; Note: a scale change occurred from 5-10 due to a mistake in the translation from English to Norwegian)*

| Questions | Valid | Missing | Mean | SD | Min | Max |
|---|---|---|---|---|---|---|
| Overall satisfaction regarding web platform | 14 | 11 | 8,21 | 1.42 | 5 | 10 |
| Ease of use | 18 | 7 | 7,11 | 1.84 | 4 | 10 |
| Overall look and feel | 18 | 7 | 7,56 | 1.46 | 5 | 10 |
| Ease of learning | 17 | 8 | 6,71 | 1.26 | 5 | 9 |
| Processing speed/loading | 17 | 8 | 6,82 | 1.13 | 5 | 9 |
| Usefulness of included features | 16 | 9 | 6,81 | 1.51 | 5 | 10 |
| Overall satisfaction regarding sensors | 10 | 15 | 7,60 | 1.43 | 5 | 10 |
| Adding new sensor to my profile | 13 | 12 | 8,31 | 1.25 | 6 | 10 |
| Sending sensor's data to hackAIR | 10 | 15 | 6,70 | 2.16 | 3 | 10 |
| Checking the PM value of my sensor | 9 | 16 | 6,00 | 2.55 | 1 | 10 |

Overall, the workshop reports are very positive, as none of the mean scores were below the 60% threshold. It can be concluded that participants had a pleasant experience during the workshops, that allowed them to explore and acquire skills and knowledge about the hackAIR web platform and sensors, giving them tools to use them by themselves once at home. Of course, we should remain cautious with those conclusions as only 25 participants have answered the survey, and while those results are representative of those workshops, it may not be fair to generalise those conclusions to the general population.

# 4.4 Evaluation survey – Phase 1: Measuring user experience, acceptance and usability of the hackAIR solution

In the following chapter, the results are reported from the online evaluation survey focusing on usability, user experience and acceptance of the hackAIR solution (web platform, mobile application and sensors). For the detail description of evaluation framework, see D7.2 (McCrory et al., 2017). For other evaluation tools mentioned in D7.2 (e.g., interview) will be implemented in next steps (see chapter 5 – Conclusions and next step actions)

## 4.4.1 Survey design

During the period between 20/2/2018 - 7/5/2018, an online survey was developed and put online to collect user feedback in the different pilots about the usability, user experience and acceptance of the hackAIR solution. The survey was developed by VUB, and reviewed by all consortium partners who provided feedback about the wording of the questions, type of questions, length of the questionnaire, etc. The questionnaire was translated into Norwegian by NILU and into German by BUND. The estimated response time of the survey is 11 minutes, and it consists of the following type of questions:

- Block I - Introduction and profile questions: pilot country, former experience in monitoring air quality, gender, age, type of the hackAIR tools (web, mobile and sensors) used. The routing is programmed as such, that the respondent will only receive questions about the tools he/she marked to use during this first testing period.
- Block II – User experience with the web platform: user performance & user satisfaction, with open text boxes for further reasoning
- Block III - User experience with the mobile application: user performance & user satisfaction, with open text boxes for further reasoning
- Block IV - User experience with the hackAIR sensors: user performance & user satisfaction, with open text boxes for further reasoning
- Block V – Feature specific questions about the tip of the day, personalized recommendations and gamification: frequency of use and perceived usefulness
- Block VI – Gathered insights and lessons learned: satisfaction about the information received, and ability to interpret the information around air quality
- Block VII – Intention to continue to use the hackAIR solution, and interest to participate in the behaviour change study of hackAIR

Certain questions, such as general user satisfaction, are asked for each type of hackAIR tool and will also be asked during the upcoming evaluation periods (with the same survey, and in combination with other evaluation activities). This allows us to check progress over time and see if the project accomplishes to reach the following milestones. This deliverable reports on the progress of the milestones for the second period (Table 6), corresponding to the end of Phase III "Full Pilot" (see point 2. "Introduction" of this document):

*Table 6 Milestones for user performance, user acceptance and user satisfaction (For more information, please consult D7.2)*

| Milestones period I (M21-M24) Phase I & Phase II | Milestones period II (M25-M28) Phase III | Milestones period III (M29-M34) Phase IV |
|---|---|---|
| hackAIR platform can be used for friendly user testing | The hackAIR solution is up and running for each pilot and is fully functional | The hackAIR platform is operational for a large base of users |
| Internal stakeholders and friendly users discover and use the first version of the platform | All types of end-user groups are able to use the hackAIR solution for various needs | All types of end-user groups are able to use the hackAIR solution for various needs |
| User performance rates are on average around 50% | User performance rates are averagely between 50%-70% | User performance rates level up to 80% |

| | | |
|---|---|---|
| User acceptance rates are on average around 50% | User acceptance rates are averagely between 50%-70% | User acceptance rates level up to 80% |
| User satisfaction scores are around 50% | User satisfaction scores are averagely between 50%-70% | User satisfaction scores level up to 80% |

During February-May 2018, the survey was spread through project specific channels and also pilot specific activities:

6) The survey link was communicated in the newsletter of March and April 2018 by ON:SUB, and on the hackAIR social media pages
7) The survey link was added on the web platform through a button «Share your feedback»
8) The survey link was distributed through the social media pages of NILU and BUND, and also through their newsletter, or at specific workshops and seminars.
9) The survey link was distributed through the communication channels of all the project partners.

After data cleaning, responses of 56 participants has been analysed. If participants filled in less than 3 questions, these cases were deleted from the dataset. The survey was developed with the survey software Qualtrics, and the analysis was performed with SPSS.

Online link to the full survey: http://bit.ly/2EGwDjD

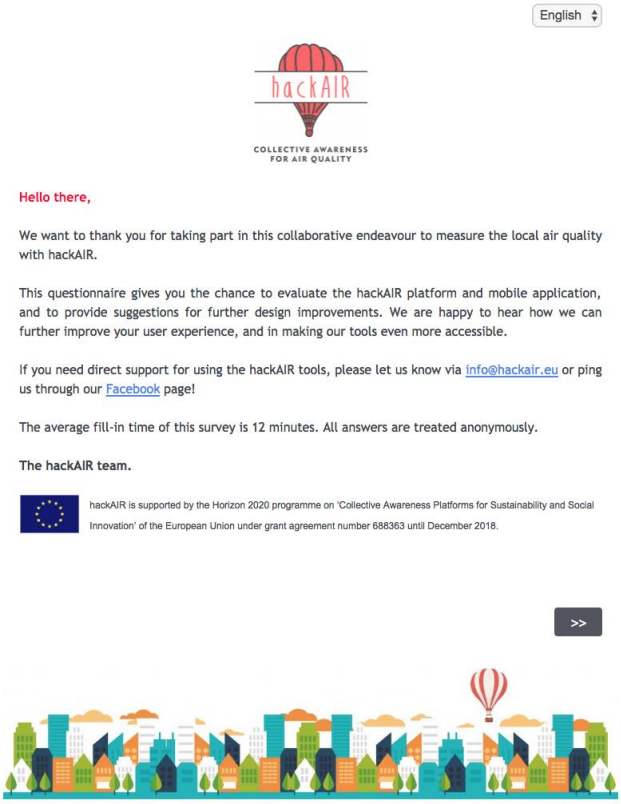



*Figure 15 - Screenshot of the landing page of the survey*

In the following paragraphs, the survey results are reported for the hackAIR web platform, mobile application and sensors. For the sake of statistical relevance and a better comprehension, the number of respondents per each question is noted as N in the tables. Hence, all given percentages are calculated in relation to the number of respondents of each question (depending the routing and amount of missing answers), and thus not always the total number of survey responses collected (*N* = 56).

## 4.4.2 Demographic profile of the hackAIR user

In total, 56 participants answered the survey. Most of the respondents come from the German pilot (51.8%, N=29), followed by the Greek test case (23.2%, N=13), and finally the Norwegian pilot (10.7%, N=6). In addition, six respondents came from Belgium and two from the Netherlands. Although a lot of effort has been made to involve users to participate to the survey, however, the participants' number in Norwegian pilot is quite low due to the difficulties to motivate those users who have expressed their interest to the hackAIR planform and tools, and/or tested hackAIR sensors.

There is a great disparity between the amount of men and women, as 75% of respondents are male. Most of the participants are aged between 31 and 40 years (33.9%), followed by 41 and 50 years (26.8%). 34% (N=19) of the total amount of respondents have former experience in air quality monitoring, those respondents are mostly from the German pilot (N=7) or the Greek test case (N=7). There seems to be an equal distribution among men and women in having former experience in AQ monitoring (35.7% female, 33.3% male).

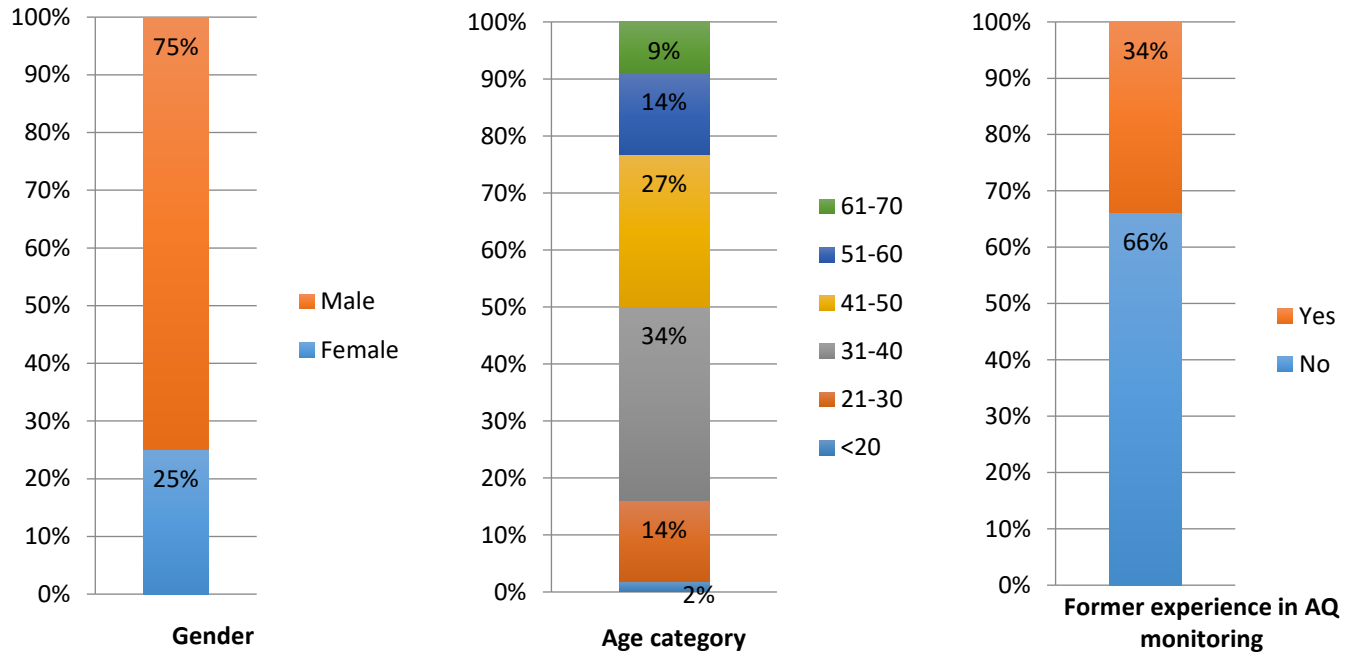
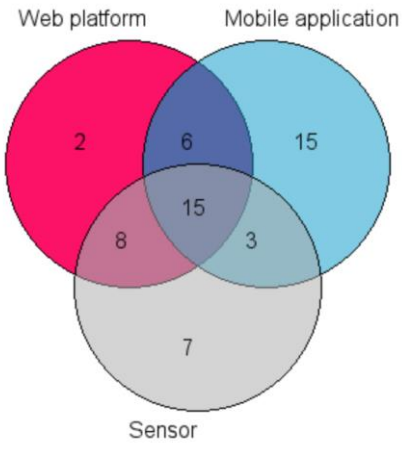



*Figure 16 - Demographic profile of respondents (N= 56)*

Looking at the distribution in usage of the hackAIR tools, the mobile application seems to be the most popular, with 69.6% (N=39) of survey respondents using it. This is followed by the hackAIR sensors (58.9%, N=33), and lastly the hackAIR web platform (55.4%, N=31). In the figure below, the distribution in combined and single usage of the hackAIR tools is visualized:




| hackAIR tool | Usage |
|---|---|
| Web & mobile & sensors | 26.8% |
| Web & mobile | 10.7% |
| Web & sensors | 14.3% |
| Mobile & sensors | 5.4% |
| Mobile (solely) | 26.8% |
| Web (solely) | 3.6% |
| Sensors (solely) | 12.5% |

*Figure 17 - Venn diagram of tools used (created with Gene List Venn Diagram[2]), and table of distribution in percentages (N=56)*

From this distribution, it is clear that most respondents have a combined usage between all hackAIR tools (web & mobile & sensors: 26.8%), followed by the usage of the mobile application solely (26.8%). Another notable result is that respondents who have a hackAIR sensor at home, mostly check the data on the web platform and not through the mobile application.

Among the sensors owners (N=33), the hackAIR home V2 Wemos sensor is the most prevailing (41.1%, N=23), followed by the hackAIR home V1 Arduino (23.2%, N=13), and finally the hackAIR mobile sensors (7.1%, N=4). Only 5.4% (N=3) of the respondents reported using the hackAIR cardboard device.

## 4.4.3 Evaluation of the hackAIR tools

### 4.4.3.1 Web platform

In the questionnaire, respondents could first indicate which hackAIR features they already explored, and which kind of activities they were able to perform successfully through the web platform. The following results are from the sample group that is using the web platform (N=31).

Users from the web platform were relatively able to perform most of the mentioned activities successfully, such as editing their user profile (67.7%), filtering data sources of air quality on the map (64.5%), and checking the air quality history of their city (54.8%). The most unsuccessful activity was the 'checking of your own contribution on the map (sensor data, photo, perception)', with 54.8% success, and 29% non-success. This issue can be attributed to the fact that at that time there was a delay between taking a picture of the sky and showing the respective result on the map, as well as a bug for uploading it which by the time of this document's delivery has already been solved. Further, there were also some issues with displaying sensor measurements on the map. These issues have been solved in the meantime.

Further, 64.5% of respondents did not yet try to compare the air quality amongst different cities, while 61.3% did also not yet try to follow a fellow hackAIR user. These rates can be explained by the fact that not all cities in Europe are yet supported by the hackAIR platform, and comparison among current available cities is limited to Berlin and Oslo. Thus, partners agreed to temporally "hide" the compare functionality from the platform as it could confuse users. Further, the social features on the hackAIR web platform are still in development and will be extended in next releases. Looking

[2] http://genevenn.sourceforge.net

to the amount of accomplished tasks per user, it is clear that only 2 respondents were able to complete all six mentioned tasks, while most respondents were able to complete between 2 to 3 of the six tasks (M=2.96, N= 31).

Overall, user performance rates are satisfactory, and are between the predefined milestones for the second evaluation period (between 50-70%) – with exception of the two tasks that are not completely implemented yet on the platform (task 5 and 6):

*Table 7 User performance of the hackAIR web platform (N=31)*

| User performance: accomplished tasks on the web platform | N | Successful | Unsuccessful | Not tried yet |
|---|---|---|---|---|
| Task 1: Editing my user profile | 31 | 67.7% | 16.1% | 16.1% |
| Task 2:Filtering data sources of air quality on the map | 31 | 64.5% | 19.4% | 16.1% |
| Task 3: Checking the air quality history of my city | 31 | 54.8% | 25.8% | 19.4% |
| Task 4: Checking my own contribution on the map | 31 | 54.8% | 29.0% | 16.1% |
| Task 5: Comparing air quality amongst cities | 31 | 32.3% | 3.2% | 64.5% |
| Task 6:Following a fellow hackAIR user | 31 | 22.6% | 16.1% | 61.3% |

For the first testing period, the overall satisfaction score for the web platform is a low 5.2/10 (*SD* = 2.06, *N* = 29). In the open text boxes, respondents suggest the following improvements:

- The map should focus by default on my chosen location, and on my sensor[3].
- The colours of the markers on the map should correspond to the air quality, and not the amount of measurements[4].
- More graphical display of own sensor measurements: from the past 24hours, last week and months per city
- The sensor measurements should have a higher update frequency; it should be close to 'real-time' data[5].
- The sensor measurements should show both PM2.5 and PM10 on the map
- The filtering on the map is not completely clear, what are hackAIR sensors and what are luftdaten sensors?[6]
- It is currently not clear how the fusion map works (users wonder if it is consistent with their solely taken measurements), and it takes a lot of time to load the map. The colours of the fusion map cannot be easy distinguished.

Satisfaction about specific aspects of the web platform are in line with the overall general satisfaction score, with mean scores between 5 and 6: ease of use (*M* = 5.51, *SD* = 2.16), overall look and feel (*M* = 5.68, *SD* = 2.22), ease of learning (*M* = 5.75, *SD* = 2.08) and processing speed/loading time (*M* = 5.34, *SD* = 2.12):

*Table 8 User satisfaction regarding the web platform (10-point Likert scale, ranging from 1 – extremely dissatisfied to 10 – extremely satisfied)*

| User satisfaction regarding the web platform | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| General satisfaction | 31 | 5.25 | 2.06 | 1 | 9 |
| Ease of use | 29 | 5.51 | 2.16 | 1 | 9 |
| Overall look and feel | 29 | 5.68 | 2.22 | 1 | 10 |
| Ease of learning | 29 | 5.75 | 2.08 | 1 | 9 |
| Processing speed/loading time | 29 | 5.34 | 2.12 | 1 | 10 |

[3] This issue has been fixed in the meantime.
[4] This feature will be developped in the following months.
[5] Sensors sending new data every minute, the platform now shows the most recent measurements.
[6] This issue has been fixed in the meantime.

### 4.4.3.2 Mobile application

In the questionnaire, respondents could also indicate which features they already explored, and how satisfied they currently are with the mobile application. The following results are from the sample group that is using the mobile application (N=37, 2 missing answers).

In terms of user performance rates, it seems that more users were able to edit their user profile details through the mobile application than the web platform (67.7% versus 56.8%). Further, the majority of the respondents could successfully take and upload a picture of the sky (67.6%), and as well as submitting their perception about the local air quality (59.5%). 37.8% of the respondents did not yet try to submit their perception about the local air quality, and, 64.5% did not yet try to compare air quality amongst cities through the mobile application. Unfortunately, none of the participants having a cardboard sensor (*N* = 3) succeeded in the first phase in taking and uploading a photo of their cardboard sensor. Looking to the amount of accomplished tasks per user, it is clear that most respondents were able to complete 2 of the 4 tasks (M=1.8; N= 37).

The user performance scores for the mobile application are in line with the scores of the web platform, and are between the predefined milestones for the second evaluation period (between 50-70%) – with exception of the activity related to the hackAIR cardboard sensor:

*Table 9 User performance of the mobile application (N=37)*

| Reported activities on the mobile application | N | Successful | Unsuccessful | Not tried yet |
|---|---|---|---|---|
| Task 1: Taking and uploading a picture of the sky | 37 | 67.6% | 18.9% | 13.5% |
| Task 2: Submitting my perception about the local air quality | 37 | 59.5% | 2.7% | 37.8% |
| Task 3: Editing my user profile details | 37 | 56.8% | 18.9% | 24.3% |
| Task 4: Comparing air quality amongst cities | 37 | 32.3% | 3.2% | 64.5% |
| Task 5: Taking and uploading a photo of your hackAIR sensors | 3 | 0% | 100% | 0% |

For the first testing period, the overall satisfaction score for the mobile application is 5.51/10 (*SD* = 2.11), which is slightly higher than the web platform (5.2/10). In the open text boxes, respondents suggest the following improvements:

- To receive feedback about the uploaded image from the hackAIR cardboard sensor[7]
- Easier access to own sensor measurement via the mobile application through the profile
- More graphical display of own sensor measurements: from the past 24hours, last week and months per city.

Satisfaction regarding specific aspects of the mobile application score higher than the web platform, and have moderate scores between 6 and 7: overall look and feel (*M* = 6.63, *SD* = 1.55), ease of learning (*M* = 6.52, *SD* = 1.48) ease of use (*M* = 6.44, *SD* = 1.55), process speed and loading time (*M* = 6.11, *SD* = 1.80):

[7] This issues has been fixed in the meantime.

*Table 10 User satisfaction regarding the mobile application (10-point Likert scale, ranging from 1 – extremely dissatisfied to 10 – extremely satisfied)*

| Specific aspects of the mobile application | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| General satisfaction | 37 | 5.51 | 2.11 | 1 | 9 |
| Overall look and feel | 36 | 6.63 | 1.55 | 3 | 10 |
| Ease of learning | 36 | 6.52 | 1.48 | 3 | 9 |
| Ease of use | 36 | 6.44 | 1.55 | 3 | 8 |
| Processing speed/loading time | 36 | 6.11 | 1.80 | 1 | 10 |

#### 4.4.3.3 hackAIR sensors

Last, respondents could also rate their experience with the hackAIR sensors. The following results are from the sample group that obtained a hackAIR sensor (N=30, 3 missing answers).

Respondents were very successfully in accomplishing activities with the sensors: adding a new sensor to their hackAIR profile (93.3%), sending their sensor's data to the hackAIR platform (80.0%) and checking the PM value of their sensors on the map (63.3%). Looking to the amount of accomplished tasks per user, it is clear that most respondents were able to complete 2 or all 3 tasks (M=2.4; N= 30).

The user performance scores for sensors are very good, and meet the predefined milestones for the second evaluation period (between 50-70%):

*Table 11 User performance scores of the sensors*

| Reported activities involving sensors | N | Successful | Unsuccessful | Not tried yet |
|---|---|---|---|---|
| Task 1: Adding a new sensor to my hackAIR profile | 30 | 93.3% | 0% | 6.7% |
| Task 2: Sending my sensor's data to hackAIR | 30 | 80.0% | 16.7% | 3.3% |
| Task 3: Checking the PM value of my sensor on the map | 30 | 63.3% | 26.7% | 10.0% |

However, in comparison to the user performance scores, the overall user satisfaction is rather moderate, with a mean score of 5.93/10 (*SD* = 2.66, *N* = 30).

In the open text boxes, respondents suggest the following improvements for the sensors:

- Easier process for assembling the sensors: no soldering, it should become more user friendly, "plug and play" especially for non-technical skilled citizens
- More information about how to interpret the results, and how it helps me in estimating the reliability of the data

Seen the disparity between the general performance scores and the user satisfaction, it can be implied that satisfaction does not end with just assembling the device, but also in interpreting the results. From the open text boxes, it seems that participants have difficulties in understanding how to interpret the data, and would like to have more graphical visualisations of their own sensor data.

### 4.4.4 Evaluation of specific features

#### 4.4.4.1 Tips of the day

hackAIR also provides «tips of the day» on the dashboard of the web platform and mobile application. An example of a tip: «If you commute to the city, think about leaving your car at park & ride spots».

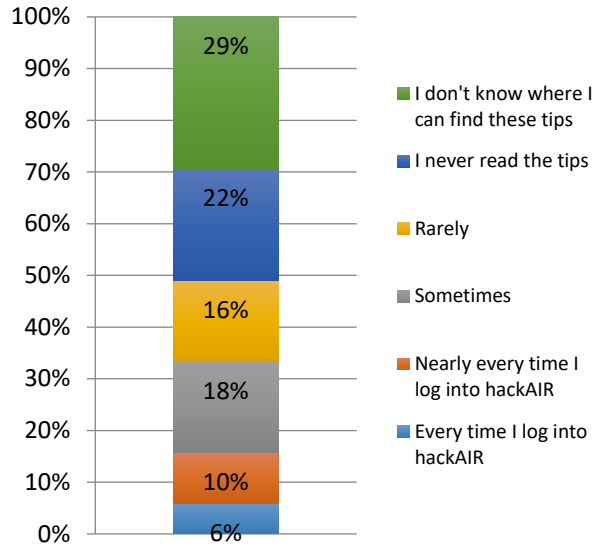



*Figure 18 - Frequency of use – Tips of the day (N=51)*

Tips are placed on the dashboard in a separate field and with a designated icon. However, it seems that the current design is *not* well noticed, as 29.9% (N=15) of the total amount of respondents (N=51) stated that they do not know where they can find these tips. Further, 21.6% (N= 11) never read the tips, while 48.5% (N= 25) read the tips. Those who read the tips don't check it at a frequent basis, but rather from sometimes to rarely. These results indicate that further improvement can be made in the design of the tips, and that further research should explore what the motivations are for not reading the tips.

The 25 respondents (1 missing) who read the tips also answered the questions about the perceived usefulness:

*Table 12 Perceived usefulness of «tips of the day» (Five-point Likert scale, 1= strongly disagree, 5= strongly agree)*

| Perceived usefulness of tips of the day | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| I think the "tips of the day" are very informative | 24 | 3.29 | .999 | 1 | 4 |
| The "tips of the day" give me sufficient information to take individual steps to contribute to a better air quality | 24 | 3.17 | 1.007 | 1 | 4 |
| I find it enjoyable to read the "tips of the day" | 24 | 3.21 | .932 | 1 | 4 |

Overall, it seems that the perceived usefulness of the "tips of the day" is rather neutral to moderate. Respondents mostly think that the tips of the day are informative. The overall calculated mean is 3,22 for the perceived usefulness of the tips of the day, which means that still further improvement can be made for obtaining higher scores.

### 4.4.4.2 Personalised recommendations

hackAIR also provides personalised recommendations based on provided profile information about particular health sensitivities or outdoor activities. An example of a recommendation that you receive when performing outdoor activities such as running is: «Air quality is good. Enjoy your usual outdoor activities!». The provided recommendations are based on the provided profile information around outdoor activities (walking, eating outside, outdoor job, running) and health sensitivities (cardiovascular diseases, respiratory diseases, pregnancy). When the user enters this type of information in the profile, it will show the relevant recommendations on the dashboard of hackAIR through particular icons (Figure 19). Receiving personalised recommendations is an integrated feature on both the hackAIR web platform, as well as the mobile application.


*Figure 19 - Personalised recommendations*

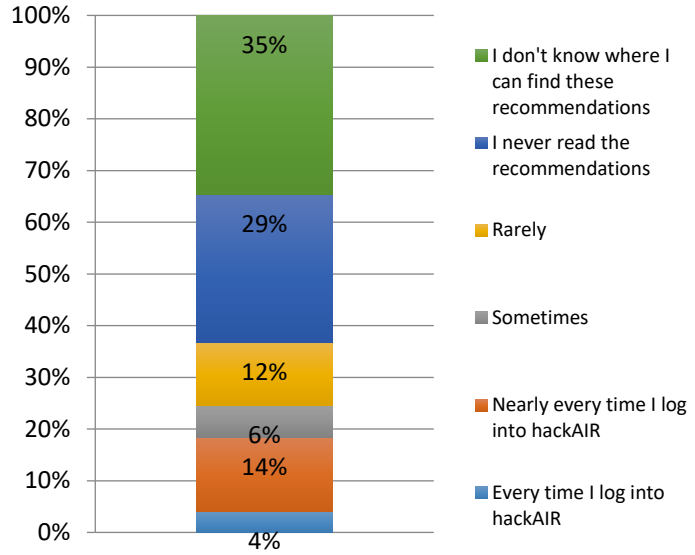



*Figure 20 - Frequency of usage – recommendations (N=49)*

It seems that for now, the personalised recommendations are *not* enough visible on the hackAIR platform and mobile application, since 34.7% (N= 17) of the total amount of respondents (N=49) did not know where to find these. Further, 36.7% (N= 18) of respondents read the personalised recommendations, while 28.6% (N=14) never reads them. The frequency of reading personalised recommendations is quite diverse; some respondents read it rarely, while others read it nearly every time they log in. These results show that further improvement can be made in the design of the personalised recommendations, while further research should explore what the reasons are for not reading and checking the recommendations.

The 18 respondents (1 missing) who read the personalised recommendations gave their opinion about the perceived usefulness of it:

*Table 13 Perceived usefulness of personalized recommendations (Five-point Likert scale, 1= strongly disagree, 5= strongly agree)*

| Perceived usefulness of personalized recommendations | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| The available user profile details allow me to describe my needs for the personalized recommendations I wish to receive | 17 | 3.41 | .795 | 2 | 4 |
| The provided recommendations make it easier for me to learn about the quality of the air | 17 | 3.35 | .702 | 2 | 5 |
| I think the provided recommendations based upon my personal health sensitivities and outdoor activities are informative | 17 | 3.41 | .795 | 2 | 5 |
| The provided recommendations give me timely information on how to protect myself against hazardous effects of air pollution | 17 | 3.24 | .831 | 2 | 5 |
| I think the provided recommendations of hackAIR efficiently reflect my specified profile details (age, location, health sensitivities, preferred outdoor activities) | 17 | 3.47 | .624 | 2 | 4 |

Overall, the perceived usefulness of the personalised recommendations is well received by the respondents. Respondents mostly think that the personalised recommendations are efficiently reflecting their profile details, are informative and are describing their information needs. All mean scores for the statements are above 3, and the calculated overall mean is 3,37. However, this also means that further improvements can still be made.

In the open text boxes, two relevant suggestions were provided to improve this specific feature:

*"The recommendations seem very general, and are most of the time the same"*

*"There is no explanation provided about how the air quality index is calculated. Therefore, I cannot trust the recommendations based on it."*

#### 4.4.4.3 Game elements

The current version of the platform also has some gamification features implemented. These gamification elements allow you to collect points and gain badges depending on the type of activities that you perform with hackAIR. Since the whole gamification process is not implemented yet on the platform, some functionalities are also currently disabled. Nevertheless, hackAIR users could share their satisfaction about it:

*Table 14 User satisfaction score with the game elements of hackAIR (Ten-point Likert scale, 1= extremely dissatisfied, 10= extremely satisfied)*

| User satisfaction – gamification | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| Overall satisfaction with the game elements of hackAIR | 46 | 4.5 | 2.69 | 1 | 10 |

From the open text boxes, it seems that respondents give the suggestion that when implementing the gamification elements it should be clearly explained on how it works (e.g. when do you gain points, what do you need to do for unlocking badges, etc.).

Further, for the statements about perceived enjoyment, or the feeling that using the game elements in hackAIR is enjoyable and motivating, it is clear that gamification is currently not a trigger or main motivation for using hackAIR more frequently (as probably more intrinsic motivations reveal).

On the other hand, participants do feel eager to contribute with more measurements in order to gain more points and badges. The answer to the latter statement indicates that users are interested in game elements related to air quality, but that currently it is not clear enough on how to do it:

*Table 15 Perceived enjoyment of using hackAIR with game elements (N46) (All scores were measured on a 5-point scale, ranging from 1 – strongly disagree to 5 – strongly agree)*

| Perceived enjoyment | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| The game elements motivate me to use hackAIR more frequently | 46 | 2.5 | 1.28 | 1 | 5 |
| I am eager to contribute with measurements in order to gain more points and badges | 46 | 3.43 | 1.15 | 1 | 5 |

### 4.4.5 Gathered insights with hackAIR

Regarding the satisfaction about the provided info around air quality on the hackAIR platform, respondents seemed to be quite pleased. Respondents are mostly able to interpret the PM value ($M$ = 3.51, $SD$ = 1.16, $N$ = 45), and they also say that the provided index is informative ($M$ = 3.47, $SD$ = 1.10, $N$ = 45). Further, respondents also say that thanks to hackAIR they now better understand the air quality in their neighbourhood ($M$ = 3.36, $SD$ = 1.02, $N$ = 45).

The self-perceived knowledge to interpret air quality data correctly is mixed, with 48.9% ($N$ = 45) of respondents clearly disagreeing ("strongly disagree" or "disagree") with the statement, opposed to more than 30.0% ($N$ = 45) agreeing ("agree" or "strongly agree") with this statement. When looking to the former experience of participants, it is clear that mostly those who have not former experience in monitoring air quality, perceive to lack current knowledge to interpret the data correctly with hackAIR. There is thus a clear discrepancy in the literacy profiles among the hackAIR users, with a segment having former experience and being more critical towards the provided air quality index; versus a segment that does not have former experience and is lacking knowledge to interpret the data correctly. However, both profiles do mostly state that they do understand the local air quality better in their neighbourhood thanks to hackAIR.

*Table 16 Satisfaction about the provided information (All scores were measured on a 5-point scale, ranging from 1 – strongly disagree to 5 – strongly agree)*

| Satisfaction about the provided information | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| I am able to interpret the PM value to understand the air quality | 45 | 3.51 | 1.16 | 1 | 5 |
| The provided air quality index on hackAIR is informative | 45 | 3.47 | 1.10 | 1 | 5 |
| Through hackAIR, I understand better how good or bad the air quality is in my neighbourhood | 45 | 3.36 | 1.02 | 1 | 5 |
| In general, I lack knowledge to interpret air quality data correctly | 45 | 2.73 | 1.19 | 1 | 5 |

Last, in the open text boxes, participants gave some suggestions for gathering data insights:

- A more feature-rich API for accessing data from a specific sensor, or by geo-location (e.g. only get the latest readings, get readings for specific time periods, filtering on high PM values, etc.)[8]
- The sensors are also measuring temperature and humidity, however, it is not clear for the participant how these data are being currently used[9]
- It is currently not clear to respondents how many sensors should be installed in order to get reliable measurement for a certain location (e.g. it is monitoring only a specific spot, or monitoring a neighbourhood, or city)
- It is not completely clear to respondents how many pictures of the sky should be taken from a certain location in order to have a reliable result
- Some respondents request better visualisation options for the sensor measurements
- One respondent suggests to improve the air quality index by using a different colour scale, and by indicating critical threshold on the scale

## 4.4.6 Conclusions: Acceptance of the hackAIR solution

### 4.4.6.1 Attitude and intention to continue to use hackAIR

The general experience of participants with hackAIR seems to be very positive, respondents report that they would continue using hackAIR to check information about air quality (*M* = 4.00, *SD* = .77) and intend to use hackAIR frequently to monitor the air quality (*M* = 3.86, *SD* = 1.00). Respondents also expressed having fun using the hackAIR tools (*M* = 3.80, *SD* = 1.00) and, overall, having a pleasant experience using hackAIR (*M* = 3.64, *SD* = .96, *N* = 44):

*Table 17 Attitude and intention to continue to use hackAIR (All scores were measured on a 5-point Likert scale, ranging from 1 – strongly disagree to 5 – strongly agree)*

| Attitude and intention to continue to use hackAIR | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| I will continue using hackAIR to check information about air quality (intention statement I) | 44 | 4.00 | .77 | 2 | 5 |
| I intend to use hackAIR frequently to monitor air quality (intention statement II) | 44 | 3.86 | 1.00 | 1 | 5 |
| I have fun using the hackAIR tools (attitude statement I) | 44 | 3.80 | 1.00 | 1 | 5 |
| Overall, using hackAIR is a pleasant experience (attitude statement II) | 44 | 3.64 | .96 | 1 | 5 |

These results are very positive, and show that respondents have interest in continue to use the hackAIR platform, although general satisfaction scores, and satisfaction for particular features were rather moderate.

[8] This feature has been developed in the meantime.
[9] An explanation has been added to the website.

## Framework of indicators and hypotheses

In relation to the stipulated framework of indicators and hypotheses in D7.2, some insights can be reported.

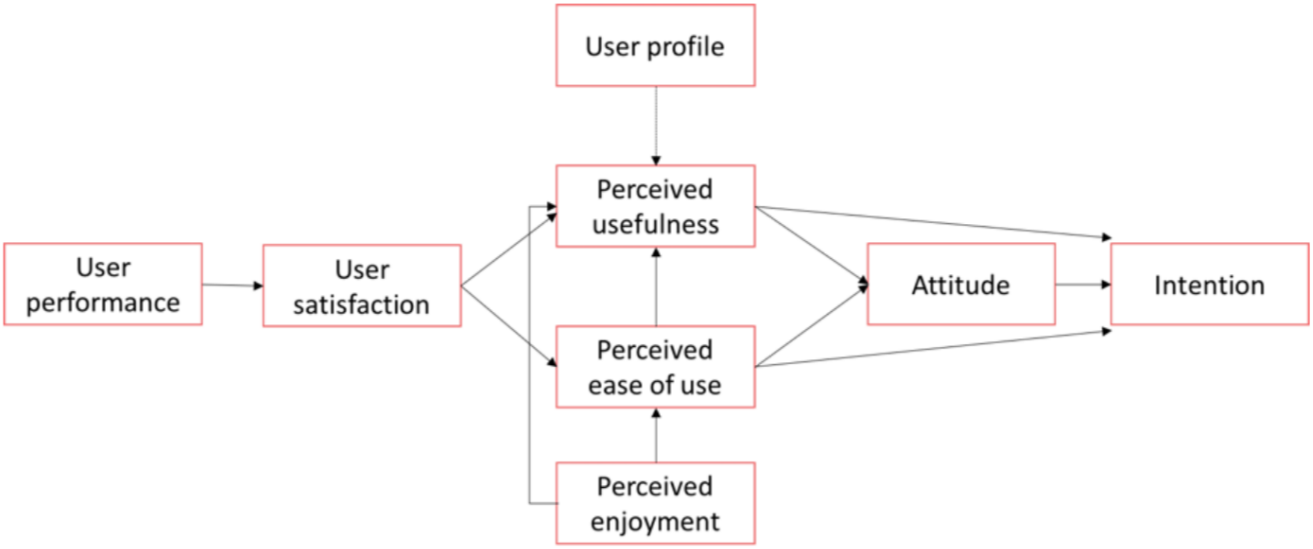



*Figure 21 - Evaluation framework with indicators measuring usability, UX and acceptance (D7.2)*

The table below shows the correlation coefficients between particular indicators of the evaluation framework. A correlation represents the linear relationship between two variables and means that a higher/lower score on one variable can also result in a higher/lower result of the other variable. The current significant correlations coefficients are reported in the table below, and are rather weak to moderate. To give an example: a higher score in user performance relates to a higher score for the general satisfaction about the web platform, the more users are able to complete tasks, the more satisfied they are.

*Table 18 Correlation coefficient with indicators of the evaluation framework*

| Correlation (Pearson or Spearman) – linear relationship between two variables | *N* | *r* | *P*-value | Explanation |
|---|---|---|---|---|
| WEB PLATFORM | | | | |
| User performance – User satisfaction web | 31 | .515 | .003 | Weak to moderate correlation |
| User satisfaction web – Satisfaction ease of use | 29 | .636 | .000 | Moderate correlation |
| MOBILE APPLICATION | | | | |
| User performance – User satisfaction mobile | 37 | .483 | .002 | Weak correlation |
| User satisfaction – Satisfaction ease of use | 36 | .579 | .000 | Weak to moderate correlation |
| MOBILE SENSOR | | | | |
| User performance – User satisfaction sensors | 30 | .512 | .004 | Weak to moderate correlation |
| | | | | |

No significant linear relationships could be found between the perceived usefulness of “tips of the day” and “personalised recommendations” and the user satisfaction with web platform, nor mobile application. Linear relationships with gamification were not explored this time, since the features are not completely implemented on the platform and could therefore result in unreliable results. No significant results could also be found between perceived ease of use of the web platform and mobile application with the computed new variable of intention to use (see below). Further, no significant regression analyses could be identified.

In terms of construct validity, two new variables could be computed. First, a new variable was computed for "intention to continue to use hackAIR" through two items. The cronbach's alpha[10] (Santos, 1999) for "I intend to use hackAIR frequently to monitor air quality" (intention statement I) and "I will continue using hackAIR to check information about air quality (intention statement II) was high enough ($\alpha$ = .819) to compute a new variable. The mean score for the new computed variable is reported in the table below.

Second, a new variable was computed for "Perceived usefulness of provided air quality information" through two items. The cronbach's alpha for 'The provided air quality index on hackAIR is informative" and "Through hackAIR, I understand better how good or bad the air quality is in my neighbourhood" was high enough ($\alpha$ =.729) to compute a new variable. The mean score for the new computed variable is reported in the table:

*Table 19 Mean scores of computed variables (All scores were measured on a 5-point Likert scale, ranging from 1 – strongly disagree to 5 – strongly agree)*

| New construct's descriptives | *N* | *Mean* | *SD* |
|---|---|---|---|
| Intention to continue to use hackAIR | 44 | 3.93 | .82 |
| Perceived usefulness of provided air quality information | 45 | 4.41 | .94 |

### 4.4.6.2 Overview of metrics

The table below provides an overview of the main user satisfaction and performance scores with the hackAIR tools:

*Table 20 Main results of the Phase 1 survey*

| Main results | *N* | *Scores*[11] | *SD* |
|---|---|---|---|
| Web platform | | | |
| General user satisfaction | 31 | 52.5% | 2.06 |
| Ease of use | 29 | 56.3% | 2.03 |
| User performance | 31 | 60.5% | - |
| Mobile application | | | |
| General user satisfaction | 37 | 55.1% | 2.11 |
| Ease of use | 36 | 64.8% | 1.46 |
| User performance | 37 | 54.0%[12]* | - |
| Sensors | | | |
| General user satisfaction | 30 | 59.3% | 2.66 |
| User performance | 30 | 78.9% | - |

As can be deducted from the table above, the sensors receive the highest scores among the participants with a satisfaction reaching nearly 60% (*M* = 59.3%, *SD* = 2.66, *N* = 30). Moreover, the user performance score are also very good, and reach up to almost 80% (*M* = 78.9%, *N* = 30).

[10] The Cronbach's alpha is an index of reliability regarding the scale being used (Santos, 1999). It translates the fact that the used scale elicit consistent and reliable responses through subjects and time.

[11] Scores were translates from a 10-point scale to a percentage when needed.

For the user performance's score, the mean score was only calculated with activities that more than 50% of the participants had tried.

[12] The task "taking and uploading a photo of your hackAIR cardboard sensor" was not included in this mean score since only three participants answered this item.

The satisfaction scores for the mobile application are rather indifferent, scoring 55.1% for general user satisfaction (*SD* = 2.11, *N* = 37), and 54.05% (*N* = 37) for the user performance. However, the ease of use for the mobile application exceeds 60% (*M* = 64.8%, *SD* = 1.46, *N* = 36), indicating a fairly good opinion.

The web platform obtains the lowest scores, with a general user satisfaction of 52.5% (*SD* = 2.06, *N* = 31) and an ease of use of 56.3% (*SD* = 2.03, *N* = 29). The user performance regarding the web platform is unfortunately below the threshold of 50% (*M* = 49.5%). However, when we leave out the task around "Following a hackAIR friend" or "Comparing the air quality amongst cities", then the average user performance rate is 60.45%. These latter two activities were not yet fully noticed by the participants, and were not yet tried by a majority of them and can therefore be left out of the total calculation. As such, the user performance reaches the threshold of 50%, and it will be further followed up if during the second evaluation period participants start to use these two features more frequently.

However, many reported issues are or were already solved at the moment. Therefore, it is expected that the user performance and satisfaction will be higher during the second period. Even though the scores are rather moderate in this first phase, it also means that there is still a lot of room for further improvement. Based on user feedback and on lessons learned during the workshops, main issues are identified, prioritised and are being improvement right now. For more information, please consult the conclusion chapter in this deliverable.

## 4.5 Improvement process of the platform

DRAXIS has set a participatory issue tracking and prioritization procedure that involves all the project partners ensuring that the platform is constantly improved and the user experience is as good as possible. After either receiving feedback from pilot users or identifying any issue on their own, project partners submit issues to an online tool (Jira) to communicate them with the development team. Partners can choose to report a bug (an issue they are facing with the application), a new feature (something that had not been included in the specifications) or an improvement suggestion. Every two weeks, DRAXIS exports issue reports from the online tool, prepares a draft plan of the issues that will be resolved within the following two weeks (a new sprint is released every two weeks), and invites all the project partners in a conference call to discuss upon the prioritization of the issues according to their importance and the received feedback from the pilot users. All partners agree on the prioritization, and for the following two weeks DRAXIS implements the discussed improvements. After these two weeks a new version of the web and mobile platform is released, all partners check that the planned improvements have been integrated, and any necessary correction action is applied by DRAXIS.

A detailed description of the hackAIR platform improvement process will be included in deliverable D7.6-Report on hackAIR updated support services and methodologies (M36).

## 4.6 Privacy impact assessment: results

In this chapter, the results of the privacy impact assessment (PIA) are described that were collected during year 2 and 3 of the project. The PIA guaranteed an on-going reflection with internal and external stakeholders on how to set up a secure and safe environment for collecting (personal) data with the hackAIR platform and tools. The PIA methodology consisted out of four consecutive phases and evaluation activities, of which the first results were reported in D2.3 (Coppens et al., 2016):

1) Identification of the need of a PIA (reported in D2.3)
2) Description of the information flow (reported in D2.3)
3) Identification of the privacy and security related risks with consultation rounds with internal stakeholders in the project, development of a risk log, and monitoring of the hackAIR platform and tools
4) Sign off and record the PIA outcomes

This part of the deliverable reports the outcomes of the third and the fourth phase in the privacy impact assessment, through the following organised consultation in year 2 and 3:

- On November 25th 2016 during the hackAIR consortium meeting in Brussels, a PIA workshop was organized with all project partners. The goal of this workshop was to discuss the hackAIR data flows through the usage of scenarios, and generate insights in key data management and security topics. Further, a PowerPoint presentation with remaining open questions was sent to the consortium partners (DRAXIS, CERTH, NILU, BUND), and they were asked to individually send their feedback to VUB.
- Secondly, the VUB conducted a final PIA assessment during the closed testing phase of hackAIR in November 2017.
- Last, a review by two privacy experts by VUB was conducted once the hackAIR solution was launched in February – March 2018. These two latter assessments were performed through checking the implementation status of the former stated privacy and security requirements from D2.3.

Based on these gathered outcomes, specific arrangements and mitigation measures were taken by the consortium to be in line with the GDPR (General Data Protection Regulation) specifications, and to protect the users' privacy and the collected citizen science data.

## 4.6.1 Examining user scenarios for defining privacy and security requirements

During the consortium meeting in 2016, six user scenarios were discussed with all consortium partners as to reflect upon the data flows in hackAIR, and related privacy requirements. The scenarios and agreed arrangements are discussed in the following paragraphs:

### 4.6.1.1 Scenario I: Privacy settings

*Karl wants to start using the hackAIR services to get informed about the air quality in his neighbourhood. He registers and fills in his basic login information, such as age, location, gender and group type information and health information in order to receive personalized recommendations. Who can see Karl's personal information?*

- All information is set public by default. Karl can change this by adjusting the privacy settings
- All information is set private by default. Karl can change this by adjusting the privacy settings.
- Some information is set public and some private by default

Among the consortium partners, it was decided that the profile should be set private by default. If the user has selected to set his/her profile as private, then no information is available to any other hackAIR user, apart from the administrator of the platform.

To be more specific, if the user profile is set as private (Figure 21), then it includes the following specifics:

- Users CANNOT
    - Be found by other users
    - Find other people and follow them
- Users CAN
    - Participate in gamification (only missions that don't include interaction with other users. e.g. upload photo, submit your perception, etc.).
    - Submit their feeling, and hackAIR displays these as anonymous by default
    - Access measurements and recommendations
    - Access the data fusion map
    - Can read "tips of the day"
    - Access history of AQ
    - Upload photos of the sky and will be displayed as anonymous by default on the map
    - Set up sensors
    - Search and join communities – it will be clear to them that their profile will be accessible only by other community members

If the user profile is set as public, then it includes the following specifics:

- Users CAN (all the above +):
    - Participate in gamification (everything)
    - Be discovered by username/email
    - Search for and follow other users
    - His/her username might feature in leader boards and other gamification related aspects
    - Join communities

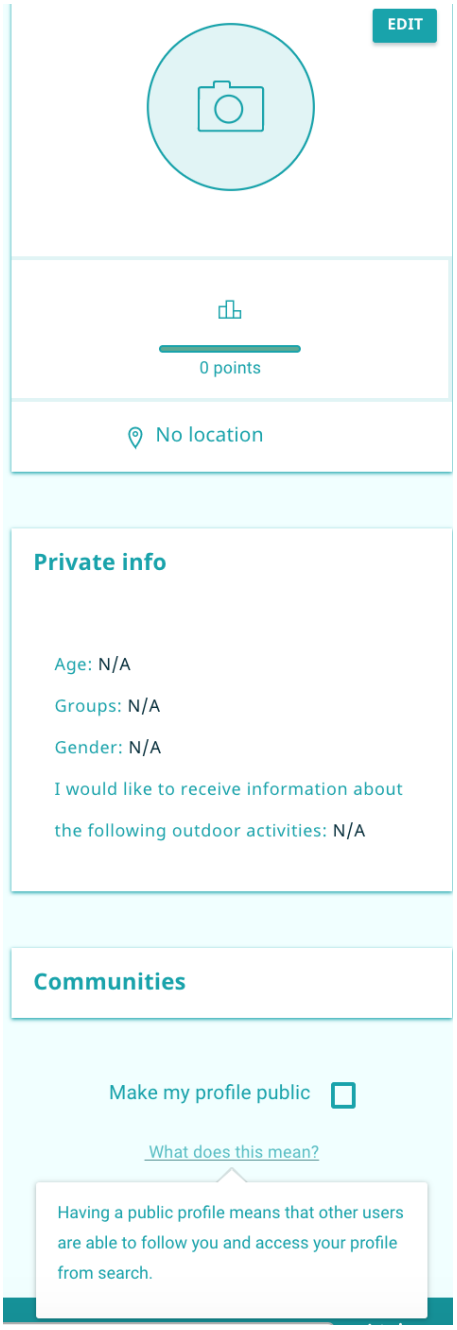



*Figure 22 - Screenshot – profile default set as private*

For the contribution of measurements, sensor data is displayed on the map with your sensor id, and submitted feelings and uploaded pictures of the sky are displayed anonymously by default.

### 4.6.1.2 Scenario II: Edit and delete personal information

*Anna is registered to hackAIR and regularly contributes with sky pictures and sensor measurements. She has also provided all personal information and health information that was asked for. At a certain moment, Anna wants to remove all her sensor measurements, because the sensor is attached to her house and she is afraid that others might find out where she lives. She also wants to remove her health information. What is possible with the hackAIR platform?*

- Anna can access, edit and delete all or some of her sensor measurement contributions. These contributions are then removed from the hackAIR database.
- Anna can access, edit and delete all personal information she provided. She removes her health –related information. This information is then removed from the hackAIR database.

Among consortium partners it was decided that it should not be possible to only delete a part of the sensor measurements. If a user decides to delete sensors measurements, then all measurements will be deleted. Further, a user is able to unlink the sensor from the platform, by deleting the sensor from the user profile. A user is also able to delete all measurements and personal data by deleted the account from the edit profile options.

Further, the user can contribute with air quality measurements (through sensors) in an anonymous way. The measurement only shows the user ID of the registered user (Figure 23), and the location of the sensor. As such, the user stays anonymous for the public, and the measurements are not linked to a personal profile.

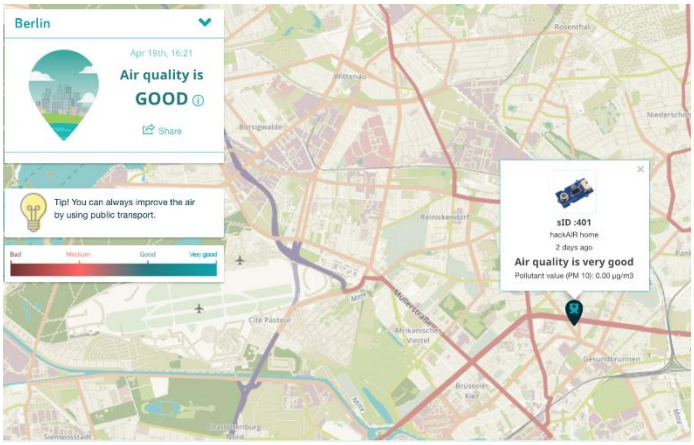



*Figure 23* - Screenshot of anonymous sensor measurement from a user

Submitted sky pictures and subjective perceptions ('How do you feel the air today') are displayed anonymously by default on the map (even if the profile is set as private).

Further, a user can access and edit all personal information, at any time. It is not obligatory to fill in any of the following fields: user name (Upon registration the user is made aware of the fact that the user name will be public, and urges users not to include any personal information), town/city, year of birth, gender, I would like to receive information about the following sensitivities (cardiovascular diseases, respiratory diseases, pregnancy), I would like to receive information about the following outdoor activities (walking, running, eating outside, outdoor job).

### 4.6.1.3 Scenario III: Deletion of user profile

*Anna no longer wishes to use the hackAIR services. Furthermore, Anna also no longer wishes to be a research participant in the BUND pilot study. What is possible with the hackAIR platform?*

- In her profile settings, Anna indicates that she wishes to delete her account. Anna's personal data are removed from the database. When deleting her account, the pilot organizer gets notified on this. He accepts the request and removes Anna's personal data from the panel database.

Among the consortium partners, it was decided that if a user desires to delete the profile on hackair (Figure 24), then all (associated) data would be deleted from the hackAIR database within a certain period of time (30 days). Further, if a user decides to delete the hackAIR account, then the pilots will be informed through regular reports (via email) about the deletion of the account and the withdrawal from the pilot study.

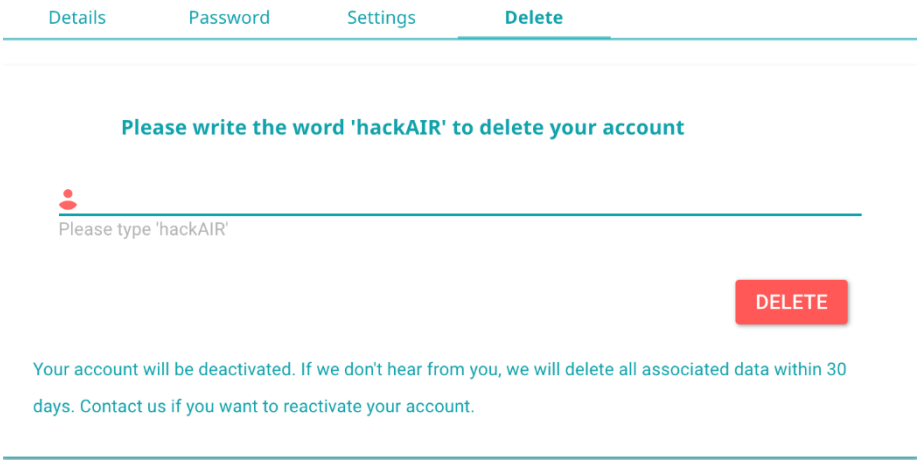



Figure 24 - *Screenshot of delete user profile*

### 4.6.1.4 Scenario IV: Informed consent

*Stephan created a hackAIR account to use the hackAIR services. He also participates in the hackAIR pilot study in Berlin. When he registered for hackAIR, Stephan agreed to the* ***privacy policy****, that describes what personal information is collected, used and disclosed to other parties, and he signed the* ***Terms and Conditions****, in which he agrees to the rules he must follow in order to use hackAIR. For his participation in the pilot study, he also signs an* ***Informed Consent*** *that gives a clear and complete explanation of participation and the collected data in the pilot study. What is possible with the hackAIR platform?*

- Stephan signs the privacy policy and the terms and conditions upon registration. If the terms and conditions of hackAIR change then Stephan will be informed about this via his email.
- Stephan signs the consent form if he participates in the pilot study.

The terms and conditions and the privacy policy are the same for the hackAIR platform and the hackAIR mobile application. The user should agree with the terms and conditions and the privacy policy upon registration through a check box. The terms and conditions and the privacy policy is provided in the local language of the pilots.

Further, a consent form is handed over to the participant if s/he wants to participate in the pilot study. If a user participates in the pilot study, then this information is controlled by NILU or BUND, no personal identifiable information is shared with VUB (e.g. all survey responses for the workshops are shared in an anonymous way, and no first and last names are shared with VUB). However, if VUB would like to invite the participant in an additional research track, such

as the behaviour change analysis, then VUB will provide a privacy policy and ask consent to contact the person for the particular study managed by VUB.

#### 4.6.1.5 Scenario V: Inappropriate content

*Stephan regularly uploads sky pictures to hackAIR. On a sunny day, Stephen is sunbathing on a beach and he takes and uploads a sky picture. He didn't notice that a topless sunbathing woman is also visible in the picture without her knowledge. What is the procedure for 'inappropriate' images?*

- Users of the platform can report inappropriate images. The image is then verified by hackAIR and if inappropriate, the image is removed from the platform.
- Images are analysed automatically to detected inappropriate content by an API. The image is then verified by hackAIR and if inappropriate, the image is removed from the platform.

Among consortium partners, it was decided to add an extra note in the terms and conditions that users are responsible for the photos they upload, and if inappropriate content is detected, hackAIR can delete any photo and may block users' account. Pilot partners and users can contact DRAXIS if they notice any inappropriate content. If a user posts (repeatedly) inappropriate content then the user will be notified about the imminent removed, if the user keeps on posting inappropriate content then the account will be removed.

#### 4.6.1.6 Scenario VI: User research

*A VUB researcher has created a survey to evaluate the use of hackAIR. NILU has sent this survey to the participants of their pilot. The VUB researcher would like to conduct some personal interviews as well to ask extra questions. At the end of the survey, the participants could indicate whether they were willing to participate in an interview. What is agreed among consortium partners?*

- VUB includes a privacy policy to collect the email of that respondent willing to participate in an interview in the Qualtrics survey software. NILU is informed about the procedure.

It was agreed among the consortium partners that surveys do not collect any personally identifiable information if this is not necessary. The collected survey data is stored in the VUB Qualtrics software. If necessary, VUB adds a privacy policy to the survey if the participant agrees to be further involved in other research steps – managed by VUB. This data will be deleted after the completion of the research study.

In the next research study, we will explore if your **behaviour** has **changed** by using the hackAIR tools. Did you learn something? Are you feeling more aware about the local air quality, or are you using the bike more frequently?

If you would like to join this research study, you can leave your contact details here. Please consult our full privacy policy here for the collection of your personal data for the purpose of this research study.

Taking part in this research study involves your participation in an interview of one hour.

○ Yes, I would like to part in the behaviour change research and you can contact me via the following email address:

○ No, I wish not to participate in this research study

*Figure 25* - Screenshot of user research

## 4.6.2 Personal data collected by hackAIR

This section relates to the collection of personal data through the hackAIR platform and application, and not the pilot study. As discussed in D2.3, different types of data about the end-users are collected through the hackAIR tool: pictures (with geo-location), sensor information (with geo-location and user ID), information of the mobile phone, and in some cases (when users participate in the pilots) data from the surveys and sometimes health-related data.

### 4.6.2.1 Volunteered data

The following data is created and explicitly shared by individuals:

Volunteered data (**obligatory for registration**):

- User name – User name must differ from the real first name/surname of the user (the user is made aware of this during registration)
- Email address

Volunteered data **(voluntary):**

10) City of residence
11) Gender (male/female/other)
12) Year of birth
13) Activities: outdoor sports
14) Activities: outdoor job
15) Preferred language (Norwegian, English, German)
16) Profile picture

Only the user name and the email address are obligatory for registration. Other fields (such as gender, year of birth, etc.) will be visible during registration, but are not required. After the registration, users are asked again to provide voluntary information in order to receive personalized recommendations about the air quality in their city. hackAIR clearly states why it is useful to provide certain data for information services, e.g. 'I would like to receive recommendations based on particular sensitivities or outdoor activities'.

**hackAIR will not ask for:**

17) Telephone number:
    - hackAIR does not send any SMS notifications.
18) Full address (street, number, city):
    - It is not necessary to know this level of detail, city level is adequate.
19) Social security number (this number is often used in Norway):
    - It is not necessary to know this level of detail

### 4.6.2.2 Observed data

The following data is captured by recording the actions of individuals.

20) Information of the mobile phone (e.g. browser, etc.)
21) Location data
22) IP address

#### 4.6.2.3 Inferred data

hackAIR will know this type of information through the analysis of volunteered or observed information:

23) Level of contribution
24) Time activities pattern and indirectly if there are a lot of 'anonymous' measurements from one specific location, then one could guess that this is the location of someone's home.

#### 4.6.2.4 Sensitive data

hackAIR does not ask for users' health data directly, but we ask whether users want to receive health related information. E.g. 'Do you want pregnancy related info?'

25) Allergies
26) Respiratory diseases
27) Cardiovascular diseases
28) Pregnancy

#### 4.6.2.5 Data from minors

29) hackAIR will collect personal data from **minors**. You must be 16 or older to use the hackAIR platform. If younger than 18 years old, then the user must claim that they have parental consent to use the platform.
30) Minors will also be able to participate in the pilot study. A parental consent form should be completed for minors.

### 4.6.3 Data processor and controller

**The data controller** in the project is DRAXIS. DRAXIS has notified the data protection authority in Greece, and is responsible for the management and monitoring of the privacy policy and terms and conditions. The storage of personal data is done on the DRAXIS severs (this is a cloud server in the EEA (European Environmental Agency)

There are multiple **data processors** in the project: **CERTH** (for the collection of social media images), **NILU** and **BUND** are data processors for the pilots (for the registration of participants). **VUB** is also data processor for survey data during activities in the pilot studies (behaviour change analysis).

### 4.6.4 Risk log: Final version of possible privacy and security risks and mitigation measures

The risk log gives a final overview of the key privacy and security risks for the hackAIR platform, and the possible solution for these risks. Risks indicated with an asteroid*, were added through outcomes in year 2 and 3:

*Table 21 Risk log*

| Name of the risk | Description | Scoring of the risk (threat, vulnerability, consequence) | Solution/requirement |
|---|---|---|---|
| **XSS attacks** | Cross-Site Scripting (XSS) attacks are a type of injection, in which malicious scripts are injected into otherwise benign and trusted web sites. The malicious script can access any cookies, session tokens, or other sensitive information retained by the | Unlikely to happen/ Minimal harm | Use of Laravel's XSS protection filters and middleware to filter inputs and HTML output. |

| Name of the risk | Description | Scoring of the risk (threat, vulnerability, consequence) | Solution/requirement |
|---|---|---|---|
| | browser and used with that site | | |
| SQL injection | A SQL injection attack consists of inserting or 'injecting' of a SQL query via the input data from the client to the application. A successful SQL injection exploit can read sensitive data form the database, modify database data and so on. | Unlikely to happen/ Minimal harm | Our web and mobile application only talks to the database (ready, write, modify) through the system's API. The API filters user's input for malicious scripts and ensures the request comes from an authorized user. All suspicious actions were logged and an email is sent to the technical team. |
| Error cases | Returned error cases might reveal sensitive information. | Unlikely to happen/ Minimal harm | As part of testing the web application, all commonly used error codes were tested (400 Bad request, 401 Unauthorized, 403 forbidden, 404 not found, 500 Internal server error) in order to ensure that the errors returned reveal no sensitive information. |
| Insecure Direct Object References | Insecure Direct Object References allow attackers to bypass authorization and access resources directly by modifying the value of a parameter used to directly point to an object. Such resources can be database entries belonging to other users, files in the system, and more. | Unlikely to happen/Minimal harm | Enforcing access control to ensure the user is authorized for the requested object. Enforced validation on both client and server side in order to avoid the use of proxy tools that can bypass client side validation. Using per user or session indirect object references. |
| Personal data collection* | The hackAIR platform and application collect more information than specified in the privacy statement, or collect information that is not necessary for the purpose. | Unlikely to happen/Minimal harm | Define a clear process to manage clear notification and consent for additional collection of data by the app (in line with the new purpose) |
| Registration information in combination with usage data* | To contribute with air quality measurements, a user has to register with an email address and user name (mandatory). Besides the mandatory fields, behavioural information is collected over time, in additional to personal information for receiving recommendations. Users might object over time to share more information, and | Likely to happen/minimal harm | The privacy policy clearly states which personal information is collected from the user upon registration and during usage of the platform. People often to do not tend to read the privacy policy, and therefore, the users can edit their personal information any time they |

| Name of the risk | Description | Scoring of the risk (threat, vulnerability, consequence) | Solution/requirement |
|---|---|---|---|
| | might abandon the hackAIR solution. | | want and also make their profile private. |
| Align the PIA requirement with the project management methodologies* | A lot of persons are being involved in the hackAIR project, and every person has to align with the requirements stated in the PIA. This requires that the PIA should fit the project's phases and should fit with every possible change in personnel, or development during the project. | Likely to happen/minimal harm | The hackAIR project chooses for an agile-like methodology, this helps to align the PIA with project management principles. |
| When collecting personal information it should come directly from the individual concerned* | In the hackAIR platform, it is possible to create a secondary profile. For this secondary profile, some personal information has to be provided, such as age, gender, year of birth, health sensitivities and outdoor activities. The information provided won't be used in a way that identifies the individual concerned. | Unlikely to happen/minimal harm | No personally identifiable information will be collected for the secondary profile. |
| Access to personal information* | An individual shall be entitled to obtain the personal information gathered, and to have access to that information and has the right to delete it. Within the hackAIR project, every user can take contact with the data controller (DRAXIS) and has the right to delete all personal information gathered. | Likely to happen/minimal harm | In the privacy policy, a clear procedure is explained on how the user can delete all its personal information. The user is also able to delete the account in the user profile. |

## 4.6.5 PIA sign off: Final check of privacy and security requirements of hackAIR

### 4.6.5.1 Informed participation and evolving consent

*Table 22 Informed participation and evolving consent*

| Nr. | Requirement | Implementation |
|---|---|---|
| R1 | A **privacy policy** should be created that describes what personal information is collected, used and disclosed/sold to other parties and for what purpose. The privacy policy should describe the risks and benefits associated with sharing data in a transparent way. | A privacy policy and terms and conditions is added on the hackAIR platform and mobile application: http://www.hackair.eu/terms-and-conditions/ The privacy policy clearly explains which personal data is collected from a user upon registration, and which information is collected for receiving personalized recommendations. An |

| Nr. | Requirement | Implementation |
|---|---|---|
| | | email address and contact are also provided if users have questions about their privacy.<br>The privacy policy is available in English, German and Norwegian. |
| R2 | If the **terms of participation change**, the privacy policy should be updated immediately and this should be communicated to the users. | Implemented. If a change occurs to the privacy policy, then users will be informed about it through the newsletters of hackAIR. The procedure is also explained in the privacy policy. |
| R3 | A clear and complete **explanation** of the participation and the collected data should be given prior to accepting contributions via an explicit informed consent process. | An informed consent form has been made available to the pilots, which they should adjust to the specifics of the research study (e.g. audio recording, taking pictures, etc.), and which should clearly state the objective of the research study. An informed consent is signed two times: one for the coordinator of the pilot, and one for the participant. |
| R4 | If the terms of **participation change**, the informed consent process should be repeated and users have to give their consent again. | Implemented. The informed consent is adjusted to the purpose of the research study. Participants are asked to sign the informed consent in every research study they participate. |
| R5 | hackAIR should **interact** with the community of users and beyond on privacy and data management to create awareness on privacy and personal data. | Implemented. During year 1 in the project, privacy requirements were discussed with prospective end-users of the solution. If users have questions about their privacy they can contact the pilot coordinator, or the data controller (DRAXIS) of the project. |

### 4.6.5.2 Registration and profile management

*Table 23 Registration and profile management*

| Nr. | Requirement | Implementation |
|---|---|---|
| R6 | The creation of a hackAIR profile is **voluntary**. It is not necessary/mandatory to register to access the AQ information. | Implemented. Users can browse the air quality map and see the index without the requirement to register. If a user would like to contribute with air quality data, then s/he needs to register. |
| R7 | hackAIR should require only a **minimum amount of personal information** of the users to participate. Only basic login information should be mandatory for registration (user name, password). Extra information (among others for the personalized recommendations) is optional. | Implemented. Only basic information is mandatory for registration, i.e. user name and email address. Other personal information is voluntary. |
| R8 | If users are given the option to give **health related information**, the risks and benefits of disclosing this information should be communicated since health related information is sensitive information. | Implemented. The user can opt to choose to receive personalized recommendations based on particular health sensitivities and outdoor activities. It is provided as an information service to which users can opt-in. |
| R9 | hackAIR should enable users to **modify and/or delete personal information** at any time. | Implemented. The users have the option to edit their profile information, and to delete their account. |
| R10 | Users always have to be able to change their **data sharing permissions** over time as the context or their privacy needs change. | Implemented. In the user profile, a user can edit and save the provided personal information. |
| R11 | hackAIR should give users the option to choose which personal data they would like to set as **private or as public**. | Implemented. The user can choose to make the entire profile set as public or private. |

### 4.6.5.3 Privacy by design

*Table 24 Privacy by design*

| Nr. | Requirement | Implementation |
|---|---|---|
| R12 | The hackAIR platform should be designed and constructed in a way to avoid or minimize the amount of personal data processed (**privacy by design**). It is important to identify privacy issues from the start so privacy protection measures can be incorporated into the overall design. | Through the PIA, privacy risks were identified early on in the project, and were verified during the internal beta-testing stage of the platform. There is a continuous and on-going monitoring of the privacy and security of the hackAIR platform, and which is aligned with the agile development methodology of the project. |
| R13 | The privacy settings should be set by default at the highest level. | Implemented. If a user creates a profile, then the profile is private by default. |
| R14 | Elaborate **privacy settings** should be integrated. E.g., users on the platform should have the option to make their profile public or private, to make their sensitive information (such as location and contact details) public or private. | Implemented. |
| R15 | A user-centered design process should be deployed from the start of the project to ensure that the users' needs and desires are built into the system from the earliest stages of design and implementation. | Implemented. |

### 4.6.5.4 Data management

*Table 25 Data management*

| Nr. | Requirement | Implementation |
|---|---|---|
| R16 | The hackAIR project should choose an **open license**, and specify this on its website and related tools. | Implemented. The license is mentioned on the air quality map of hackAIR: Map tiles by Stamen Design, under CC BY 3.0. Data by OpenStreetMap, under ODbL.<br>The specified license is creative commons by 3.0, which means that users are free to share, copy and redistribute the material in any medium or format, and can adapt the material for any purpose. The user must give appropriate credit and indicate if changes were made.<br>More information can be found here: http://www.hackair.eu/api |
| R17 | The hackAIR project needs to determine how long it will make the citizen science data available. | The anonymized data will be available through an open data repository (Zenodo) after the end of the project. |
| R18 | The hackAIR project should implement specific **metadata standards for discovery of the data**. | Implemented. Documentation about the access and use of the data is provided on: http://www.hackair.eu/docs/api/ |
| R19 | hackAIR should choose an **aggregated form to publish its data**. Under no condition may the hackAIR project reveal personal data. | Implemented. Any user can download the hackAIR air quality data for further analysis through an Application Programming Interface (documentation available here: http://www.hackair.eu/docs/api/). No personal data is shared when downloading the citizen science data. |
| R20 | hackAIR should discuss the **data quality control** process to be followed before, during and after data collection. | The hackAIR project aims to provide estimations on the air quality trends and not accurate measurements. However, a quality control module logic is applied to these estimations with the use of specific outliers that exclude extreme values from the system. |
| R21 | hackAIR should define the **type of access**. Is it necessary to be able to download every citizen | The hackAIR API returns latest data from the last two days, there is a limit of 5000 points per request. |

| Nr. | Requirement | Implementation |
|---|---|---|
| | science dataset? Which dataset should only be discoverable, viewable and downloadable? | |

### 4.6.5.5 Risk mitigation

*Table 26 Risk mitigation*

| Nr. | Requirement | Implementation |
|---|---|---|
| R16 | hackAIR should identify all the possible privacy and security risks and undertake the necessary protection measures. It should be carefully considered whether the identified privacy risks will be eliminated, mitigated or accepted.<br>• **R16a: Privacy risk elimination**: If an alternative less privacy invasive solution exist that can be easily implemented, the privacy risk should be eliminated.<br>• **R16b: Privacy risk mitigation**: If there is no other solution, then the privacy risk should be mitigated as much as possible.<br>• **R16c: Privacy risk acceptance**: If it is not possible to eliminate and mitigate the privacy risk, then the privacy risk has to be accepted. The possible privacy risk should be clearly described to the end-users, e.g. by means of the privacy policy and informed consent. | Implemented. The monitoring of the privacy and security requirements of the hackAIR platform and mobile application is an ongoing activity of DRAXIS. |

# 5 Conclusions and next step actions

Despite some initial delay in the pilot launch, we can conclude that the project activities are successful (Table 27).

*Table 27 Pilot success indicator and achieved number*

| Success indicator | Unit | Achieved value after pilot I activities | Target value |
|---|---|---|---|
| O1: To develop collective sensing approaches for measuring air quality | | | |
| Environmental nodes on air quality to be indexed | Number | 17 | >10 |
| Environmental measurements to be indexed | Number | 20,000 per day | >10,000 |
| Public images from social media to be used | Number | 1,500 per day | 2200 |
| User captured images to be used | Number | 486 | 800 |
| Low cost open hardware devices to be assembled | Number | 328 | 300 |
| O2: To develop a methodology for synthesising heterogeneous air quality data collected in order to generate meaningful information, personalised to the requirements of citizens. | | | |
| Gridded fused data improves base maps and sensor data vs independent data | Normalized difference | Ca. 0.72 | <1 |
| Accuracy of data provided | % error | Ca. 25 | 25 |
| Time response of the personalisation services | Number | 1.6009secs (average) | <10secs |
| Semantically integrate heterogeneous content (environmental data, user preferences, profile) | Boolean | TRUE | YES |
| O3: To develop the hackAIR open platform for collecting, analyzing and sharing air quality measurements to community members through web and/or mobile phones | | | |
| Acceptance of hackAIR platform by end-users | % | 78.6 | 80 |
| Number of engaged individuals | Number | 1,468 registrations | >300 |
| O4: To develop and deploy strategies for increasing engagement in monitoring air pollution and encouraging behavior change | | | |
| Number of engaged individuals | Number | 7,447 | >8,000 |
| Reach of hackAIR messages to external communities and activists organizations | Number | 330 | >35 |
| O5: To pilot test the hackAIR open platform in an operational environment, with the participation of user communities | | | |
| Simple users engaged in Germany | Number | 1135 | 5,000 |
| Advanced users engaged in Germany | Number | 161 | 200 |
| Simple users engaged in Norway | Number | 158 | 3000 |
| Advanced users engaged in Norway | Number | 64 | 100 |
| User satisfaction level<br>Web platform<br>Mobile application<br>Sensors<br>Overall mean score of the hackAIR tools | % | 52.5<br>55.1<br>59.3<br>**55.6** | 90 |
| Increased awareness | % | N/A | 85 |
| O6: To assess the usability and effectiveness of the hackAIR platform, and its social and environmental impact | | | |
| Effectiveness in promoting behavioural change | % | N/A | 80 |
| Usability of hackAIR platform<br>Web platform<br>Mobile application<br>Sensors<br>Overall mean score of the hackAIR tools | % | 60.4<br>54.0<br>78.8<br>**64.4** | 80 |
| O7: To effectively disseminate the project activities and results, and ensure their sustainability and exploitation54 | | | |

| Success indicator | Unit | Achieved value after pilot I activities | Target value |
|---|---|---|---|
| Visits to the project website | Number | 14,048 | 36,000 |
| User downloads of hackAIR Application | Number | 1,240 | 30,000 |
| Social media impressions | Number | 334,628 | 200,000 |
| Newsletter impressions | Number | 3,010 | 3,000 |
| Media- and online impressions | Number | 26,338 | 1,000,000 |
| NGOs and other civil society organizations informed about hackAIR | Number | 330 | 35 |
| NGOs and other civil society organizations adopting hackAIR platform | Number | 2 | 2 |
| Number of organized workshops | Number | 10 | 7-10 |
| Number of workshop participants | Number | 69 | 500 |
| Number of meetings of network of interest | Number | 3 | 4 |
| Total number of participants | Number | 47 | 100 |
| Number of external meetings with hackAIR representation | Number | 59 | 10 |
| Number of hackAIR stakeholders reached in project events and through the platform | Number | 5,728 | 150 |

Pilot activities are running well and as planned both in Norway and Germany (here with a number of workshops planned before summer). Also the additional pilot activities in Belgium and Greece are promising.

NILU implemented a technical assessment of the hackAIR home v2 sensor and obtained very positive performance results. Even though the sensor measurements are not very reliable for $PM_{10}$, the results show that real-world measurements of $PM_{2.5}$ are very good and even can be further improved through machine learning methodologies. The hackAIR home v2 sensor has thus great potential for implementation in larger numbers as complement to official monitoring stations.

The KPIs evaluation of hackAIR tools by the consortium showed relative good levels of success regarding their performance. Complaints from the consortium have led to the compilation of a priority list at the last consortium meeting, which is followed carefully by the platform developers every week. So far, hackAIR workshops have been carried out only in Norway. Workshop evaluation results showed that the participants were overall quite content with these workshops, both in terms of content and execution.

Users' evaluation survey in phase I showed that, contrary to user's acceptance of the hackAIR platform which is quite high, both the levels of satisfaction and users' performance are quite low, with a general satisfaction remaining below 60%. As those scores are means score, it can be observed that, regarding the users' performance, only some of the tasks are actually scoring low, pulling the mean score down. Indeed, it seems that regarding the users' performance on the web platform, it is mainly the tasks "Comparing air quality amongst cities" and "Following a fellow hackAIR user" that bring issues. The same situation can be observed for the users' performance related to the mobile application, with the task "Comparing air quality amongst cities" scoring very low. The users' performance related to the sensors are as far as they are concerned quite high, indicating no further issues.

Priorities of improvement of the hackAIR platform should thus focus on those two tasks "Comparing air quality amongst cities" and "Following a fellow hackAIR user" as they can both raise the users' performance and satisfaction score, as users will experience less frustration when interacting with the hackAIR platform. Nevertheless, it has been decided that the task "Comparing air quality amongst cities" will not be further improved as there is no sufficient data to compare several cities. Further improvements should focus on the visibility of the personalised recommendations, since a high number of respondents did not know where to find these, while further research should explore the reasons for not reading and checking the recommendations. Lastly, users demand clearer guidelines as regards to how the game elements work.

Results of a privacy impact assessment by VUB showed that some adjustments to protect the users' privacy had to be made. These were in place at the beginning of the pilot. A risk log gives a final overview of the key privacy and security risks for the hackAIR platform, and the possible solution for these risks. Based on a final check of privacy and security requirements of hackAIR, additional changes have been carried out accordingly.

Feedback will continuously be collected through survey forms during the different organised workshops, as well as through the extended online survey. Those collected data will enable us to compare progress in milestones regarding the usability, user experience and acceptance of the hackAIR platform.

Regarding the impact assessment track, one self-assessment survey was already undertaken by the consortium partners and in the future, interviews will be organised with the users in the pilots. As to the behaviour change track, the first experiment will take place in Brussels in June, and will follow in autumn for the two other pilots (Figure 25). Both the impact assessment and the behaviour change track will be reported in deliverable D7.7 (Pilot implementation and final evaluation report: pilot performance and impact of hackAIR, M36).

| Tools | Month | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| Period 1 Evaluation | | | | | | | | | | | | | | | | | |
| Discussion rounds | | | | | | | | | | | | | | | | | |
| Self-assessment surveys | | | | | | | | | | | | | | | | | |
| D7.4: Intermediate pilot implementation report | | | | | | | | | | | | | | | | | |
| Period 2 Evaluation | | | | | | | | | | | | | | | | | |
| Period 3 Evaluation | | | | | | | | | | | | | | | | | |
| Interviews and testimonials | | | | | | | | | | | | | | | | | |
| D7.7: Pilot performance and impact assessment | | | | | | | | | | | | | | | | | |

*Figure 26 - Gantt chart showing hackAIR overall evaluation time. Green = Track 1, Red = Track 2/3*

# 6 References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- McCrory, E., et al. (2017). D7.2 – Evaluation and impact assessment framework. Available at: http://www.hackair.eu/about-hackair/deliverables/ [Accessed 11th May. 2018].
- Santos, J. R. A. (1999). Cronbach's alpha: A tool for assessing the reliability of scales. Journal of extension, 37(2), 1-5.

# 7 Annex

German pilot - Printed Tutorials



### Tutorial Software installation:

https://www.bund.net/fileadmin/user_upload_bund/publikationen/mobilitaet/hackair_anleitung_software_messstation.pdf

### Tutorial Casing Assembly:

https://www.bund.net/fileadmin/user_upload_bund/publikationen/mobilitaet/hackair_anleitung_gehaeuse_feinstaubsensor.pdf

### Tutorial Assembly Sensor:

https://www.bund.net/fileadmin/user_upload_bund/publikationen/mobilitaet/hackair_anleitung_zusammenbau_feinstaubsensor.pdf

### Tutorial Data handling:

https://www.bund.net/fileadmin/user_upload_bund/publikationen/mobilitaet/hackair_anleitung_umgang_messdaten.pdf