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Development of sensor-based Citizens' Observatory Community for improving quality of life in cities

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Collaborative project

# Deliverable D3.4

# Evaluation of the performance of the Empowerment Initiative at schools
# Appendix I – BELGRADE

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## Summary

This appendix describes activities performed in four schools in Belgrade during Indoor Air Quality case studies in the framework of the CITI-SENSE project. During the pilot and the main campaign, developed platforms with low-cost sensors were first collocated at ATM (Automatic Monitoring Station for air quality monitoring that belong to the State Network) to be tested and calibrated.

Later, the sensor pods were installed in schools to monitor indoor air quality, as well as outdoor environment at the schools. Several types of measuring devices were used during the CITI-SENSE case study in Belgrade, namely: pods developed in the framework of CITI-SENSE, commercial low-cost devices, as well as available mobile instruments that measures particulate matter (PM).

The recruitment process of schools in Belgrade included schools either from previous collaboration (one school) or newly established connections (two schools). In addition, a fourth school was included in the CITI-SENSE case study on their own initiative. First interaction and meetings were with the headmasters at the schools. These meetings were followed by meetings with teachers that expressed interest in collaboration. After that, we had designated teacher/s in each school that participated in the implementation of the different activities

The Belgrade CITI-SENSE team gave at least two introduction lectures at each school about the air quality (AQ) indoor and outdoor environment. In addition, specific lectures were given that focused on topics related to the engagement activities. Teachers participated in installation of AQ pods and checked and maintained them during the measurement campaigns.

Difference in type and level of engagement activities of elementary school pupils and students from secondary school could be noticed. It is not entirely clear whether the level of engagement depends more on the teacher's ability to motivate the students or if it depends more on the age of the students.

In Belgrade, school questionnaires were completed only once. In addition, half of the students filled both a school questionnaire and the Long Questionnaire developed by WP2. Similarities were identified, but also some differences in opinion of elementary and secondary school students regarding air pollution issues.

Several rounds of interviews were conducted in elementary school in order to gain insight into adoption level and benefits stemming from CITI SENSE tools. It must be underlined that children provided valuable input comparing with answers given by other participants/stakeholders.

The participating school had a corresponding web site on citi-sense.eu domain. All the sites shared the same basic information about the CITI SENSE project and air pollution in general, but specialized content was also developed for each school.

Engagement activities were reflected in preparation of small research works in secondary school and active participation in measurements, data collection, data analyses and preparation of presentations in elementary school.

## Summary (In local language)

U ovom prilogu opisane su aktivnosti u četiri škole u Beogradu za vreme sprovođenja studije "Kvaliteta vazduha u školama" u okviru CITI-SENSE projekta. Tokom pilot kampanje i glavne kampanje, jeftine platforme za praćenje kvaliteta vazduha (AQ) , koje su razvijene u okviru projekta, su najpre testirane i kalibrisane na terenu tako što su postavljene pored automatske merne stanice (AMS) koja pripada državnoj mreži AMS za praćenje kvaliteta vazduha.

Zatim su platforme sa senzorima postavljane na izabrana mesta da bi se pratio kvalitet vazduha u unutrašnjem prostoru i spoljašnjoj sredini u neposrednom okruženju škole. Tokom CITI-SENSE studije u Beogradu korišćeno je više tipova senzora: platforme razvijene u okviru CITI-SENSE projekta, komercijalni jeftini uređaji kao i raspoloživi merni instrumenti za merenje respirabilnih čestica (PM).

Tokom procesa regrutovanja u studiju su uključene i škole sa kojima je CITI-SENSE tim Beograd prethodno sarađivao (jedna škola) i škole sa kojima se uspostavio novi kontakt (dve škole). Na inicijativu nastavnog osoblja u studiju je naknadno delimično uključena i četvrta škola.

CITI-SENSE tim Beograd je u svakoj od škola održao najmanje po dva uvodna predavanja o kvalitetu vazduha u spoljašnjoj sredini i unutrašnjem prostoru. Pored toga održana su i specijalna predavanja usmerena na aktivnosti vezane za aktivno učešće u studiju. Nastavnici su učestvovali u postavljanju senzora za praćenje AQ, njihovoj proveri i održavanju tokom kampanje merenja.

Uočena je razlika u vrsti i stepenu angažovanja učenika osnovnih i srednjih škola tokom studije. Nije sasvim jasno da li je nivo angažovanja učenika učesnika zavisi više od sposobnosti nastavnika da motiviše učenike ili od njihovog uzrasta.
U Beogradu učenici su upitnike popunjavali samo jednom. Pored toga polovina učenika je popunila oba upitnika o kvalitetu vazduh, i upitnik specijalno razvijen za škole i upitnik razvijen u okviru WP2 za opštu populaciju. Identifikovane su i sličnosti i neke razlike u odgovorima na pitanja u vezi aerozagađenja između učenika osnovnih i srednjih škola.

U osnovnoj školi je napravljeno niz intervijua kako bi stekao uvid u nivo usvajanja i prednosti koje pružaju CITI-SENSE alati. Mora se naglasiti da deca prikazala značajan i interes i doprinos za teme aerozagađenja u poređanju sa odgovorima koji su dali druge učesnici/zainteresovane strane.
Za škole koje su učestvovale u studiji formiran je sajt na citi-sense.eu domenu. Svaki od sajtova deli iste osnovne informacije o CITI-SENSE projektu i aerozagađenju uopšte, a ima specijalne sadržaje vezane za svaku od škola.

Aktivnosti u angažovanju se ogledaju i u pripremi malih istraživačkih radova učenika u srednjim školama, i aktivno učešće u merenjima, prikupljanju podataka, analizi podataka i pripremu prezentacije učenika osnovne škole.

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# 1 Methods

## 1.1 Recruitment of users

In Belgrade, we decided to recruit both elementary and secondary schools to the CITI-SENSE case study. The elementary school that was chosen was one of the schools that previously participated in the SINPHONIE project (2010-2012). During this project, we established very good collaboration with the school and they were interested in further collaboration. In the elementary school, we worked with a biology teacher and $5^{th}$-$6^{th}$ grade students.

Collaboration with secondary schools was established for the first time. Teachers of informatics and chemistry were leading the collaboration with the gymnasium, and students from different classes participated in the project. In the second secondary school, we collaborated with a meteorology and a chemistry teacher.

## 1.2 Interaction with the users to identify their needs

As a rule, first contact was always with school headmaster, who recommended one or several teachers for further activities. The teachers were leading the collaboration after this. From time to time, we had meetings with teachers, and when it was necessary with headmasters or deputies. Each time when we installed sensors inside the school during the pilot or main campaign, teachers were fully involved.

## 1.3 Tools and products

During the pilot campaign in schools in Belgrade we used EK700 DunevNet nodes, which have ability to measure concentration of NO, $NO_2$, CO, $CO_2$, $PM_{2.5}$, $PM_{10}$, and also have temperature (T), relative humidity (RH) and atmospheric pressure (p) sensors. All sensors for gases and meteorological data were produced by Alphasense, while Dylos 1700 integrated in platform were used for particulate matter monitoring. Firstly, pods were collocated at AMS (Automatic Monitoring Station that belong to the state network) for purposes of synchronous in-field calibration and after that they were installed to collect data at schools. We also successfully tested the Obeo radon sensor during the pilot campaign. Results collected with the Obeo radon sensor were compared with results obtained by screening methods with carbon canisters, when both units were installed in several different environments in the Institute Vinca.

As ATMOS sensors were not available on time, an alternative plan had to be devised during which we provided the schools with several commercially available instruments, namely IC-meters. We used a total of nine IC-meter devices which have the ability to measure $CO_2$, T, RH and noise. In addition, we conducted two campaigns of measuring particulate matter in schools with laboratory grade continuous devices, TSI OPS, Model 3330 and TSI NanoScan SMSP, Model: 3910. Together with students, we performed two short campaigns of measuring PM pollution in indoor area and outdoor environment. PM data were collected in classroom during lessons under different scenarios and conditions of ventilation

(open/closed windows) and student activity (sitting/walking around classroom). In addition, PM pollution was measured under different scenarios in the outdoor environment.

After ATMOS nodes co-location at AMS, we conducted campaigns in schools. During these campaigns, ATMOS nodes were installed at four schools. Simultaneously, IC-meters were monitoring in the same areas in three schools. During the co-location campaign, it became clear that the ATMOS nodes are not suitable for outdoor measurements, due to what appeared as not good enough hydroisolation and packaging under rainy conditions. For this reason we installed EK700 (DunavNet) or AQMesh devices in front of schools.

Other CITI-SENSE tools that were used in Belgrade case study consisted of several questionnaires and smartphone apps. Beside questionnaire for students and long questionnaire for general population, the CityAir app was presented to teachers and students.

## 1.4 Engagement activities

Several different engagement activities were performed in the framework of the Belgrade case study, which involved various participant groups (Belgrade CITI-SENSE team, school staff, municipality representative, students). The CITI-SENSE Belgrade team performed or was involved in the following engagement activities:

- Official correspondence and meetings with headmasters and other school representatives
- Organizing lectures in initial stage for headmasters and if it was necessary with Parents Council
- Meetings with teachers to analyse previous and plan upcoming activities
- Organising for students introductory lectures about air pollution and specific lectures targeted to case study activities
- Organization of measurement campaigns using developed sensors
- Organization of measurement campaigns with other available devices
- Communication between school keepers and other school staff before or during campaigns
- Training and motivating students to fill questionnaire and use smartphone applications
- Discussing with teacher and student about topics in data analysis
- Offering students to participate in or perform small research project
- Planning, with teacher and students, presentations of collected data of air quality in schools



*Figure 1: Lectures for students*

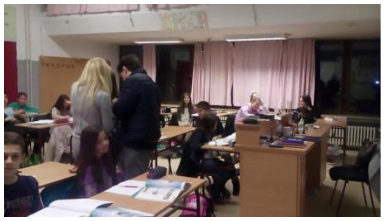



*Figure 2: Training for students*


*Figure 3: Short measurement test with students' participation*




*Figure 4: Sensor installation in schools*

*Figure 5. Students' presentation for parents and public*

*Figure 6: Interview with students*

The CITI-SENSE team Belgrade participated three times in the Institute Vinca Open days, which are organized every year in May. Every year, CITI-SENSE team Belgrade organized lectures for several groups of students. Titles of presentations/poster were:

**2014. 8th – 9th, May**

Lecture "Air quality in schools – contribution of CITI-SENSE project"

**2015. 8th May**

Lecture "Application of modern sensor technologies and information systems for air pollution monitoring"

Lecture "The importance of indoor air quality monitoring"

Poster "Air pollution in outdoor and indoor environment – join to measurement to understand "

**2016. 25thMay**

Lecture, "CITI-SENSE products, tools and technologies (COT) for monitoring air pollution in urban area"

*Figure 7: Lecture at Vinca's Open day*


*Figure 8: Poster for elementary school "20. Oktobar"*

One of the activities was the initial testing of the Long Questionnaire by students that participated in "Vinčaonice" research projects and presentation of results of research during Vinca's open day in 2015, during which 50 long questionnaires were completed.

One successful story of engagement activities was a presentation of results of the measurement campaign with IC-meters in an elementary school. This event was organised for the parents and also open for wider auditorium in June 2015. The next presentation has been organised late in September 2016, when students have presented results of

measurements with ATMOS and IC-meters in their school for the period from March to June 2016.

Activities during the official duration of the CITI-SENSE project finished with participation of elementary school students at Researchers' night 2016, on September 30, Figure 9.


*Figure 9: From program of Researcher night in Belgrade, [http://nocistrazivaca.rs/en/program/vazno-je-znati-kakav-vazduh-udises/](http://nocistrazivaca.rs/en/program/vazno-je-znati-kakav-vazduh-udises/)*

## 1.5 Empowerment evaluation

### *1.5.1 Participants evaluation*

Participant evaluation was performed through interviews and questionnaires. Interviews were conducted with:

- Informatics teacher from gymnasium, biology teacher from elementary school and two groups of students from elementary school.
- Questionnaires were completed by students anonymously during case study.

### *1.5.2 Stakeholder evaluation*

There were no stakeholders outside the participants groups, except teachers and students that were at lectures at Vinca's Open day. All representatives of schools that attended lectures about the CITI-SENSE project expressed interest to participate in the case studies, but due to limited resources, it was not possible to involve more than four schools.

# 2 Results

## 2.1 Recruitment of Users

Originally, the plan was to recruit three school in each town for the Indoor Air Quality study. The schools that we recruited in Belgrade were one elementary and two secondary schools. During the study, one more school was partially involved. The level of activity was different in the four schools. The most intense activities were of 5th and 6th grade class of elementary school and the teacher that lead them.

## 2.2 User overall objectives

In general, elementary and secondary schools were interested to participate in the CITI-SENSE case study as the teachers meant it would be useful and important for students to:

1. Learn more about air pollution in general
2. Learn about air pollution from school and living environment point of view
3. Learn to conduct experiments, read graphs, download data, draw diagrams, describe results and discuss.
4. Become aware of why indoor and outdoor air quality is important for health
5. Start to think about taking measures relating to improving air quality.


Diploma

Jovani Jovanović

učenici V/3
osnovne škole "20. oktobar" u Beogradu

za uspešno učešće u
*CITI-SENSE studiji o kvalitetu vazduha u školama*
tokom drugog polugodišta školske 2014/2015. godine

Beograd, 12. jun 2015.

Milena Jovašević-Stojanović
rukovodilac CITI-SENSE studije u školama u Beogradu

Alena Bartonova
rukovodilac CITI-SENSE projekta

*Figure 10: Example of Diploma for elementary school students*

## 2.3 Specification of the user needs

### *2.3.1 Hardware needs*

There was not opportunity to involve users is hardware specification.

### *2.3.2 Data services needs*

The way the students and teachers could download data during case study were different from one device to another:

- The data from EK700 devices were downloaded from DunevNet server by CITI-SENSE team members form Vinca.
- The data form IC-meters may be easy check and downloaded, as that is commercial device.

- The data from ATMOS devices were downloaded from SEDS server by CITI-SENSE team members form Vinca and hang at school web portal.

Of main importance for students was the ability to look at real time data and easy download historical and near to real time data. During teh pilot campaign, when we used the EK700 platform, DNET and Vinča created an appropiate visulisation web page. The commercial device “IC meter”, used during the main campaign, has its own visualisation web page and service for downloading collected data that fulfilled the students’ criteria. For data collected with the Atmosperic Sensor unit, adequate data service for students was not provided.

Elementary and secondary school students were instructed by teachers to fill-in the school questionnaire and Long questionnaire on-line.

### *2.3.3 Supporting services*

The CITI-SENSE team in Belgrade prepared a short explanation in Serbian language for elementary school students about the procedure of downloading data from the IC-meter web page.

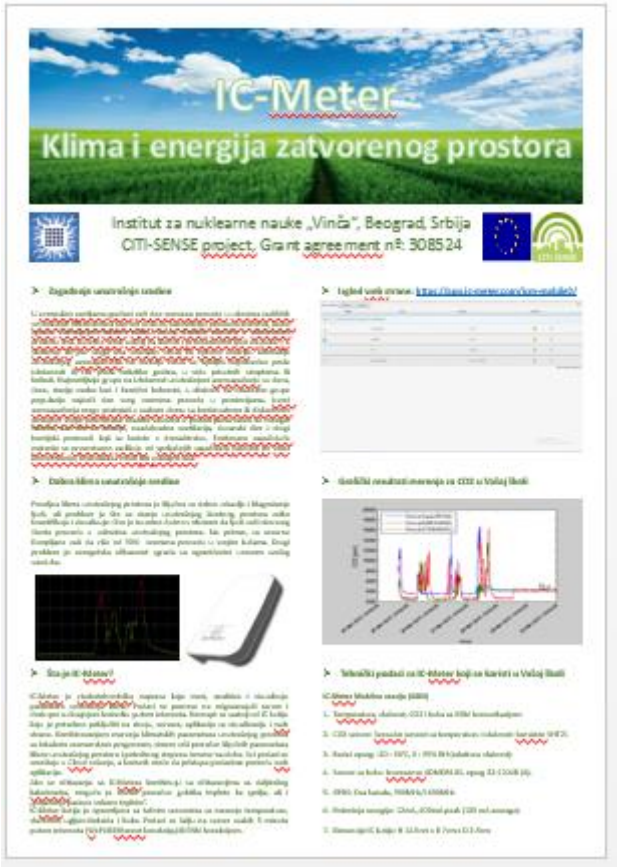



*Figure 11: User manual for the IC-meter and explanation of how to download data*

## 2.4 Evaluation of tools, products and services

The results of the evaluation process for the CITI-SENSE tools, products and services in the campaigns that were carried out in Belgrade schools will be presented in this section.

The CITI-SENSE team in Belgrade has applied a uniform strategy of location of devices in the schools. The campaigns involved four schools: Elementary School “20. oktobar” and three secondary schools: VI Belgrade Gymnasium, Geological-meteorological school “Milutin Milanković” and The Aviation academy “Petar Drapšin”.

During both pilot campaign and main campaign, EK700 platforms were used. IC-meter devices collected data during the campaigns in 2015 and 2016. Finally, this year three Atmospheric Sensor platforms were installed in three schools, while the three IC-meter devices were placed in the first three of the above-mentioned schools.


*Figure 12: First trial of real time visualisation of air pollution in schools*

In addition to the Atmospheric Sensor platforms, we also introduced the following CITI-SENSE tools and systems to the students: Web page for data visualization, Web page for data downloading and the CityAir mobile application for mapping of subjective feeling of air pollution in cities.

Different types of measurement instruments for indoor air pollution received great attention from the students, teachers and parents. Everyone wanted to know more about which pollutants these instruments can detect, as well as the basic principles that underpin the operation of sensors for the detection of hazardous gases and particles.

IC-meters worked without problems, which was expected because these are commercial available devices. On the other hand, we had a regular data transfer from the Atmospheric Sensor platforms to the server. Gas sensors from the Atmospheric Sensor platforms have demonstrated logical trends, but on the basis of previous evaluations, we were aware of the fact that measurements can be observed primarily at the indicative level. Particle sensors on several platforms were giving constant concentrations, which was an indication that something is wrong with these sensors. The manufacturer was informed about that and a firmware update was provides, but without positive changes.

Students have kept records of measurement results from IC-meter platforms. We believe that in this way we encouraged a different way of thinking and working which caused positive effects, especially when it comes to younger children in elementary school. Based on the results of measurements, children made a large number of posters, and also wrote a few essays. In elementary school, children prepared an event related to the problem of air pollution and measurements that were conducted with IC-meters.

The web page for data visualization was not functional for students. From this page, children could not follow the values of pollutant concentration from platforms because there was no regular update from Belgrade.

The CITI-SENSE web page for data downloading (http://schools.citi-sense.eu/) was very useful. Here, we were downloading the data in Excel documents (the downloading procedure in CSV format was not operational), and then data update was carried out on the special school web site. From this site students and teachers were able to access the measurement data. The only problem with this web page was an extremely long time for downloading.

The CityAir application was presented in classes with help from the teacher. Many children installed the CityAir app on their phones and have shown interest for this app. Sometimes there have been some problems with the application that were repaired with the updated versions that could be easily downloaded through the Google Play store.

### *2.4.1 Interviews with students and teachers*

Several rounds of interviews were conducted in the schools in order to gain insight into adoption level and benefits stemming from CITI-SENSE tools. Two rounds of interviews were conducted with professor of biology and students in elementary school “20. oktobar” and one round was conducted with professor of informatics in 6$^{th}$ Gymnazium Belgrade. These

interviews had previously established and formulated questions, but also allowed some room for free form answers. It must be noted that similar interviews were conducted with other participants/stakeholders, with similar goals, but that, somewhat surprisingly, the children were the ones that took the whole interviewing process most seriously and provided valuable input that was on par with answers given by other participants/stakeholders.

Some of the main points that can be drawn from interviews conducted in elementary school "20. oktobar" are as follows. Children liked the CityAir smarthpone app and used it in variety of places, not only limited to Belgrade, for example they used the app to mark good air quality in popular mountain resorts Kopaonik and Divcibare. In addition, they noticed poor air quality in city centre and main highways, and attributed it to cars. They also thought about the options map of perceptions gives them, stating that sometimes it is possible to take alternate, less polluted routes. Since the interview was conducted among children that will soon go to secondary school, it was noticed that the route planning and level of air pollution would then become more important, since they will take much longer routes to the school and back home again. Children used the CityAir app a few times per week, and also had some suggestions for improvements of the app, most notably, more visible comments area and more robust app functioning in absence of high speed internet connection.

In the second round of interviews, the children were asked about the impact the questionnaires had on them. The children stated that the main impact was awareness raising compared to their friends. Some suggested that it would be good to clearly state the impact air pollution has, and that questionnaires should contain that information. Some of the children changed their habits a bit, thinking more about walking and cycling when going outside. They also thought that they could do more in the future, when they become adults, and support initiatives like car-free day to become more frequent. One major remark of the children regarding the tools is that they are simply not popular enough, and that for some tools directly impacts their usability. They proposed organizing popularization event, for children by children, that would promote CITI-SENSE tools and raise air pollution awareness.

The interview with professor of informatics in 6$^{th}$ Gymnazium Belgrade was very informative, and it quickly turned into a series of proposals on how to improve engagement of students when they are filling in the questionnaires. The professor provided his insights into online questionnaires, and said that students are typically very interested in what answers their peers gave, and especially what score they make when doing online tests. In addition, the professor suggested that it would be good to give feedback to the users of the questionnaire immediately, and not at some later stage when the whole campaign is over.

### *2.4.2 Participating schools webpage*

Each of the participating schools had a corresponding web site on the citi-sense.eu domain. All sites shared the same basic information about the CITI-SENSE project and air pollution in general, and also had specialized content for each school. Figure 13 Figure 14 show front pages of elementary school "20. Oktobar" and 6$^{th}$ Gymnasium Belgrade web portal.

In addition to basic information about air pollution and the CITI-SENSE project, the web site content was specialized depending on each school activities. As an example, let us consider our campaign conducted in the elementary school “20. Oktobar”. The front page features the campaign, which consisted of several student groups measuring air pollution in their school using several different instruments. One group was also dedicated to counting students in classrooms, and the number of open windows during class. Each of the groups could enter the measured/or counted data in an online form, which was specifically tailored for that group and task.

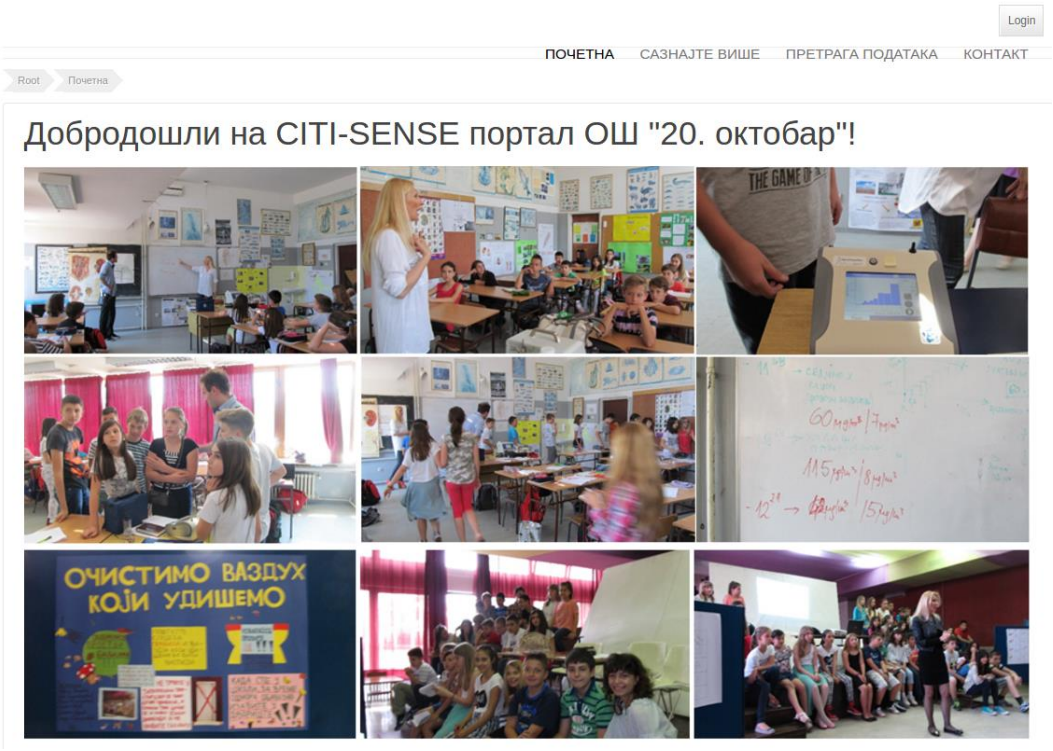



*Figure 13: Web portal for elementary school “20. oktobar”*


*Figure 14: Web portal for 6th Gymnazium Belgrade*

Figure 15 shows the front page of the school portal featuring measuring campaign which consisted of 3 groups of student (2 groups used IC-meter and Atmospheric platforms and 1 group was assigned to count students and number of open/closed windows in classroom).

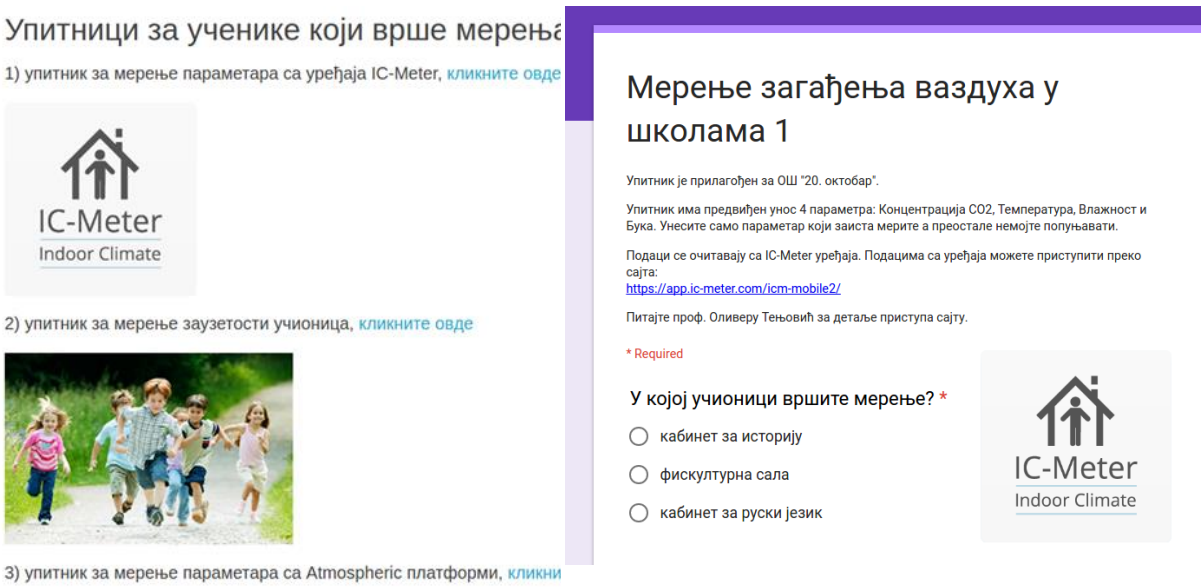



*Figure 15: Front page of elementary school "20. oktobar" web portal featuring measuring campaign a) and linking to corresponding online forms b)*

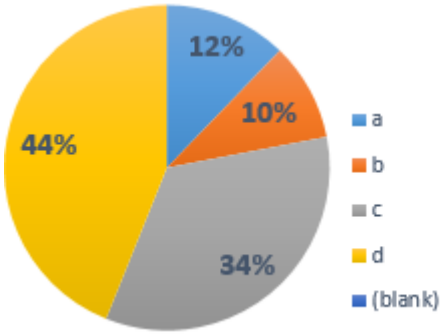
This type of campaign organization allowed for results of student efforts to be immediately visible and available on school web portal. By clicking on the link “Data search” (“Претрага података” in Serbian), students and site visitors could see parameters that were measured, for example temperature, CO concentration, noise, etc.

## 2.5 Empowerment evaluation

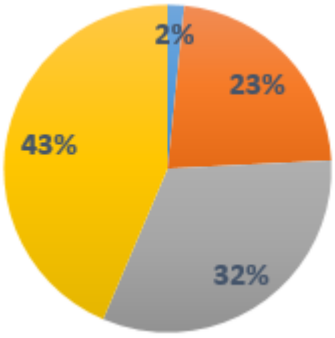
### *2.5.1 User evaluation*

In the Belgrade schools, questionnaires were completed only once. It was not possible to demonstrate an elevation of student knowledge pre/post, because we started with lectures and measuring air pollution in the pilot campaign. In addition, more than half of the students from both elementary and secondary school filled both school questionnaire and Long Questionnaire. Figure 16 shows the responses of elementary and secondary school students to selected questions from the Long Questionnaire.

**Elementary school**



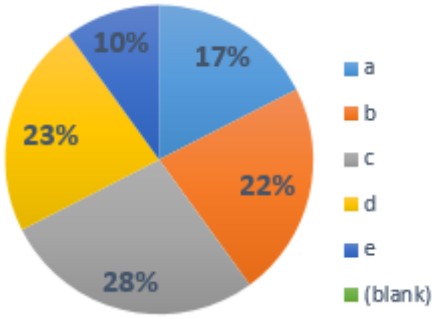

**Secondary school**



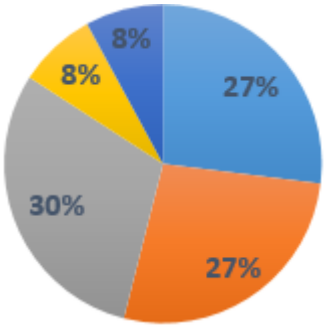

**How you are interested in Air Quality in general?**

*a-no, b- little, c-medium, d – very, blank*

**Elementary school**



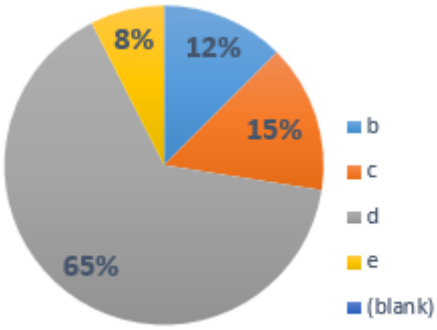

**Secondary school**



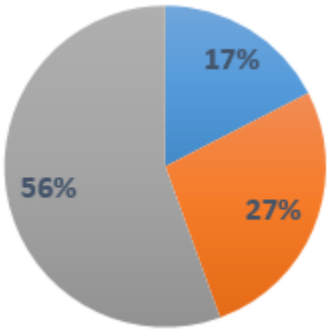

**How would you describe the air quality in Belgrade in general?**

*a-very bad, b - bad, c-good, d – very good, e- I don't know*

**Elementary school**



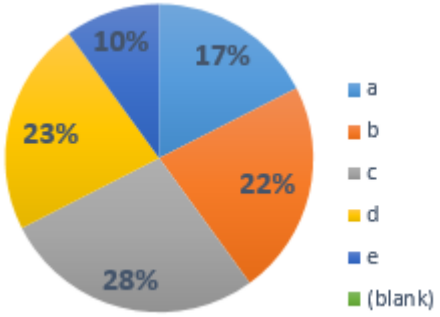

**Secondary school**



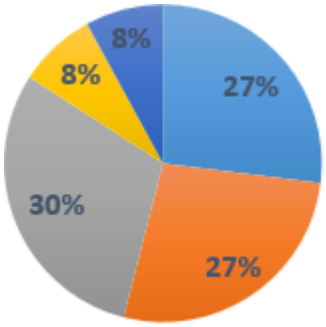

**To what extent do you think that the air quality in your city affects your health?**

*a-no, b- little, c-medium, d – very, e – I don't know*

**Elementary school**

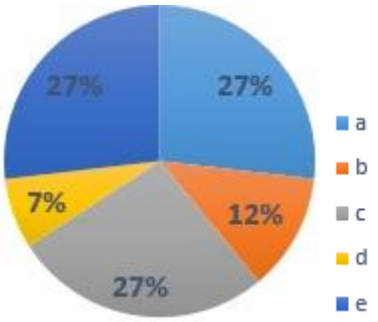



**Secondary school**

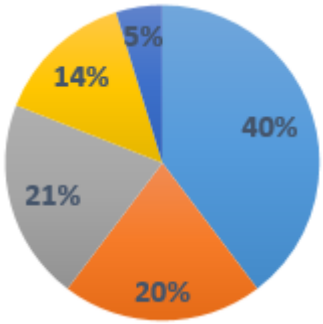



**Do you consider air quality when moving around in your city (e.g. avoid cycling in busy roads or exercising?** *a-no, b- little, c-medium, d – very, e – I don't know*

**Elementary school**




**Secondary school**




**How often do you consciously look at air quality information (e.g. via television, newspapers, internet)?***a-never, b- once per year, c-once per month, d – once per week, e – I don't know*

*Figure 16: The responses of elementary and secondary school students to selected questions from the Long Questionnaire*

More than 40% of students are very interesting in air pollution issues, while ¾ are very or medium interested. In the elementary school 45 % and more than half, 57%, of the students think that air quality in Belgrade is very bad or bad. About 60% of students think that air quality has a strong influence on health, about 20% think that air quality does not influence or they don't know. About 30% answered "medium" to the question if they care about air quality during walking or driving bicycling, about ¼ of the elementary school students and less than 10% of the secondary school students replied "very". Looking at how many of them are checking information on air quality in the media, it is rather surprising that 40% of the secondary and 27 of the elementary school students never look for such information. Between 21-27% check information about Air Quality once per month.

Taking into account that the majority of the students answered that air quality is not good in Belgrade and that it affected their health, it is necessary to offer them more information for Belgrade such they are able to find at Belgrade's CO at web page, http://belgrade.citi-sense.eu/.

# 3 Contribution to Citizens' Observatories

## 3.1 Lessons learned

The main lessons learned during collaboration with the schools in the framework of the CITI-SENSE case study are:

- In studies like this one, where it is imperative to work together (i.e., teams of researchers with teachers and school students), one of the most important issues is to recruit experienced and strongly motivated teachers. Engagement of the students is very much dependent on the teacher's skills .This depends also on the age of the students. From our experience, the students from the final classes of elementary school and graduating class of secondary school were the ones that were most motivated for collaboration.
- In an early stage of the case study, it was noticed that students had a lack of knowledge about indoor air pollution. Through the pilot and main campaign, step by step, the students increased their interest in air quality issues. In collaboration with the CITI-SENSE team and teachers, the knowledge and awareness of the students were highly improved.
- In studies where it is expected that student use measuring devices, it is necessary that all characteristic are well known at the beginning. Delays in delivery and cases when requirements are not fulfilled makes it difficult to work with the students and handle the expectations from both teachers and students. During the development process of tools for visualisation of collected AQ data, it is important to leave enough time for improvement of the tools according to feedback form students.

## 3.2 Expectation of Impact

The collaboration is planned to continue in the framework of national and international projects.

## 3.3 Recommendation for public bodies

Institute Vinca has a long tradition in collaboration with teachers and students form elementary and secondary schools, which are very interested to learn more and participate in short research studies in a wide range of topics.

Air Quality in living environments is one of the topics that need more attention through the education process. Researchers need to collaborate with students at widespread audience, to educate students how to reduce their own exposure to air pollution, how to keep and build healthier environments, improve air quality and how to involve them in research studies relating to air pollution by using simple devices and modern IC technologies.

Project title:
Development of sensor-based Citizens' Observatory Community for improving quality of life in cities
Acronym: **CITI-SENSE** Grant Agreement No: **308524**
EU FP7- ENV-2012
Collaborative project

# Deliverable D3.4

# Evaluation of the performance of the Empowerment Initiative at schools

## Appendix II – Edinburgh

**Version: 1.2, Date: 04/12/16**

Author(s) (alphabetically): Joanne Crawford (IOM)

Dissemination level: PU (Public)

# Versioning and contribution history

| Version | Date issued | Description | Contributors |
|---|---|---|---|
| 1.1 | 09/09/16 | Input for Edinburgh as Separate Appendix | Crawford, JO |
| 1.2 | 04/12/16 | Additional input from Edinburgh | Crawford, JO |
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## Summary

This appendix decscribes the work and collaboration done with three schools in Edinburgh; one secondary school and two primary schools. Although engagement exercises were carried out with all three schools, a number of problems were identified during the project including a lack of uptake in the secondary school because the project was perceived as risky, one school being unable to fit it into the curriculum and the final school being one of 17 that were shut down in the city due to serious building structure issues.

During the period of the project, the schools were engaged in different ways. The secondary school via a local conservation trust and a further two through local contacts of a national lobbying group. Initial meetings were followed up by a second meeting where further information was exchanged and discussions of how CITI-SENSE could be implemented. At this stage of the work the data flow was no in place and there were a number of delays.

No evaluations took place in the main study due to the limitations highlighted within the appendix. However, there were some useful learning points made in that the research team perceive that air pollution (both internal and external) is not seen as a major issue; it is hoped that our engagement has raised awareness of that. This was also the first time that the research team had been involved with schools and our understanding of curriculum planning has been raised as well as other barriers such as no access to wi-fi within schools. We did go to the schools with an outcome in mind and the schools who were able, took our offering and did something different.

There are other moves in Scotland at government level to improve air quality and educate people about its sources, CITI-SENSE has also contributed to this discussion.

# Table of contents

# 1 Methods

## 1.1 Recruitment of users

During the pilot phase, one secondary school was recruited to the project with the help of the Trust for Conservation Volunteers which is a charity that aims to educate schools about convervation. This relationship continued into the main phase of data collection as the school was willing to be involved. Our main contact who was the head of science at this school, retired the year preceeding the receipt of the sensors. However, she ensured that introductions were made to the new teacher and an initial introductory meeting was set-up. This allowed the opportunity to describe CITI-SENSE to the new teacher and to discuss how to move the project forward in coming months.

Two primary schools were also recruited to the main study. This was achieved via contact with Keep Scotland Beautiful, an organisation involved in increasing environmental awareness and aiding in professional skills for teachers. Two primary school teachers who had shown a willingness to be involved were contacted and an initial meeting set up with them to describe the CITI-SENSE project. At the conclusion of the meeting, the schools were willing to use the sensors.

A third primary school was also met with during this phase but their interest was in outdoor air pollution rather than indoor air pollution. It was felt that any problems identified with indoor air quality could not be solved due to it being an old building and any complaints would be seen as extremely negative to the local authority. However, WP2 did meet with the school to discuss outdoor air pollution.

## 1.2 Interaction with the users to identify their needs

After initial meetings with the schools, a second meeting was set up with all the schools to show them the sensing equipment and to discuss how best to present the data to each of the schools. Each of these is descrbed below.

The high school meeting involved a number of different teachers (computing, biology, physics) as well as pupils involved in the Eco-Schools group. After discussion with this group, it was decided to aim any project work to the more senior pupils involved in Advanced Higher courses. At this stage of education this allows individual pupils to run and manage their own projects supervised by teaching staff.

For the two primary schools, the second meeting involved showing the teachers the monitoring equipment and discussion around how to engage the pupils as well as sharing data collection methods (the civic poll survey) and discussion of comparing indoor and outdoor air quality. With both schools this allowed an opportunity to identify the resources they needed from IOM as well as how this could be built into the curriculum.

## 1.3 Tools and products

For the pilot phase AirBase Sensor units were used. This gave us the opportunity to present data to participants when discussing the overall project and how the school could become involved.

While encouraging the schools to take part, prototypes of the visualisation were shared with the schools to gain input into how best to present the data. Both the secondary school and one primary school were interested in actually gaining access to the raw data. The secondary school to enable pupils to use the data and analyse and present it as part of their advanced higher work. The primary school teacher was going to use it and present it to her pupils. Both groups did see the value in the 5 minute data that could be obtained from the dashboard.

The use of the survey tool on civic flow was also seen as a useful method of data collection about environmental perceptions.

Although there was discussion within the CITI-SENSE team about using other sensor technology during this phase of work, the Edinburgh team were unable to go down this route as using Wi-Fi based in schools in Scotland is not possible. Thus the team had to wait on the sensors going live and the data-flow being available on the website. This was one of the major limitaitons of the timing of this work.

*Figure 1: Air Sensor Unit*

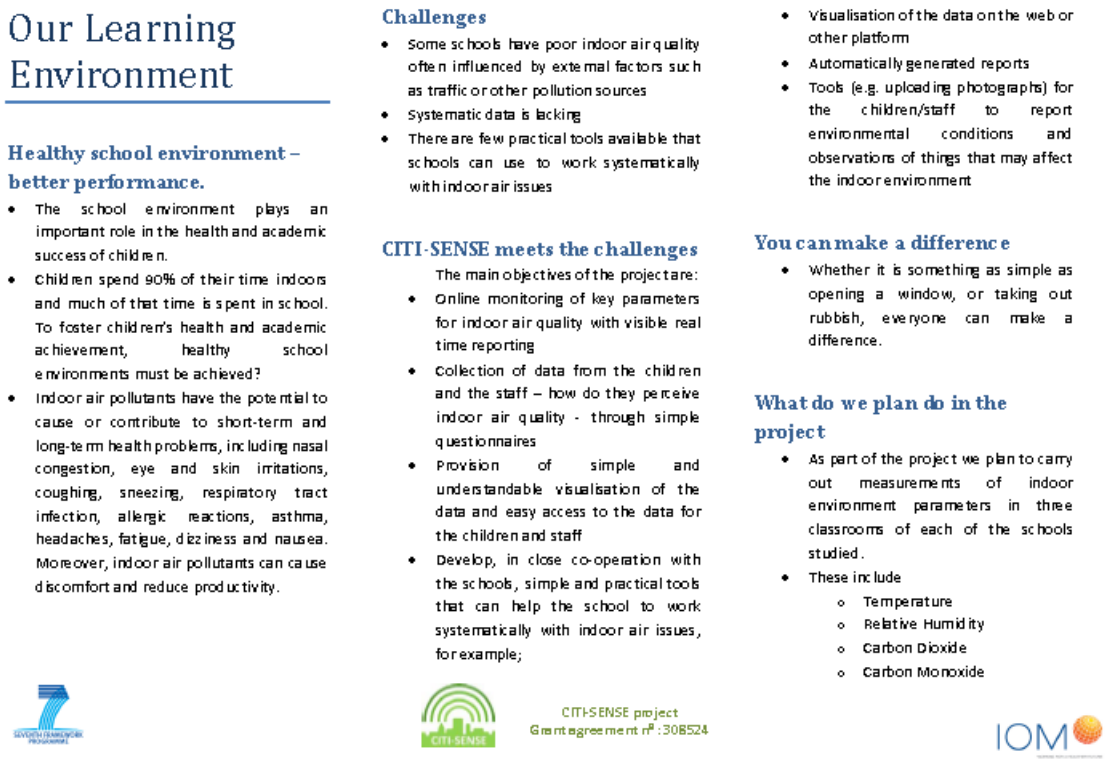
## 1.4 Engagement activities

Meeting with secondary school and presentation on what could be done, the pilot study the previous year and the findings from that.

For one primary school, an IOM researcher presented at the school assesmbly about the project and its objectives as well as discussing with the pupils the impact that indoor air quality can have on learning.

The second primary school was subject to emergency shutdown, along with 16 other schools in Edinburgh due to problems with the safety of the buildings. They withdrew from the study at this point.

Other local engagement activities were also carried out including an afternoon workshop session at the National Museum of Scotland where IOM had a stand to explain the project and try to engage interest in both the schools research and the outdoor measurement research.



Our Learning Environment

**Healthy school environment – better performance.**

- The school environment plays an important role in the health and academic success of children.
- Children spend 90% of their time indoors and much of that time is spent in school. To foster children's health and academic achievement, healthy school environments must be achieved?
- Indoor air pollutants have the potential to cause or contribute to short-term and long-term health problems, including nasal congestion, eye and skin irritations, coughing, sneezing, respiratory tract infection, allergic reactions, asthma, headaches, fatigue, dizziness and nausea. Moreover, indoor air pollutants can cause discomfort and reduce productivity.

**Challenges**

- Some schools have poor indoor air quality often influenced by external factors such as traffic or other pollution sources
- Systematic data is lacking
- There are few practical tools available that schools can use to work systematically with indoor air issues

**CITI-SENSE meets the challenges**

The main objectives of the project are:

- Online monitoring of key parameters for indoor air quality with visible real time reporting
- Collection of data from the children and the staff – how do they perceive indoor air quality - through simple questionnaires
- Provision of simple and understandable visualisation of the data and easy access to the data for the children and staff
- Develop, in close co-operation with the schools, simple and practical tools that can help the school to work systematically with indoor air issues, for example;
  - Visualisation of the data on the web or other platform
  - Automatically generated reports
  - Tools (e.g. uploading photographs) for the children/staff to report environmental conditions and observations of things that may affect the indoor environment

**You can make a difference**

- Whether it is something as simple as opening a window, or taking out rubbish, everyone can make a difference.

**What do we plan do in the project**

- As part of the project we plan to carry out measurements of indoor environment parameters in three classrooms of each of the schools studied.
- These include
  - Temperature
  - Relative Humidity
  - Carbon Dioxide
  - Carbon Monoxide

CITI-SENSE project
Grant agreement n°: 308524

IOM

*Figure 2: The Information Sheet Prepared for Schools*

## 1.5 Empowerment evaluation

### *1.5.1 Participants evaluation*

No formal evaluation of the participants was undertaken by this point of the study.

### *1.5.2 Stakeholder evaluation*

No formal stakeholder evaluation was carried out as there were no other stakeholders outside the schools involved in the project.

# 2 Results

## 2.1 Recruitment of Users

The recruitment of users to the study was mainly via already made contacts through the Trust for Conservation Volunteers or through Keep Scotland Beautiful. Although other routes had been tried, this “cold calling” type of approach was not successful in recruiting the schools.

## 2.2 User overall objectives

After the schools had been recruited a number of activities were undertaken. During the pilot phase, pupils in the secondary school used the outdoor sensors to measure differences when school buses were parked with engines idling versus air quality on days when the buses were not there. In the secondary school, the Head of Science proposed that the measurement and data be used for an Advanced Higher project. The project idea was not taken up by any of the pupils.

Within one primary school, the teachers were planning to use the sensors in different areas of the school (a five storey building) as well as using them outside. However, this was constrained by our main contact taking time off on maternity leave and a lack of time available within the curriculum.

Our final primary school was closed from the summer of 2015 as after building checks, it was one 16 schools in Edinburgh that had not been constructed safely. They had to withdraw at this point.

## 2.3 Specification of the user needs

After the presentation at the high school, although communication was maintained, there were no pupils willing to take the project forward into a project. At this point the data flow was not completely in place and there was perhaps concern about whether this would be in place in time for an Advanced Higher project. However, due to the importance of Advanced Highers in education (university entrance), there was perhaps an unwillingness to take a risk on the project, as more traditional projects are seen as the safer option.

### *2.3.1 Hardware needs*

There was no attempt made to involve the users in the development of the hardware due to the long lead in time until sensors were available and usable. However, it was the discretion of the researchers to ensure that some basic measurements including temperature, relative humidity and noise were available. There was initial interest in measuring radon by the secondary school but this was because it is sited within Holyrood Park in Edinburgh on previously volcanic land. As the school was a new build, buildings are required to ensure ventilation for any radon gas.

### 2.3.2 Data services needs

The users identified that being able to download historical data would be the most useful means of accessing information, especially for the secondary school.

## 2.4 Evaluation of tools, products and services

### 2.4.1 Air Base sensors and data products

The sensor units had issues with temperature measurement, as the sensor was affected by heat produced by the unit. $CO_2$-measurements had large unresolved calibration issues. Sensors for other parameters than T, RH and $CO_2$ were considered unreliable, even if the VOC-sensor showed a promising responsiveness. Web pages had many functions, but were somewhat hard to manoeuvre for the participants

### 2.4.2 Atmospheric Sensors –sensors and data products

Only sensors for T, RH and $CO_2$ were shown to the participants. This was mainly as it was perceived by the project team that other parameters were unreliable.

Access was given to one primary school to the data from the web page and it was identified that slowness was an issue when trying to download data.

### 2.4.3 IC-meters – sensors and data products.

Edinburgh could not use IC meters or the Netatmo product as both required the use of Wi-Fi. It was identified early on within the project that schools will not allow access to Wi-Fi by users outside the staff.

### 2.4.4 Supporting services

Our contacts with the school enabled a relationship to be built between the researchers and the schools. While the experience was made available to the schools, it was clear that with an already full curriculum timing was not going to be easy.

## 2.5 Empowerment evaluation

### 2.5.1 User evaluation

No evaluation work was carried out with participants but we went to schools with a commitment to be involved for a few years. We went with an outcome in mind – to help improve the quality of the environment in schools. The schools took our offering to do something different to help them with their curriculum in relation to projects especially that our young people can do.

### 2.5.2 Stakeholder evaluation

No relevant evaluation performed.

# 3 Contribution to citizens' observatories

Here we try to identify the critical elements for success or failure of future similar initiatives.

## 3.1 Lessons learned

One of the main issues in Edinburgh is that air pollution is not seen as a major issue in certain city parts. Although there are known hot-spots in Edinburgh, our schools were not situated within any of those areas, although one primary school was sited next to a busy road. This lack of awareness is likely to change with government policy and continuing pressure from different groups involved in measuring air pollution and increasing awareness more generally.

One of the main difficulties was that of building projects to fit with the school's curriculum and timing of the academic year. This was made even more difficult by delays in the delivery of the sensors as there are only certain times of the year that schools (especially secondary schools) are able to take part in research projects. Any future projects need to consider that and ensuring that technology is ready for use before participants want to use them.

The impact of change in personnel within schools and maternity leave also needs consideration and the lesson would be to involve more than one teacher who has an interest. This is likely to be easier in the secondary environment.

Understanding that school Wi-Fi is not for public use – you will not get access and through this we were unable to use other products for this project.

None of the staff who worked on the CITI-SENSE project had been involved in research with schools. This was a major part of our learning from the project and how to gain access to teachers. It was important that we were introduced to the schools via third parties (including the Trust for Conservation Volunteers) rather than cold calling. Relationship building is an essential part of engagement with participants and stakeholders in projects such as this.

## 3.2 Expectation of Impact

At the current time the Sustainable Scotland Network, Scottish Environmental Protection and Keep Scotland Beautiful are testing air pollution monitors with schools. Although the two projects are not related, this will further increase awareness of issues around air pollution in indoor environments. Although our three schools were made more aware of the issues around indoor air, the continuing work by the group above and other lobbyists in Scotland will hopefully continue momentum in this topic.

Project title:

Development of sensor-based Citizens' Observatory Community for improving quality of life in cities

Acronym: **CITI-SENSE** Grant Agreement No: **308524**

EU FP7- ENV-2012

Collaborative project

# Deliverable D3.4

## Evaluation of the performance of the Empowerment Initiative at schools

## Appendix III – HAIFA

**Version: 1.0, Date: 07.09.2016**

Author(s) (alphabetically): Yaela Golumbic (Technion)

Dissemination level: PU (Public)

# Versioning and contribution history

| Version | Date issued | Description | Contributors |
|---|---|---|---|
| 2.1 | 07.09.2016 | Input for Haifa Annex as separate document | Golumbic, Y.N |
| 3.0 | 21.11.2016 | Input from NILU | Britt Ann K. Høiskar |
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## Summary

This appendix describes the work and collaboration done in five schools in the Neve-Shaanan neighbourhood in Haifa, with the a collaboration of the "youth to adulthood" initiative carried out by the education department of the Haifa municipality. Throughout the project, air-quality sensors were distributed in these schools, which continuously monitored air-quality in the local environment. During a year long process, we identified our participants' needs and requirements through a series of interaction and routine meetings, which included hardware support, help with data interpretation and experiment planning. Together with the teachers in the 5 schools, we discussed how to implement the project in the schools, where to locate the sensors and collaborative work between schools.

Student knowledge, perception, behaviour, and scientific and critical thinking regarding air-quality concepts, were examined using pre-post questionnaires and combining observations and teacher feedback. Our results demonstrate that following their participation, the students' content knowledge and scientific thinking increased; however, perception and behaviour did not change significantly. Overall, students attained a sense of achievement and had positive feelings during participation. Many students stated that participation had increased their awareness towards air quality concepts and that it increased their knowledge about air pollution.

To conclude, we quote one of the teachers in-charge, who wrote the following thank you note, "In my name and in the name of the whole community, we appreciate and respect the meaningful contribution in raising awareness to air quality issues and in taking responsibility on the environment we live and work in".

## סיכום

נספח זה מתאר את שיתוף הפעולה אשר נעשה בחמישה בתי ספר בנווה-שאנן בחיפה, בשיתוף יוזמת "מלידה לבגרות" של מחלקת החינוך של עיריית חיפה. במסגרת הפרויקט, חיישנים-איכות האוויר הותקנו בבתי הספר וניטרו באופן שוטף את איכות האוויר בסביבה המקומית. במהלך תהליך אשר ערך בשנה, אינטראקציות ופגישות תכופות, זוהו הצרכים והרצונות של המשתתפים. אלו כללו תמיכה בחומרה, עזרה בפרשנות של נתונים ובתכנון ניסויים. יחד עם המורים המלמדים בחמשת בתי הספר, דנו כיצד ליישם את הפרויקט בבתי הספר, היכן למקם את החיישנים ובעבודה שיתופית בין בתי ספר.

ידע, עמדות, התנהגות, חשיבה מדעית וביקורתית על איכות-אוויר, נבחנו אצל תלמידים באמצעות שאלוני פרה/פוסט ובשילוב תצפיות ומשובי מורים. תוצאות המחקר מראות כי ההשתתפות תרמה לידע וחשיבה מדעית תוכן אולם עמדות והתנהגות לא השתנו באופן משמעותי. בסך הכל, תלמידים השיגו תחושה של הישג והיו רגשות חיוביים במהלך השתתפות. תלמידים רבים ציינו כי ההשתתפות העלתה את מודעותם לאיכות האוויר וכן הגדילה את הידע שלהם בנושא. כדי לסכם את העבודה שנעשתה בשיתוף עם בתי הספר, אחת המורות בבית-הספר כתב מכתב תודה בו ציינה: "בשמי ובשם כל קהילת "חשים את האוויר",אנו מוקירים ומעריכים את התרומה המשמעותית עבור הקהילה, בפיתוח המודעות לאיכות האוויר ובלקיחת אחריות על הסביבה בה אנו חיים ופועלים".

# Table of contents

# 1 Methods

## 1.1 Recruitment of users

We worked in five schools in one neighborhood in Haifa where the deployment plan was intented for. Four of the schools were elementry schools, working with 6th grade students and one was a middle school, where we worked with 7th grade students. This was made possible by a collaboration with the "youth to adulthood" initiative carried out by the education department of the Haifa municipality.

## 1.2 Interaction with the users to identify their needs

Interaction were mainly with the head of the "youth to adulthood" initiative in the neighborhood and with the science teachers of the five schools participating. We had bi-monthly meetings, discussing how to implement the CITI-SENSE project in the schools, where to locate the sensors and collaborative work between schools.

## 1.3 Tools and products

We mainly used the "AirBase" sensors (PerkinElmer) used by CITI-SENSE. For one school we also used the Geotech AQMesh pod for a certain period at the beginning of the project. Locations of the sensors were both indoor and outdoor and changed throughout the year. The locations were decided upon in the bi-monthly meetings with the teachers. Data collected from the sensors were downloaded by the Haifa team and sent to the science teachers in excel sheets and as ready made graphs.

## 1.4 Engagement activities

Participation in the project included meetings with project managers, planning of sensor locations, student research projects and dedicated lessons on air quality topics.

An initiatial meeting took place with participating students at the local highschool at the beginning of the school year. The meeting included an interactive class conducted by Technion experts presenting the air quality topic, monitoring and project plan.

Throughout the year, students conducted a research project, based on data received from the sensors located within the school and submitted a report summarizing their research questions, hypotheses, results and conclusions. A few of these projects were presented in a regional research-fair at the National Science Museum in Haifa. One of the group of students won a certificate of excellence for their work on this relevant and important topic.

At the end of the year, the students had a meeting at the Technion. During the meeting, students recived a map of the campus and an air quality sensor. They hypothesysed air quality in different locations across campus and planned a walk according to their hypotheses. The air quality information measured was uploaded to google maps, presenting the students' routes and values of the measured pollutants and was further presented on the board and discussed to compare initial hypotheses and results. Finally, all routes and values were sent to the the teachers for further exploration in the class room. The activity was a great success and many of the participants stated it was the highlight of the project.


## 1.5 Empowerment evaluation

### *1.5.1 Participants evaluation*

Evaluation was done using written questionnaires. The questionnaires were completed by students anonymously (due to ethical considerations) at the beginning and end of the school year and comparisons were done on group level. The questionnaires were composed of five sections: knowledge, attitude, behavior and scientific and critical thinking. The post questionnaire had an additional section with open questions examining participation, satisfaction and perceived personal benefit.

### *1.5.2 Stakeholder evaluation*

No formal evaluation of other stakeholders' experiences was performed, as the activities as actually carried out to a very small degree involved stakeholders outside the participant groups.

# 2 Results

## 2.1 Recruitment of Users

Engagement of schools was very successful. All schools contacted were happy to participate and acknowledged the additive educational value. Both students and teachers stated they were very happy with the project. The favorite activity throughout the project, as stated by students, was the hands-on meeting at the Technion.

## 2.2 User overall objectives

Schools were interested in the educational value of participating from a number of aspects:

1. Scientific knowledge- science teachers were interested in seeing increased knowledge of students in the scientific processes taught, types of pollutants and their relationships.
2. Scientific thinking- science teachers also were interested in exploring the scientific process, such as asking scientific questions, planning experiments, reading graphs, analysing data and forming conclusions.
3. Social involvement- teachers aknowledged the additive value of contributing to the community and teaching values of being involved and active citizens.

## 2.3 Specification of the user needs

### *2.3.1 Hardware needs*

The sensors chosen for the use in the schools were the "AirBase" sensors (PerkinElmer), as used within the CITI-SENSE project. The sensors measured Temp, $NO_2$, $O_3$ and VOC. One big obstacle in the installation process was the need to get the municipality security approval for installation of sensors in the schools. The approval included the need of an approved electrician to conduct all sensor installations and extensions of electrical outlets.

### *2.3.2 Data services needs*

The data from the sensors were downloaded by the Haifa project team and sent to the science teachers in excel sheets and as ready made graphs. Since the studens conducting the research projects were relatively young, excel files had to be substantially reduced and averaged.

### *2.3.3 Supporting services needs*

Not all teachers had the relavent background to teach air quality topics. Therefore, some guidance was needed from Technion scientists regarding the meaning and relationships of different pollutants in addition to explanation of the Haifa air quality status.

## 2.4 Evaluation of tools, products and services

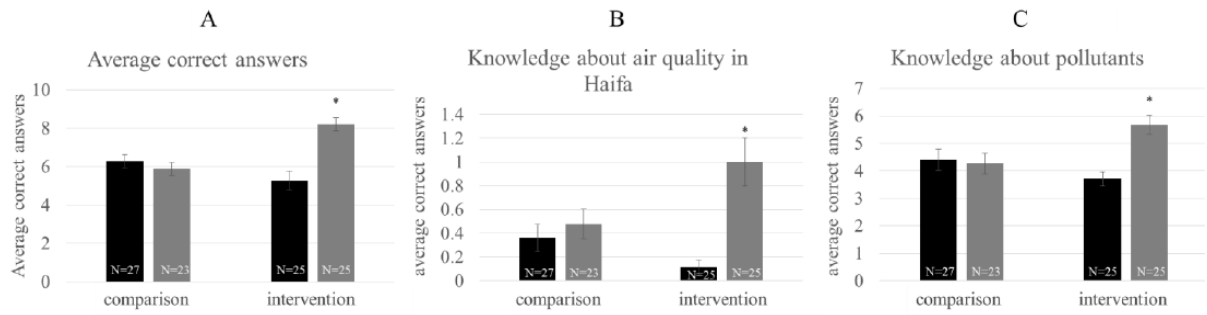
## 2.5 Empowerment evaluation

### *2.5.1 User evaluation*

Results from the pre/post questionnaires demonstrate an elavation in student knowledge of air quality concepts and a decrease in number of times they replied "I don't know". Specifically, a major increase was found in questions regarding air quality in Haifa, for example in the reply to the statment: "Air pollution in Haifa has decreased significantly over the past 20 years" (true). An increase was also found in the participants' content knowledge of air quality and pollutants, between the pre and post group, for example in reply to the statement: "Ozone is not considered an air pollutant since it is a major factor in filtering the radiation from the sun" (false).

Student scientific thinking was also found to increase following participation in the project activities. This increase was represented by student phrasing better research questions and identifying factors influencing air quality in specific situations. In addition, the open post-questionnaire section indicated the students' sense of acquiring new scientific skills, such as reading and understanding graphs, writing research questions and performing experiments.

No differences were found between groups in critical thinking, attitudes or behavior towards air quality. Attitudes toward the environment and air quality issues were fairly positive in all four groups with an average of 3-3.2 on the likert 1-4 scale. These positive attitudes are illustrated by agreeing to statement such as "it is important for me to protect the environment" and "I am worried about the medical implications of high air pollution". Behavior towards the environment and air quality resulted in 2.2-2.5 average on the likert 1-4 scale, demonstrating students sometime engage with pro environmental and air quality behaviour.Overall, students attained a sense of achievement and had positive feelings during participation. 54% of students stated participation had increased their awareness towards air quality concepts and an additional 25% stated it increased their content knowledge.



# 3 Contribution to Citizens' Observatories

Here we try to identify the critical elements for success or failure of future similar initiatives.

## 3.1 Lessons learned

The two main lessons we have learned during this collaboration are related to the desire and ways to collaborate and to the educational values.

**Ways to approach schools for collaboration**- The schools we have been working with really wanted to collaborate with a big university such as the Technion. They feel it is empowering for their students, and gives the school a good reputation. However, the focus has to be on collaborating and working together in order for it to really work (not saying we want to use your spaces for our sensors, but rather we want to work together to find out what the air quality is...).

**Setting educational goals**- If you have specific educational goals beyond participation and content knowledge (such as critical thinking), you have to specifically introduce the students to the topic and teach them how to approach it. Critical thinking will not "just happen" if you do not set the goal and ways to obtain it. Prolonged work with students, emphasizing the nature of science, setting goals for higher level thinking and promoting action may further promote critical thinking and a global understanding of what science is and engage students in action for improving the local environment.

## 3.2 Expectation of Impact

The participation is expected to continue and involve additional schools and institutions, and enhance collaboration of the schools with other projects in the future.

## 3.3 Recommendation for public bodies

Collaboration of schools and academia is a powerful tool which empowers both students and teachers. Creating a clear plan is essential for meeting social and educational goals and for working with the complex schedule in the school environment (see lessons learned).

Project title:

Development of sensor-based Citizens' Observatory Community for improving quality of life in cities

Acronym: **CITI-SENSE** Grant Agreement No: **308524**

EU FP7- ENV-2012

Collaborative project

# Deliverable D3.4

## Evaluation of the performance of the Empowerment Initiative at schools

### Appendix IV – Ljubljana


Author(s) (alphabetically): David Kocman (IJS), Johanna Robinson (IJS)

Dissemination level: PU (Public)

# Versioning and contribution history

| Version | Date issued | Description | Contributors |
|---|---|---|---|
| 1.0 | 15.7.2016 | First input | Johanna A Robinson, David Kocman |
| 2.1 | 2.9.2016 | Second input | Johanna A Robinson, David Kocman |
| 3.0 | 26.10.2016 | Editing - restructuring | Britt Ann K. Høiskar |
| | | | |
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| | | | |

## Summary

In Ljubljana one high school and two primary schools were recruited to participate in the CITI-SENSE project. Altogether, this resulted in involvement of approximately 80 high school students and 15 classes of primary school students, their teachers and other stakeholders. Depending on the specific interests and abilities of students involved, a wide range of activities were carried out. In addition to traditional science projects where students used the equipment and other support provided by the project, they were also involved in various awareness raising activities both within the school and publicly. In addition, special nature days were organized for the youngest stakeholders.

Activities were documented and evaluated by means of questionnares, interviews and written feedbacks depending on the type of activity and the age of the participants; high school students receiving questionnaires, teachers being interviewed and youngest students writing feedback in a form of a letter. In the course of the project, numerous win-win situations were created in Ljubljana based on interaction between researchers and schools. Amongst others, CITI-SENSE activities resulted in changed awareness regarding the indoor and outdoor air quality and consequently more pro-environmental behaviour of the people involved. One of the most important outcomes is also the very successful participation of students at national and international school competitions. Moreover, numerous positive chain reactions took place, leading to enhanced cooperation and interaction of various local stakeholders involved.

## Summary (Slovene)

V Ljubljani so bile v projekt CITI-SENSE udeležene ena srednja in dve osnovni šoli. Skupaj je bilo v projekt vključenih približno 80 dijakov, 15 razredov učencev, njihovi učitelji ter drugi deležniki. Izvedene so bile številne dejavnosti prilagojene interesom in sposobnostim sodelujočih. Pri raziskovalnih nalogah so imeli na voljo opremo in strokovno pomoč s strani projektne skupine. Za najmlajše udeležene, to je učence osnovnih šol, so bili organizirani tematski naravoslovni dnevi. Poleg tega so bili učenci in dijaki vključeni v različne aktivnosti za ozaveščanje o problematiki kvalitete zraka in sicer tako znotraj šole kot tudi širše.

Vse dejavnosti, ki so bile izvedene, so bile dokumentirane in ovrednotene. Glede na vrsto dejavnosti in starost sodelujočih smo uporabili različne načine pridobivanja povratnih informacij: izpolnjevanje vprašalnikov, razgovore in zapisovanje doživljajev. Posledica vzajemnega sodelovanja med šolami in raziskovalci v okviru projekta CITI-SENSE v Ljubljani so številne obojestranske koristi. Eden izmed bolj pomembnih rezultatov projekta je povečana ozaveščenost o problematiki kvalitete notranjega in zunanjega zraka ter posledično izkazano bolj okolju prijazno vedenje udeležencev. Izpostaviti velja tudi zelo uspešno sodelovanje učencev in dijakov na domačih in mednarodnih šolskih tekmovanjih. Zaključimo pa lahko z dejstvom, da smo kot posledica dejavnosti v okviru projekta, zaznali in evidentirali okrepljeno in tudi na novo nastalo sodelovanje med različnimi lokalnimi deležniki.

# Table of contents

# 1 Methods

## 1.1 Recruitment of users

The recruitment of schools in Ljubljana was based on both existing collaboration as well as new connections. Two primary schools and one high school were recruited to participate in CITI-SENSE. One of the primary schools was already involved in a previous biomonitoring study taking place in Ljubljana. The high school is constantly looking for collaboration with institutions acting in science, making the participation in the project a good arena for various types of research activities the school was after.

## 1.2 Interaction with the users to identify their needs

Various face-to face meetings took place to identify what kind of activities the schools wanted to carry out. The meetings included both teachers and students. Headmasters were present on preliminary meetings which took place at the schools. The schools were mainly interested in finding meaningful research activities, while in few cases known indoor issues e.g. on radon were also carried out.

## 1.3 Tools and products

The school in Ljubljana used both CITI-SENSE sensor units (Atmospheric Sensors and OBEO) as well as the plan B off-the-shelf Netatmo units (https://www.netatmo.com).

In addition, the local scientific partner Jožef Stefan institute (JSI) provided some additional equipment e.g. a $CO_2$ meter for more specific activities.

After identifying a radon issue at one of the primary schools, which was first mapped with the CITI-SENSE Obeo radon sensor, a professional Radon Scout (Sarad) was used to assess the radon levels in more detail and be able to identify proper actions.

A prototype of an early portable AQ measurement device VESNA-AQA was both used in group activities in high schools as well as in primary schools. One high school and two primary schools were also provided with CITI-SENSE outdoor AQMesh. Walks around school neighbourhoods were conducted several times with CITI-SENSE LEO – Little Environmental Observatory (http://citisense.ateknea.com/).

The high school showed interest and knowledge on building their own $CO_2$ sensor unit (Figure 1) which displays the $CO_2$ concentration on a led screen.

A high school in Ljubljana made use of the webpage http://vic.citi-sense.eu/en-us/ to promote their activities through their participation in the CITI-SENSE project. The school has plans to continue using it also in the future. In addition to the web page, the high school also created a Facebook page (Figure 2) which they are actively using for awareness raising purposes on environmental issues.


*Figure 1: The $CO_2$-sensor unit built by the students*

## 1.4 Engagement activities

Introductory and thematic lectures were held at the schools during the first meetings, as well as when specific themes were discussed. PowerPoint slides were prepared in Slovene and adjusted to the age groups.

The main engagement activities in Ljubljana were:

- Nature days
- Science projects
- Poster campaign
- Bike and balloon campaign
- Open school day events

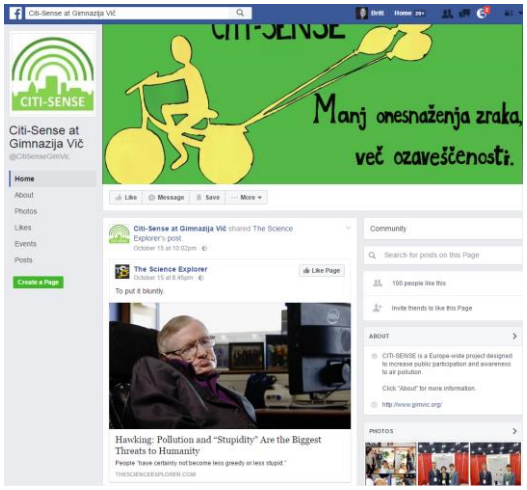


*Figure 2: The Facebook page designed and operated by the students, https://www.facebook.com/CitiSenseGimVic?fref=photo*

### The Nature day concept

The concept of Nature days was developed in Ljubljana. This involved various activities in the woods for young primary school children. CITI-SENSE project in Ljubljana has a strong focus on engaging with young stakeholders. The approach, which the Ljubljana case study adapted, knits together technology, education and active citizenship. Organizing Nature days in a local forest introduces the youngest ones to the topic of air quality through various activities. Different activities were designed for two different age groups. The youngest ones were 6-7 years old, and the oldest ones 9-10.

In a Nature day for the youngest elementary school kids, the concept was tied around an introduction to the concept of measurements and uncertainty which researcher tackle in their daily tasks. The storyline for the activities was based on explaining and experimenting how there are things around us that we can measure ourselves based on our observations and tools, but for some we need special devices, e.g. for air quality. The children got to learn

about it through various measurements techniques, where instruments were used together with or by the children and coupled with gaming exercises.

The instruments used were for example a $CO_2$ meter, portable air quality unit, infrared camera, 1 m stick and a laser distance measurer. We divided for example the group (around 20 children) in two, where the first half went into a tent and immediately saw how the $CO_2$ concentration raised inside, while the other half were standing outside, pointing at the tent with an infrared camera seeing the otherwise invisible for bear eyes - people in the tent. In the Nature day in summer 2016, an outdoor laboratory where kids could pipet and measure water was included.

Nature days for higher classes i.e. 3rd and 4th graders included a treasure hunt. A Treasure map was prepared, which the kids used for orienting in an urban forest. Seven activities were marked with dots on the map. The children had to find their way to these locations where centrifuge tubes were hidden. Once found, they included instructions for activities, as well as a hint to find the next location. On each location, children were asked to colour the air quality either green=good, orange=medium, red=bad. At the final dot, a treasure was waiting to be found.

*Figure 3: Nature day in Ljubljana for 1st graders.*

At the end of the Nature days, the classes were provided with group images taken with an infrared camera, as well as a printed map of air pollution measured in the location covered during that day's activities. Altogether six Nature days were organized in the summer 2014, 2015 and in 2016. The teachers have asked us to repeat the concept again the following summer. The activity also led to an article in Naravoslovna solnica – journal for teachers of science subjects, which was initiated by a teacher.

*Figure 4: A Nature day in Ljubljana, 4th graders*


*Figure 5: Nature day collage from Ljubljana*

**Science projects**

In Ljubljana, both primary school and high school students participated in science projects. The primary school science projects included measurements of $CO_2$ in a classroom in relation to classroom size, ventilation and amount of pupils. Another science project focused on particulate matter (PM) in a classroom. As a part of the latter one, a cleaning activity was arranged to test a hypothesis that the dust levels will change after the classroom has been cleaned.

The high school focused on very technical science projects as well as awareness raising activities. The titles of the measurement based science projects were:

- Air quality in occupied and non-occupied room,
- Measuring with the VESNA-AQA instrument,
- Changes in air quality parameter concentrations of CO, $NO_2$ and $O_3$ by opening a window,
- Comparison of air quality at home and at the seaside,
- The chemistry of the air,
- NETATMO - measurements in a room with open and closed windows,
- Air quality in classrooms at Vič high school
- Development of a mobile application for displaying air pollution in cities

The more applicable activities at the high school included the development of a mobile phone application to display air pollution in cities and the production of a short film. The two high school students that developed the mobile application displaying air quality in cities presented their work in various international competitions (e.g. Genius Olympiad in Houston, US), receiving awards for their accomplishments. The phone application enables inclusion of measurements from any amateur air quality monitoring product, CITI-SENSE data and cities being just one of many global sources of data. The municipality of Ljubljana acknowledged their success by arranging a meeting with the mayor as well as including them in the green capital activities in 2016.

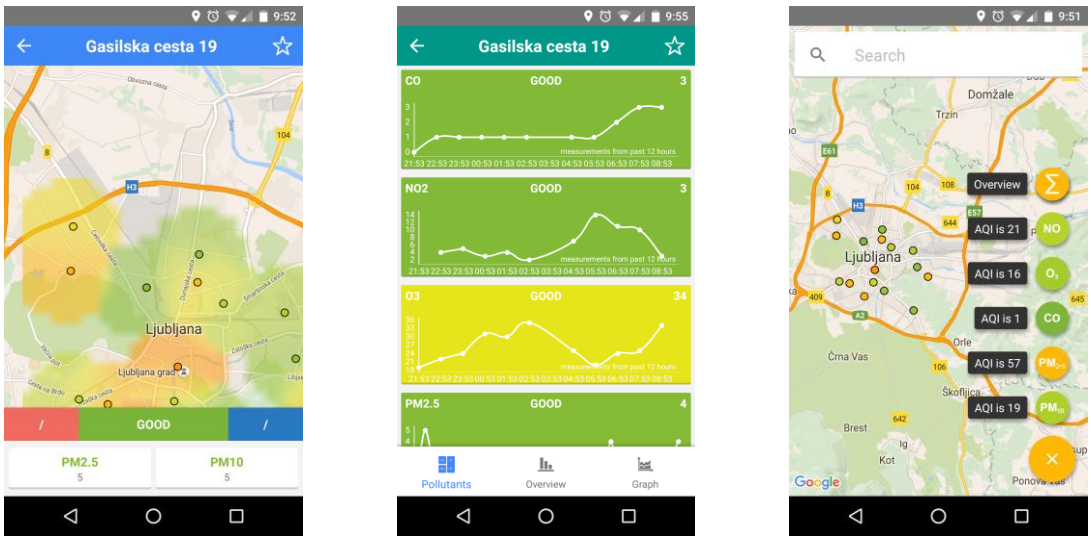


*Figure 6:The phone application to display air pollution in cities developed by high school students*

Consultation with various teachers took place face-to-face throughout the school years. The focus was on air quality at school, designing and assisting research activities for smaller groups of students, who later also competed and succeeded in national school competitions. The winners travelled to lake Garda, Italy.

One of the science activities in a primary school earlier mentioned was a classroom cleaning activity regarding PM in a classroom. JSI was invited to participate in the school's open day events in 2015 and 2016 where the students presented their research activities.

As separate activity for 8$^{th}$ graders from two different primary schools was involved in a tour around their schools' neighbourhood. During these walks, portable air quality units were carried and air quality discussed during and after the walks, see Figure 7 and Figure 8.

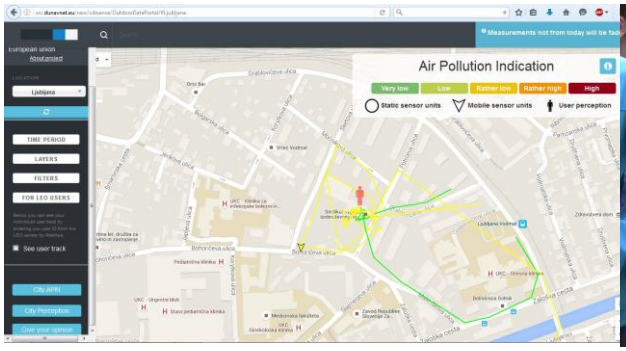


*Figure 7: User track from a walk around a school neighbourhood.*

*Figure 8: Walk around a school neighbourhood with a portable AQ device*

The students and teachers were rewarded for their participation by providing complementary promotional items from the project. The youngest ones received reflectors and older ones T-shirts, see Figure 9.


*Figure 9: Complementary promotional material for the participants*

**Poster campaigns**

This awareness raising activities included designing weatherproof outdoor posters in front of the school, which have been on display for over a year at one of the busiest roads leading to the centre of Ljubljana. Two sided informative posters prepared by the high school students were installed in front of the school early spring 2015. The posters inform the passers-by not only about the schools involvement in air quality activities but sparks the spirit for others do something about it as well.

**Bike and balloon campaign**


*Figure 10: Outdoor posters in front of Gimnazija Vič*

Another awareness raising activity was a so-called “Bike and Balloon” event organized together with high school students at the centre of Ljubljana. Prior to the event, cookies were baked and balloons were decorated with slogans like “-50% ozone”. During the event, local people were approached on the streets and were given cookies, balloons and small QR-code equipped business cards. The QR-codes took the visitor to the schools CITI- SENSE webpage http://vic.citi-sense.eu/ where they could find more information related to the air quality questions printed in the business cards. Similar activities were repeated during other public outdoor and indoor activities.

**Interaction with local authorities**

Prior to the Bike and Balloon event, the most active high school girls met with the head of the environmental department at the city of Ljubljana, where they described their awareness raising activities. Later the same year, the boys who developed the phone application were invited to meet the mayor of Ljubljana after successfully competing in an international high school competition in the USA.

*Figure 11: Friendly messages being delivered at the streets of Ljubljana*

**School open day**

Several open day activities were arranged both at the schools and on the streets of Ljubljana where especially the high school boys who developed a phone app presented their work. Girls repeated the cookie, QR code and balloon activities during these events.

Both primary and secondary schools invited us on their open day events where they wanted to promote and disseminate their activities as well as presented the research done at schools.

In addition to direct activities at schools, we demonstrated the activities to other science teachers in other schools in Slovenia during a third natural science teacher's conference where a workshop was organized together with participating high school teachers.



*Figure 12: Examples of posters and stands at the open day event at a primary school and outdoor event with high school students*

## 1.5 Empowerment evaluation

The evaluation of activities in schools in Ljubljana was assessed in various ways. The seven most active high school students received an online questionnaire mapping the motivation and benefit of participation, evaluation of the success, topical understanding of air quality issues and other skills learned, pro-environmental behaviour, decision making during the participation, communication, the role of scientists, mentoring and improvements for next year's activities. The results and more detailed methods are available in Robinson (2015). In addition, a couple of statements from high school students were recorded on video.

Two high school teachers were interviewed about their motivation to participate, their role, the benefit for students participation, learning, evaluation of success, change in awareness and behaviour, communication and feedback for improvements.

Feedback from primary school teachers was collected during a final project meeting. Children who participated in Nature days were asked to write the LOs a feedback letter describing their day.

# 2 Results

## 2.1 Recruitment of Users

The schools have been very interested in participating in the CITI-SENSE project, which made the recruiting process easy. New connections between research institution and local schools created win-win situations enabling students to interact with the scientists.

In Ljubljana, this aspect was particularly welcome, as many schools are interested in participating in national and international school competitions, where the school children can work with advanced science projects, having scientists as outside mentors.

The Ljubljana case study involved three schools for indoor activities. In addition to the official three schools that were participating in CITI-SENSE, many more showed interest. One school who we made contact with at the science teachers conference was included in outdoor air quality activities. Altogether 82 high school students directly participated in the project. However, through less scientific outreach activities and local promotion, many more learned about the project.

In primary school, three classes of eighth graders participated in walks around their school. Two groups of students conducted research on air quality. Altogether 12 classes of primary school children ($1^{st}$-$4^{th}$ graders) participated in our nature days during summers 2014, 2015 and 2016.

## 2.2 User overall objectives

Schools in Slovenia are interested in participating in national and international school competitions. CITI-SENSE provided a good opportunity to both have equipment to do student research as well as support from the scientists. The high school is constantly looking for new scientific partners to provide the scientific content on the activities at their school.

For some students, the international dimension of the project works as a motivation. The project also gave possibilities both for those who like experimental work and research, as well as those who are more into social studies and arts. The students were given free hands to come up with their own research projects, and the self-initiative of the students is highly encouraged especially at the participating high school. Motivation to do indoor related research can also raise from the fact that the students are exposed to different environmental conditions in every classroom, and it is mainly left to the teachers control the classroom conditions.

Benefits which students saw by participating vary from being able to work with scientist and technical tasks to having access to knowledge which is otherwise not accessible thru the education system. The knowledge they get thru this kinds of projects is transferable in life.

## 2.3 Specification of the user needs

The schools considered $CO_2$ to be the most relevant parameter. This was however not available in the first phase of the project, which resulted in some disappointment.

Later on, focus switched on access to data, especially for the boys working on a phone app. They needed access to CITI-SENSE data in JSON, which was later granted. Primary schools needed help on data download and processing, leaving the CITI-SENSE solutions not easy enough to use for youngest stakeholders.

As high school students had the capabilities to edit web pages on their own, access was provided for them to add and edit content. However, during public events (e.g. high school competitions abroad) when the web page was planned to be on display, the servers hosting it where down. This caused constant disappointment, among other technical unfunctionalities the DNN page featured.

## 2.4 Evaluation of tools, products and services

### *2.4.1 The sensor units*

The CITI-SENSE sensors are valuable tools for engaging young stakeholders. The challenges related to the sensor data quality provided a great opportunity for introducing the principles of metrology to the students, as well as to demonstrate that science is a process, where first prototypes are just one phase of the development of new products.

The sensors also proved to have a great educational potential since they allowed for quick demonstrative experiments outdoors (e.g. portable ones during nature days).

Access to the data was challenging for some teachers and students. On the other hand, the boys who developed the phone application were able to use the data coming from the CITI-SENSE outdoor sensors and accessed it in JSON format.

The schools were particularly happy with the off-the-shelf Netatmo (see Annex VI), and asked to continue working with them also after the project officially ends. One of the primary school class was actively inquiring the air quality information in their classroom by pressing a button on top of the Netatmo device, which gave an indication of the current air quality with colour codes (green=good, yellow, medium, red=bad). This also triggered a pop-up in our phones every time they did so, as the Netatmo comes with a phone application enabling this feature.

Primary school teachers and children are not familiar with drawing graphs in Excel. An easy to use downloading option of readymade graphs from the sensor pods would be very useful. The sensor pods were not accurate enough to provide information that could be compared to regulative values. Many schools are interested in this kind of information in order to know where their indoor air quality stands. $CO_2$ and PM were the most interesting parameters for schools in Ljubljana. However, all other parameters received attention as well.

### *2.4.2 Questionnaires as tool for providing user feedback*

The case study in Ljubljana tried introducing questionnaires several times in the high school both online (Civic Flow/Google Forms) and paper based during the first year of activities. However, the school was reluctant to answer any questionnaires.

Similar feedback was gained by other means, e.g. listening and writing down the stakeholders' opinions during meetings. However, two groups of students were collecting feedback from their peers using their own questionnaires. In the high school, the students' opinion about the indoor air quality was mapped, whereas in the primary school, the focus was on PM. Unlike in the Oslo case study, individuals were working on the project at the high school rather than whole classes, which made the questionnaire used in Oslo less applicable.


*Figure 13: Treasure map with coloured air quality*

Similarly, groups of primary school students were involved in one-time activity outdoors (The Nature Day), which also made the Oslo questionnaire not applicable. Instead, the children were asked to write us a letter about the Nature days (what they learned, what they liked and so on). Some of the children drew images and mind maps instead. Primary school children also coloured subjective air quality during nature days on a treasure map, see example in Figure 13.

In one of the activities outdoors, the primary school children were answering questions in groups about air quality on coloured sticky notes, see example in Figure 14.

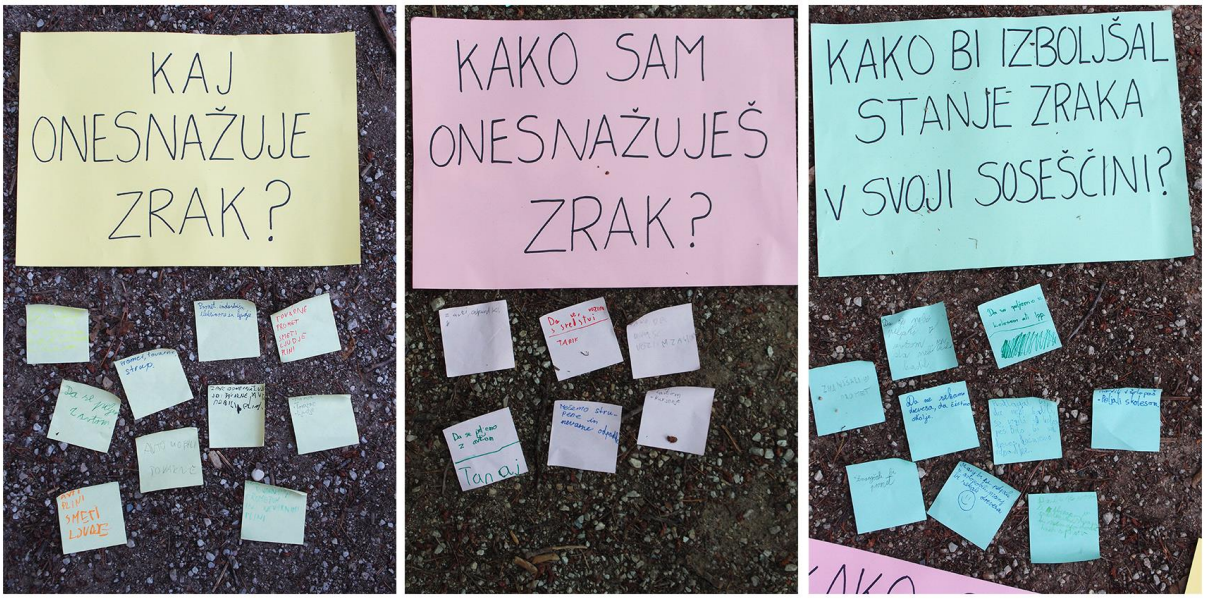


*Figure 14: Questions and answers about air quality during outdoor activities*

Statements from students at primary school were recorded on a video during a nature day, see Figure 15. Similarly, high school students self-recorded statements at their school.

*Figure 15: Student giving video statements about the Nature day.*

## 2.5 Empowerment evaluation

Results of questionnaires of high school students and interviews with teachers are presented in detail in Robinson (2015).

In general, the high school students appreciate the possibility to participate and liked to work with scientists. This is illustrated in some of the video statements from high school that are shown in Table 1.

*Table 1: Video statements from high school students*

| **Teacher at Gimnazija Vič (or Vič high school)** |
|---|
| - Project CITI-SENSE brings together students, scientists and teachers to study the quality of air around us. The spirit has been creative and relaxed. We have also been raising public awareness of these problems. |
| **Student at Gimnazija Vič** |
| - In the course of the last two years, me and my classmate in co-operation with researchers from Jožef Stefan institute made a phone application, which will display air pollution in Ljubljana. Currently, the phone app is in a testing phase at Google play, and it will be available soon to the general public. |
| **Student at Gimnazija Vič** |
| - Participating in the Genius Olympiad was a great experience. We met many interesting people. In addition, we were able to compare our assignment to |

| |
|---|
| similar assignments from all over the world. When our phone app will be publicly available, we will participate in another international competition. |
| **Student at Gimnazija Vič** |
| - Together with my classmate Rok, I have been dealing with indoor air quality while participating in the CITI-SENSE project. In order to raise the public awareness about the air quality, we created a web page and distributed QR codes. Next year we are planning to participate in Genius Olympiad high school competition. |
| **Student at Gimnazija Vič** |
| - It has been really interesting to co-operate with scientists and use professional equipment. Because we realised what important role the indoor air quality plays on the feelings of the high school students we are going to make a scheme of an optimal ventilation of classrooms. |
| **Student at Gimnazija Vič** |
| - I made a video which features environmental protection and about how each individual can contribute to a cleaner environment. I learned a lot about filmmaking and about the environment while making the film, as well as when participating in the Genius Olympiad. |

The video statements from primary school kids about the Nature days are all positive. They enjoyed the day. The letters (see below image) also reveal that kids like the Nature days. Not just subject wise, but also because they can spend the day in nature with friends and run around freely.

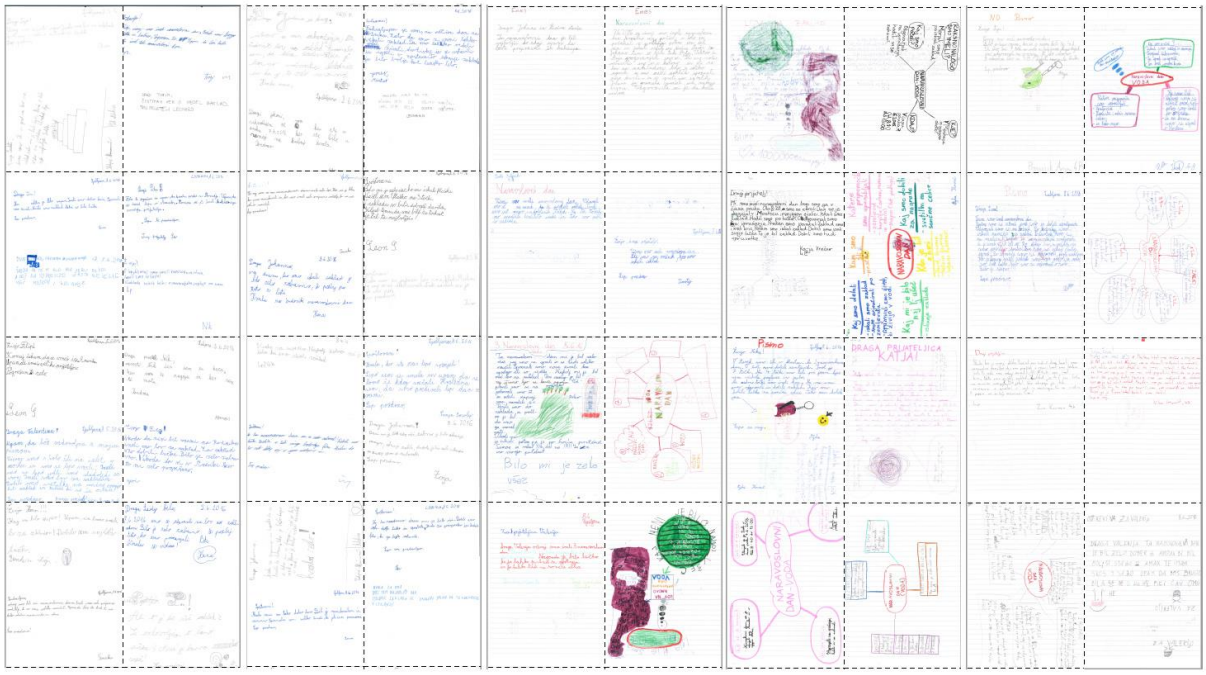

*Figure 16 : Children's feedback letters about nature days in Ljubljana*

We learned how air quality issues are well understood even by the youngest ones. They are already familiar with locations and sources of good and bad air and how one can influence it. Gaming was both fun and productive. Good preparation of activities is essential, so that the work flows smoothly. Documenting the events with a camera is recommended, but challenging.

### *2.5.1 Stakeholder evaluation*

In the Ljubljana case study, several positive chain reactions occurred. Teachers and students, not originally recruited to participate, heard about the project and wanted to participate too. The interactions within the school evolved in the lifetime of the project as well as beyond.

Connections were also made between stakeholders from WP2 and WP3. One stakeholder for example from WP2 was interested in finding school partners for a project dealing with noise and we made the connections to our primary school.

The engagement activity that received most attention was the phone application developed by the high school boys. The local media wrote about them several times and the boys have made several new contacts since they participated in the Genius Olympiad highs school competition the first time. The air quality mobile application has been receiving both local and global attention.

One primary school had a radon issue. JSI arranged for three professional Radon devices and a specialist to investigate more after the initial problem was identified. An official report was then delivered to the school that concludes that some rooms have urgent need for remediation to lower the radon levels.

At the primary school where most of our activities took place, all the involved teachers said that they are now able to ventilate properly and more efficiently.

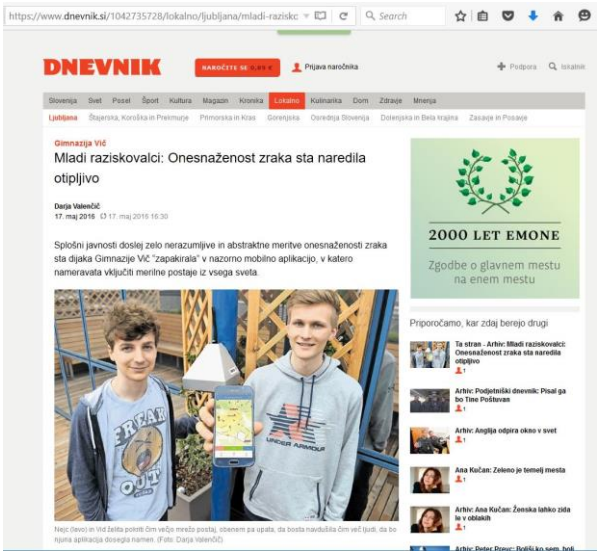


*Figure 17: Local newspaper wrote about high school boys who developed a phone app.*

At one primary school, the activities were not only focused on measurements. Our biggest success was the six Nature days, which we arranged. In addition to nature days, teachers from other fields e.g. Slovene language also took the opportunity to teach about the subject through other means, for example introducing key words in the field.

New schools contacted us repeatedly and wanted to join in. For one school in Ljubljana we installed an outdoor unit and organized a walk around a neighbourhood with a portable AQ device. Another school will be visiting our institute later this year, and they expressed their interest to participate in air quality experiments.

# 3 Contribution to Citizens' Observatories

## 3.1 Lessons learned

The case study in Ljubljana shows that the students and teachers are very interested in participating in research projects.

Our experience is that young students e.g. ten years old are capable of conducting valuable research, and giving space for creativity often results in great products/results. However, the children need help from their teachers and local scientist to define and guide the activities. In addition, technical help was needed at the primary school level e.g. for data downloading, processing and analysis.

Non-sensor related engagement activities, such as the Nature days and the Bike and balloon campaign proved to be very good ways to raise awareness and engagement in air quality issues. This is particularly the case for the youngest children.

The high school preferred to have mentors from the scientific community for the older students to work in small groups, whereas guided activities are preferred for younger students e.g. primary school.

It is important to know what your products are capable of, as well as to know their limitations when approaching schools to avoid too high expectations. It is crucial that the technology (sensor pods, software etc.) to be used are user-friendly. Close collaboration with producers and developers of associated services is crucial on ending up with usable products.

Many of the off-the shelf sensors on the marked are ready for use with minimal set-up effort and a stable/reliable dataflow. The sensors very often measure the parameters that the schools are most interested in, that is temperature, relative humidity and $CO_2$.

The length of the project enabled us to adapt and improve our non-sensor related activities, which were repeated year after year (e.g. the Nature days)

## 3.2 Expectation of Impact

The schools have stated clearly their interest to collaborate with the CITI-SENSE partners from Ljubljana also in the future.

The air quality application developed by some of the students during the CITI-SENSE case study has received attention both locally and internationally.

## 3.3 Recommendation for public bodies

Public bodies should encourage the collaboration of research institutes with local schools. This can be done through introducing various programs providing budget for activities, national competitions with prices etc.

Many schools expressed their interest in participating in the project, but the limited amount of sensor pods available within the CITI-SENSE project made it impossible to include more

schools. It would be very useful to have a readymade low-cost kit for schools that could be used to integrate air quality issues in their school activities.

# 4 References

Robinson, J.A., 2015. Empowerment initiative in air quality : master thesis. Jožef Stefan international postgraduate school, Ljubljana. http://social.citi-sense.eu/Portals/1/Users/030/30/30/Master_Thesis_Robinson_Empowerment_initiative_in_air_quality.pdf?ver=2016-02-12-110401-950.

| | | |
|---|---|---|
| | | Project title:<br>Development of sensor-based Citizens' Observatory Community for improving quality of life in cities<br>Acronym: **CITI-SENSE** Grant Agreement No: **308524** |
| | | EU FP7- ENV-2012<br>Collaborative project |
| | | |

# Deliverable D3.4

## Evaluation of the performance of the Empowerment Initiative at schools

### Appendix I – OSLO


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Dissemination level: PU (Public)

# Versioning and contribution history

| Version | Date issued | Description | Contributors |
|---|---|---|---|
| 0.1 | 24.08.2016 | Input for Oslo Annex as separate document | Holøs, S.B. |
| 0.2 | 21.09.2016 | Draft for review | Holøs, S.B. |
| 0.3 | 12.10.2016 | Input from Britt Ann Høiskar | |
| 0.9 | 02.12.2016 | Final draft | Holøs |
| | | | |
| | | | |

## Summary

The overall objective of the CITI-SENSE project (EU FP 7) was to develop “Citizens’ Observatories” to empower citizens and citizens’ groups: (i) to contribute to and participate in environmental governance; (ii) to support and influence community and policy priorities and the associated decision making; and (iii) to contribute to European and global monitoring initiatives.

Within the project, "Empowerment Initiatives" – there were cooperative efforts between researchers and local stakeholders – in Barcelona, Belgrade, Edinburgh, Haifa, Ljubljana, Oslo, Ostrava, Vittoria og Viennna.

I the Oslo region this has encompassed the "Oslo Citizens Observatory" for outdoor air quality, and three highschools working with indoor environment. Pupils following "Teknologi og forskningslære[1]" 1 and/or 2 at Horten, Lambertseter og Lørenskog highschools has participated in a set of CITI-SENSE activities where they after an introduction to the subject, have designed and carried out short research projects with support from their teachers and researchers from NILU og SINTEF Byggforsk. CITI-SENSE has also supplied measurement equipment, and solutions for the dowload of data. The participants have presented their work in a poster format at students' conferences.

The project have shown that high-school pupils are capable of high quality work. Through the participation in the CITI-SENSE project the students and teachers have learned about indoor environment, increased their understanding of research methods, and enabled them to improve thir own indoor environment.

Data being collected in cooperation between schoools and researchers may contribute valuably to publishable research, but there are challenges p.t. data quality and registration of contextual data, that have to be adressed. The pupils prefer to take part in study design, and data collection often happens in short periods and under manipulated conditions.

It is recommended that coopereation between schools and researchers be strengthened, and that the combination of rewarding learning activities and a more systematic work to ensure that data quality fit both for research purposes, for educational purposes and for local improvement of indoor evironment.

[1] Subject within “Technology and research”

## Sammendrag

EU-prosjektet CITI-SENSE har hatt som mål å utvikle “Citizens’ Observatories” for å sette vanlige borgere i stand til å: (i) bidra til og delta i miljøforvaltning, (ii) støtte og påvirke samfunnets prioriteringer og beslutninger, og (iii) bidra til europeisk og global miljøkartlegging.

Prosjektet har omfattet "empowerment initiatives" – lokal utprøving av samhandling mellom forskere og lokale interessenter – i Barcelona, Beograd, Edinburg, Haifa, Ljubljana, Oslo, Ostrava, Vittoria og Wien. I Osloregionen har dette omfattet "Oslo Citizens Observatory" for uteluftkvalitet, og 3 videregående skoler som har arbeidet med inneklima. Elever som har tatt Teknologi og forskningslære 1 og/eller to ved Horten, Lambertseter og Lørenskog videregående skoler har tatt del i et opplegg der de etter et introduksjonsforedrag har utarbeidet sine egne korte forskningsprosjekter med inneklima som tema i samarbeid med sine faglærere og forskere ved NILU og SINTEF Byggforsk. CITI-SENSE har bidratt med måleutstyr og løsninger for nedlastning av måledata, i tillegg til veiledning og annen faglig støtte. Elevenes arbeider har blitt presentert i form av postere på avsluttende elevkonferanser.

Prosjektet har vist at elever i videregående skoler er i stand til å gjennomføre arbeid av høy kvalitet. De oppgir at prosjektarbeidet har gjort at de har lært mer om inneklima, lært mer om forskningsmetode og satt dem i stand til å bedre eget inneklima.

Data som samles inn i samarbeid mellom skoler og forskningsinstitutter kan gi verdifulle bidrag til publiserbar forskning, men det er utfordringer knyttet til kvaliteten på måledata og til registrering av data om kontekst som må møtes for at dette kan realiseres. Elevene ønsker ofte å designe sine egne forsøk, noe som ofte innebærer at datainnsamling skjer i avgrensede perioder, og under manipulerte betingelser.

Det anbefales å arbeide for fortsatt samarbeid mellom forskningsmiljøer og skoler, og at det særlig fokuseres på å kombinere givende læringsaktiviteter med et mer systematisk arbeid for å sikre at data har en kvalitet som er god nok både til forskningsformål, til bruk i undervisningsøyemed og for å gi grunnlag for lokal handling for bedre inneklima.

# Table of contents

# 1 Methods

## 1.1 Recruitment of users

From the start of the project, it was clear that the sensors available within the project would be few. For this reason, as well as to limit the resources needed to follow up the users, we decided to target single classes in three different schools. A search for "indoor climate" in curricula for high schools revealed that this topic was mentioned in the curricula of "Technology and research". Schools in Oslo and the surrounding counties offering these classes were identified, and three of the schools were contacted. In one case, it was possible to make the contact through existing contacts, in the two other cases, an inquiry was made through the head masters.

## 1.2 Interaction with the users to identify their needs

Introductory meetings were arranged with the teachers of the potentially participating classes, together with heads of sections. A brief presentation of the CITI-SENSE project was given, emphasizing the overall objectives and objectives for WP3. Also, the plans for developing sensor units and data services in the project was presented. The teachers then gave an overview over the time schedule for the classes. This was followed by an idea-generating session, aiming to match the needs of the schools with the available resources and objectives of CITI-SENSE.

After prioritizing the ideas, a list of ideas for student projects and compilation of web resources was produced and refined through a series of meetings and e-mails.

Initially, also a meeting discussing the need for more extensive web page was arranged with one of the schools.

*Figure 1: Pre-pilot working meeting with teachers to discuss needs and possibilities*

## 1.3 Tools and products

For the pilot phase, AirBase Sensor units were used. This unit provided data through the company's proprietary web interface, including near real time-visualisation. However, for the student projects only the possibility to download historical data in .csv-format was used.

Due to events affecting the supplier's strategies, further development and use of this unit within the project was halted.

For the first year of full-scale implementation, no CITI-SENSE developed hardware was available. Instead, commercially available indoor air quality monitors were purchased from IC-meter AS, Copenhagen. Data downloads and visualisations by company's proprietary web interface (www.ic-meter.com).

*Figure 2: AirBase sensor unit explained by provider.*

For the second year of the full implementation, static sensor units from Atmospheric Sensors were used, supplemented with IC-meters and one NetAtmo unit. In addition, the schools were given the possibility to use a TSI DustTrak to measure particles.

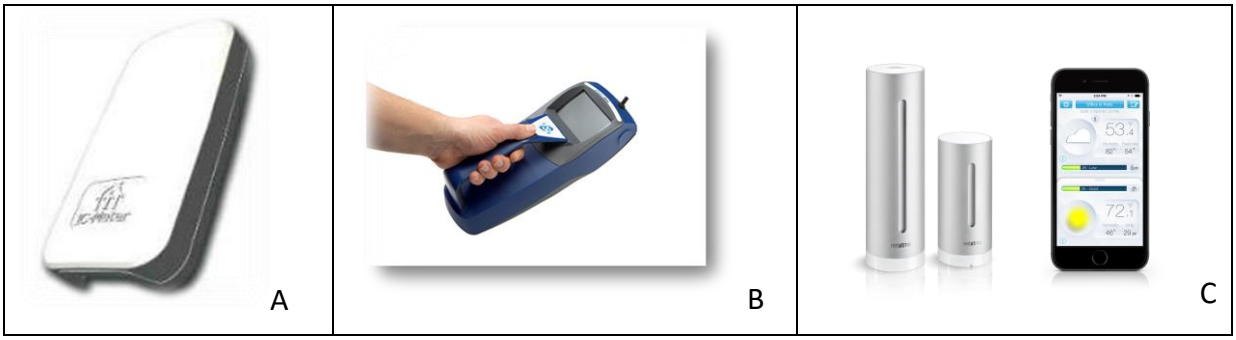


*Figure 3: The IC-meter used in first year full-scale implementation is shown in figure 3.A (Photo: IC-meter), the TSI DustTrak is shown in figure 3.B and the NetAtmo unit is shown in figure 3.C.*

## 1.4 Engagement activities

Introductory lectures were given by one or two researchers involved in the project for all participating classes. At the same time, a simple questionnaire was distributed to the students and a booklet with ideas for student projects was presented and distributed. It was stated that the list of ideas was incomplete, and most of the project ideas were described with room for individual adaptations. The only fixed criteria for the projects were that they were:

- Related to the broad topic of indoor environment
- Scientific in approach
- Ethically acceptable

- Feasible with the equipment described above, with short-term use of a TSI DustTrak optical particle counter made available by NILU, or any suitable equipment available at the school.
- The results should be possible to present in form of a poster.

The students then formed groups and selected projects of interest with aid from their teachers. During the project period of 1-4 weeks, researchers were available for consultation, either on site or by e-mail.

*Figure 4: Example of group project: measurement of particles in a temporary workshop with the DustTrak*

A student conference for the three local schools in Oslo involving a poster competition was organized, where scientist from the scientific institutes participating in the CITI-SENSE project worked as evaluators. Criteria for evaluation of posters were:

(1) Does the poster clearly state the objectives and scope of the research, summarize what was done and state principal results in a scientific correct manner?

(2) Does the title and overall organization motivate interest?

(3) Is the information presented in a logical sequence? Are the main points, conclusions, and interpretations developed and integrated in a logical way?

(4) Does the poster state conclusions clearly with a clear take-home message?

(5) Does the poster have significant aesthetic appeal (poster design, quality of images/graphics)?

(6) What is the quality of the interview (meaning how well the students explain their poster, answer any questions, etc.)

*Figure 5: The CITI-SENSE student conference combined oral presentations by researchers and student poster sessions*

*Figure 6: Groups of 2-4 students presented their work in poster format. This group selected acoustic environment as their topic*

## 1.5 Empowerment evaluation

Questionnaires (Appendix I) were distributed at the introductory lecture and at the student conference, asking about expectations and experiences, respectively. At the second (2016) student conference, two group interviews with six participating students per group examined the participants' experiences with the project.

Involved teachers were asked for suggestions for improvements after the pilot study as well as after the first year of implementation.

No formal evaluation of other stakeholders' experiences was performed, as the activities actually carried out to a very small degree involved stakeholders outside the participant groups.

# 2 Results

## 2.1 Recruitment of Users

All contacted schools were willing to participate in the project. The school participating in the pilot enrolled for the two years of implementation, and the two schools recruited for implementation also participated for two consecutive years. As the project activities were embedded in normal class activities all students in the involved classes participated.

## 2.2 User overall objectives

According to the predefined alternatives in the questionnaires, the participants' main objectives were to learn more about indoor environment and research methods, but many also wanted to improve indoor environmental conditions. The open questions in the 2016 questionnaires did not uncover any other objectives than the four given categories, even if some were more specific, e.g. "Achieve improvement of school, less draught, more even temperatures", "learn about research work...how to construct buildings that are efficient in many aspects..", "get better air in all classrooms, not as awful as now". The user response is shown in Figure 7.


*Figure 7 Users' motivation (before) and experience (after) according to the questionnaires.*

## 2.3 Specification of the user needs

### *2.3.1 Hardware needs*

Due to the long time needed to develop hardware (sensors and sensor platforms) and the short time available for the implementation phase, it was not attempted to involve users in hardware specifications. Retrospectively, hardware fulfilling the specifications suggested by the researchers in January 2013 would probably have been adequate, but the selection of student projects was in practice determined by the available equipment. None of the schools showed interest in radon measurement, partly due to the extended periods necessary for dependable measurements.

*Table 1: Prioritized "wish-list" of environmental parameters for monitoring.*

| Parameter | Typical range | Acceptable accuracy | Integration time | Method | Rationale | Priority (A-C) | Ref |
|---|---|---|---|---|---|---|---|
| **Air temperature** | 10-40 ºC | 1ºC | 5 minute | Fixed sensor | Important for concentration and well-being | A | EN ISO 7730 |
| **Air humidity** | 10-85 % RH | 5 % RH | 5 minute | Fixed sensor | Indicator for ventilation. Indicator for condensation / mould risk. | A | |
| **$CO_2$** | 350-4000 ppm | 100 ppm | 5 minute | Fixed sensor | Important indicator for ventilation and bioeffluents | A | EN 15251 |
| **Particulate matter** | To be discussed. Do we want PM10, 2.5, 1 or particle counts ( | | 5 minute | Fixed sensor | Indicator for air pollution / combustion products. Health relevant. | B | |
| **Noise $L_{p,A}$(dB)** | 20-100 dB | 3dB | 5 minute [2](integrating, setting "fast"?) | Fixed sensor and supplementary measurements | Relevant for noise from technical equipment, outdoor sources and neighbouring areas | B | |
| **Radon** | 10 – 2000 Bq/m³ | 50 Bq/m³ | 1h[3] | Fixed sensor or 6-8 week integrating measurement | Health relevant (lung cancer) | B | WHO Radon handbook |

[2] Integrating from "fast" measurements according to IEC 804

[3] Floating average. Longer integration times necessary to achieve desired accuracy if passive sampler type.

| Parameter | Typical range | Acceptable accuracy | Integration time | Method | Rationale | Priority (A-C) | Ref |
|---|---|---|---|---|---|---|---|
| **$NO_2$** | 0-400 µg/$m^3$ | 0.04–10 µg/$m^3$[4] | 5 minute | Fixed sensor | Health relevant, outdoor sources | B | WHO Guidelines |
| **VOC** | 0-10 mg/ $m^3$ | 0,05 mg/ $m^3$ | 5 minute | Fixed sensor | | B | WHO Guidelines |
| **Ozone** | 0-400 µg/$m^3$ | 0,02-2 µg/$m^3$ | 5 minute | Fixed sensor | Health relevant, outdoor sources | B | WHO Guidelines |
| **Lighting** | | | | Short term measurements, possibly simple sensor | | A | EN 12464 |

### 2.3.2 Data services

The data service of highest demand by the participants was the ability to download historical data up to "near real time" in a format convenient for further processing in spreadsheet.

For questionnaires, paper format was the most popular, even if one group used Google Forms. The participants reported that it was easier to have high response rates with paper, and that this more than outweighed the extra work with manually recording data.

Project specific web-pages or Facebook groups / pages were not prioritized by the participants in the Oslo case study.

### 2.3.3 Supporting services

It was realized that a huge amount of information is available online, but that a short-list of information sources with high-quality relevant information in an appropriate form would be useful. Also, to ease the burden of the teachers and increase the relevance of the student projects, direct guidance for the student groups by participating scientists was wanted.

[4] Journal of Analytical Methods in Chemistry Volume 2012, Article ID 568974, 5 pages doi:10.1155/2012/568974

## 2.4 Evaluation of tools, products and services

### *2.4.1 Air Base sensors and data products*

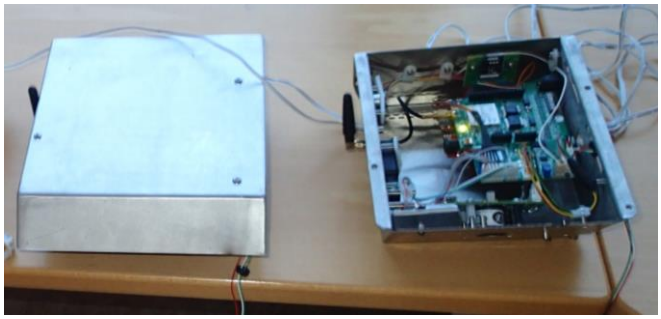

*Figure 8. Air base sensor units under testing*

The sensor units had issues with temperature measurement, as the sensor was affected by heat produced by the unit. $CO_2$-measurements had large unresolved calibration issues. Sensors for other parameters than T, RH and $CO_2$ were considered unfunctional, uncalibrated or in other ways unreliable, even if the VOC-sensors showed a promising responsiveness. Web pages had many functions, but were somewhat hard to manoeuvre for the participants.

### *2.4.2 Atmospheric Sensors –sensors and data products*

*Figure 9: The Atmospheric Sensor Unit*

Only sensors for T, RH and $CO_2$ were used. Sensors for other parameters were considered unfunctional, uncalibrated or in other ways unreliable, and were not used by participants.

One of the schools reported that the noise from the sampling fan was considered to annoying for extended classroom use. The webpage for download was extremely slow, and the time lag between measurements and update was some hours. Some of the students were hampered by this, because they wanted to analyse results from short-term interventions. The Atmospheric pods were delivered without a proper user guide and technical documentation.

### *2.4.3 IC-meters – sensors and dataproducts.*

Only sensors for T, RH and $CO_2$ were used, however they also provided a noise sensor. These units were easy to install and the webpage was intuitive and responsive.

### 2.4.4 Supporting services

Both introductory lectures, suggestions for student projects, counselling during the project and the student conferences were given positive evaluation from the participants in the final group interviews.

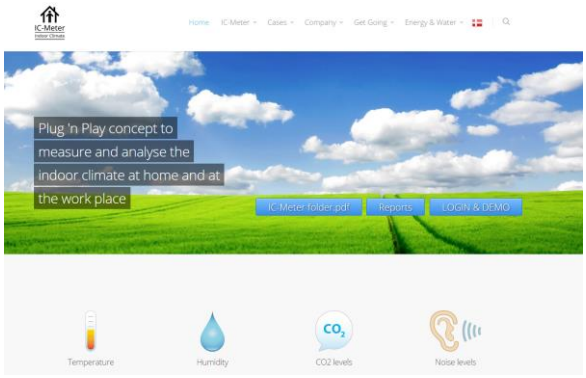


*Figure 10: The IC-meter web-page*

## 2.5 Empowerment evaluation

During the second CITI-SENSE student conference, in-depth interviews were arranged with two focus groups. Six students from the three schools participated in each focus group and the interviews were done by SINTEF as part of WP5.

The interviews were transcribed and translated to English and the results from the groups interviews, together with the analysis of the questionnaire data will be presented in D5.5 “Coordinated analysis & Evaluation of empowerment initiatives”.

*Figure 11: Group from Horten after comparing $CO_2$ measurements with model*

The questionnaire results shown in Figure 7 indicate that the users' (high) expectations were not fulfilled in all cases; there is a larger proportion of the participants disagreeing with statements that they learn research methods, learn about indoor environment or improve their indoor environment. Still, the majority agreed strongly or partially to the first two statements, and approximately 40 % to that they actually achieved better indoor environment. Pertaining to the last statement, it should be noted that both the measurements and the results on perceived indoor environment indicated that the conditions were relatively good in all three schools.

Thus, some might have concluded that the need for improvement was less important than they have previously believed. The open questions on which expectations were not met did not provide any additional insights (very low reply rate, most common answer "none"). Hopefully, the interviews may shed some additional light on user experience.

# 3 Contribution to citizens' observatories

## 3.1 Lessons learned

Results from the collaboration indicate that students and teachers are motivated to engage in these environmental studies, and are able to perform studies of good quality. Students involved in such projects may be valuable collaborators with broader professional or citizen science projects, as they can measure physical parameters, collect observations and perception or performance data while having a support network of experienced teachers. Furthermore, they can provide insight into the priorities and goals of the participants as well as the drivers and barriers for improving school environments. However, we also have identified some challenges that need to be overcome to realize this potential:

- Successful cooperation with schools requires adaptation to curricula and relatively strict schedules. A two-week delay may imply a full year lost.
- Students are motivated when they are free to implement their own ideas and priorities into the projects. This may lead to datasets that are hard to reuse or compare with others.
- Indoor environments vary widely between rooms and with usage and meaningful interpretation of measurements and other results often requires that a lot of context be recorded with the measurements. This is not always practicable/feasible. Despite the challenges, there is a tremendous potential of empowering the schools when providing them with tools to conduct research in their premises.

## 3.2 Expectation of Impact

The participating schools have clearly stated their interest in future participation in similar activities / projects. Also, the Norwegian Asthma and Allergy Association, NILU and SINTEF are interested in engaging in future Citizen Science and Empowerment activities in schools. Necessary funding is not secured, and an application for two years of funding to "ExtraStiftelsen" have already been submitted

*Figure 12: One group studied the effect on $CO_2$ of introducing multiple potted plants into a sleeping room.*

## 3.3 Recommendation for public bodies

Based on the experiences from the project, it is recommended that the schools are given access to funding of local activities involving them in research on locally important topics. Further, it is recommended that a national (or international) "hub" providing easy upload of and access of data and results from school research, is secured long-term funding.

The data could be of considerable value for the authorities and make it possible to follow the development of the indoor air quality in schools over time. This data would also be of interest for the scientific community.

# Annex A: Questionnaires given before and after the engagement activities

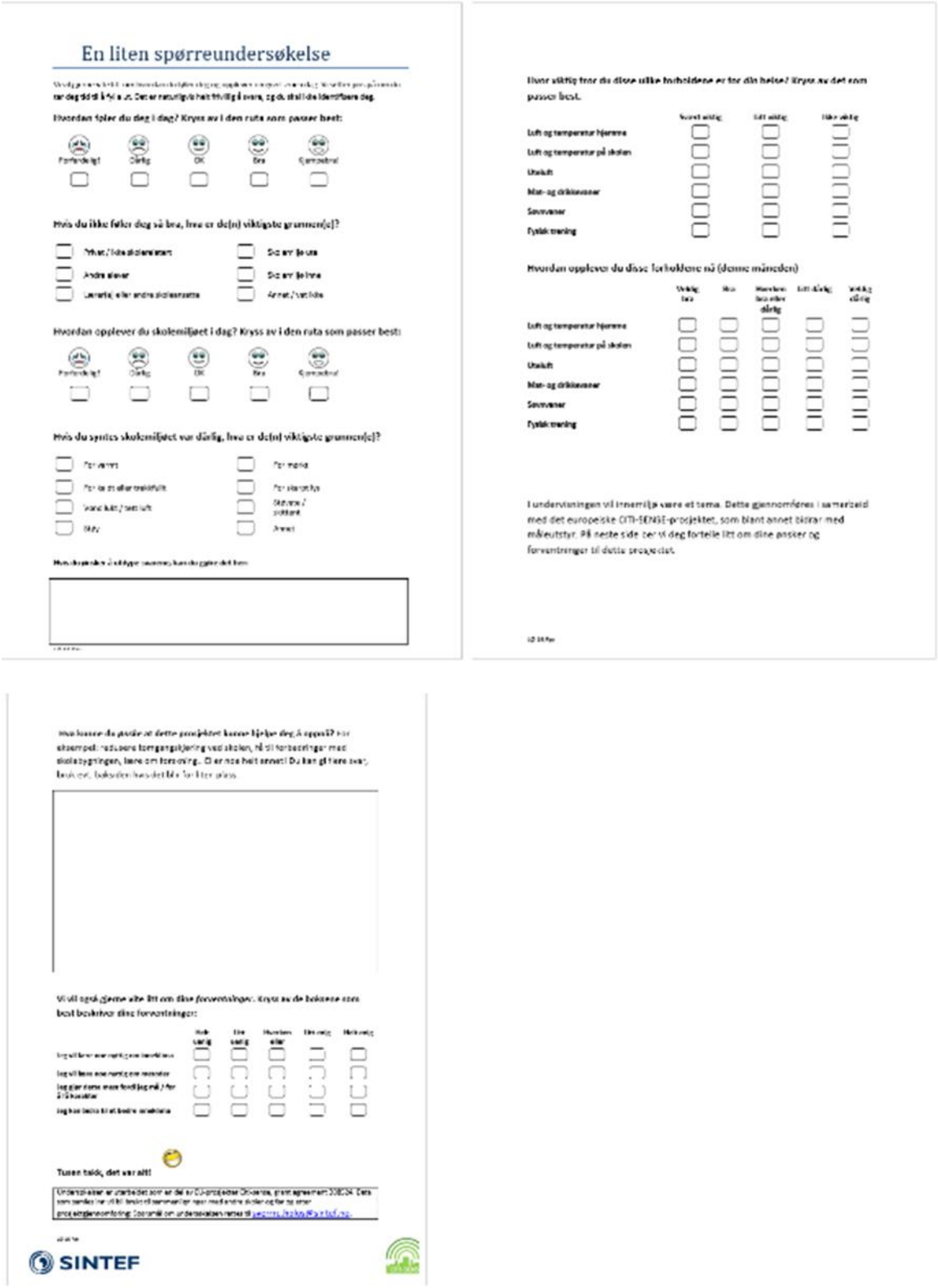


*Figure 13: Example of questionnaire given at introduction*

# Annex VI: Product Descriptions

## *Atmospheric Sensors*

The Atmospheric Sensor (AS) unit for fixed-site monitoring deploys four electrochemical sensors ($NO_2$, NO, CO and $O_3$): an NDIR sensor for carbon dioxide, a PID sensor for VOCs, a laser particle monitor, relative humidity monitoring and temperature measurement. GPS is fitted to provide location and timestamp information.

*Figure 1: The Atmospheric Sensor unit*

The units alsohad an integrated microphone to monitor ambient noise. Data can be stored locally and transmitted to a central management site over the cellular network, minimizing infrastructure requirements.

During the CITI-SENSE project, the data was pushed automatically into the CITI-SENSE database.

## *Radon sensors*

The Obeo radon sensor device is a portable sensor package for measurement of radon concentration in indoor environment. Obeo requires a constant power supply. The device for radon measurement is equipped with a detector whose measurement resolution is 1 Bq / m3. The radon sensor has a 1h time resolution of measurement.

In addition to the GSM module, the instrument has a QUAD BAND antenna, which, together with GSM module enables the transfer of data from the sensors to the server. Data from the server is then further visualize on prepared web site. Site visualization can be accessed on the basis of IMEI number which is located on the instrument. Therefore, for each platform, there is a different web address for measurements access. The Web page for visualization are shown in Figure .

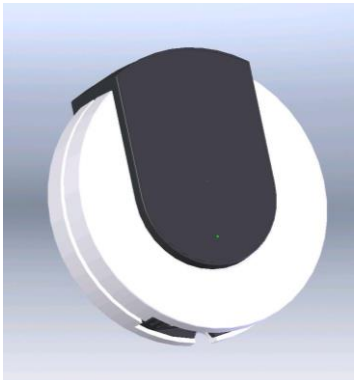

*Figure 10: The Obeo radon sensor unit*

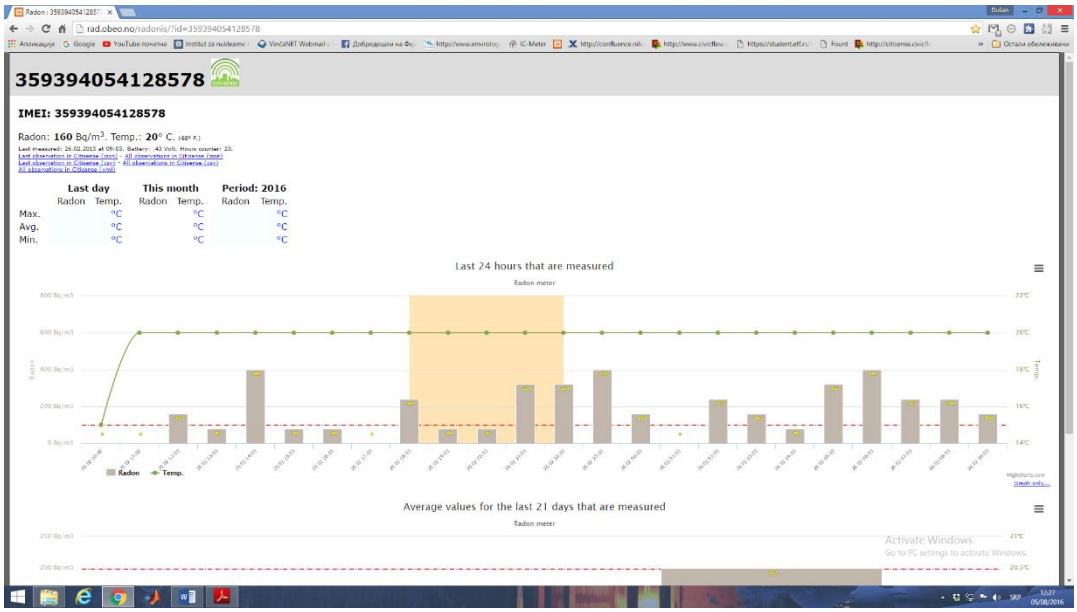


*Figure 2: Web interface for the Obeo radon sensor unit.*

On this web page, measurements from the last 24 hours can be accessed, as well as the average values of measurements for the last 21 days.

## *IC-meters*

The Indoor Climate Meter (IC-Meter) measures, visualizes and analyses indoor climate in a room or a building. The concept is comprised by a data measurement device, a server and website with APP client for mobile units (IOS/Android).

The meter device measures temperature, humidity, $CO_2$ and noise level.

Measurements are uploaded to the server every 5 minutes, via the client's own WiFi/Internet. At the same time, the server automatically retrieves local weather forecasts, energy measurements, etc. from public and commercial suppliers' servers.

The data can be accessed via the web-page, www.ic-meter.com.

*Figure 12: The IC-meter unit*

## *Netatmo*

The Netatmo weather station is a smart measuring device of the indoor and outdoor air, coupled with a phone app to display the data. Netatmo measures humidity, atmospheric pressure, temperature, noise and $CO_2$ and transmits the data via WiFi connection. Data can be accessed in real time both on the web and on the Netatmo app. The app also receives information from the nearest AQ monitoring station and displays a pollution index for

outdoors. A basic package includes one indoor module and one outdoor module. However, additional modules can be installed. Modules communicate wirelessly within a range of 100 meters.


*Figure 13: The Netatmo unit*

The main Netatmo unit also facilitates an immediate feedback of the indoor air even without accessing the web or the app. After pushing a button top pf the Netatmo unit, either a green (good air quality), yellow (moderate air quality) or red (bad air quality) light indicates the direct reading of the $CO_2$ concentration. The school was regularly checking the air quality by help of this devise, which also prompted a pop-up note on the location officers' smartphones.

Netatmo has helped the primary school to ventilate the classrooms. Various experiments were made regarding the number of pupils, the size of classrooms and the type of ventilation used. On a final meeting with the primary school, multiple teachers reported how they nowadays have much better air in their classroom due to improved ventilation practices.

Netatmo was also used for high school students' research to measure air quality, comparing various $CO_2$ devices, one of them being built by the students themselves.