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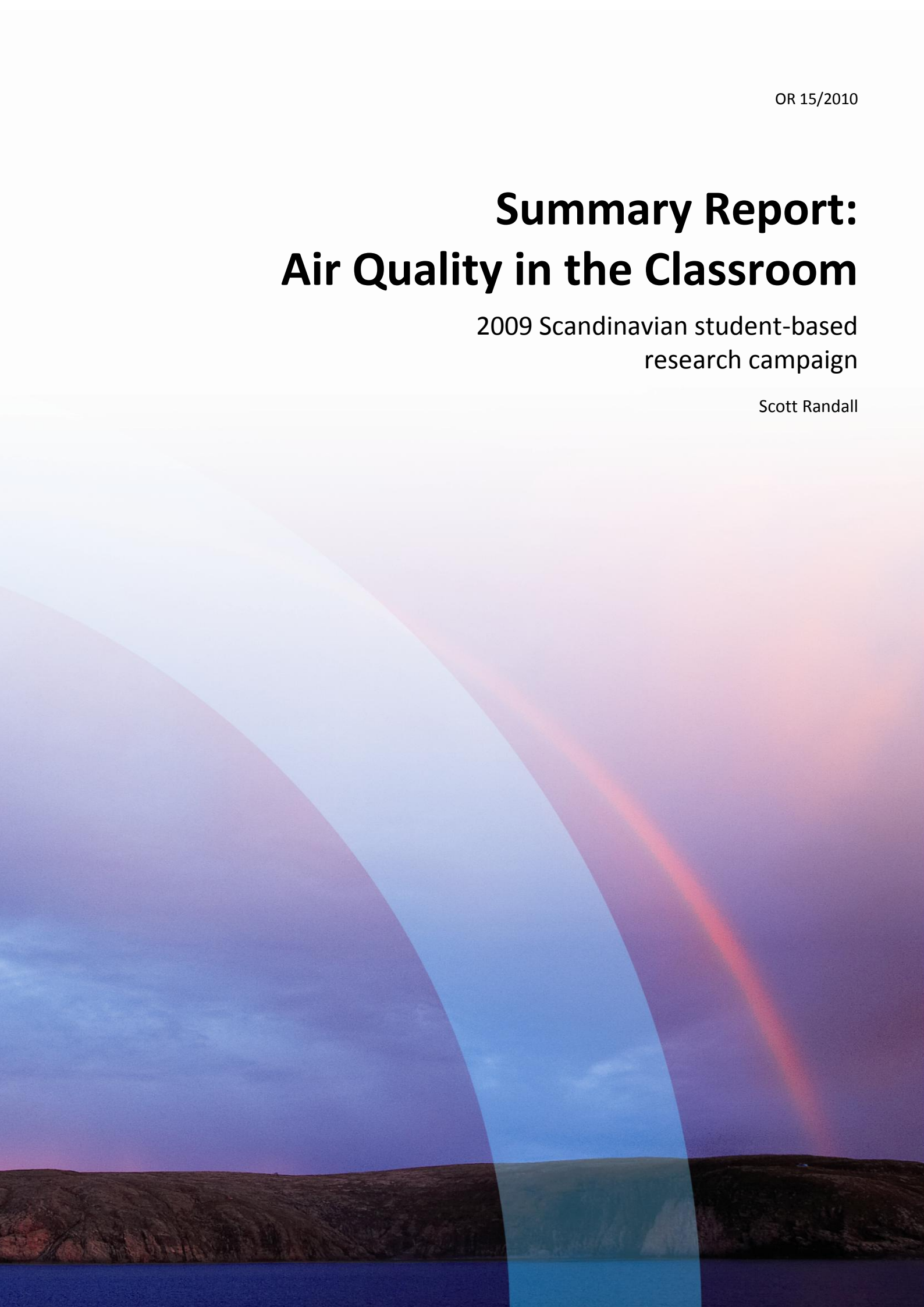
Summary Report: Air Quality in the Classroom

2009 Scandinavian student-based research campaign

Scott Randall



Summary Report:
Air Quality in the Classroom
2009 Scandinavian student-based research campaign

Scott Randall

Flaktveit School in Hordaland

In collaboration with:

Teknolab as

PÅ 17 ORTER DEN 25 SEPTEMBER FORSKARFREDAG

Naturfagsenteret
Nasjonalt senter for naturfag i opplæringen

Dansk NATURVIDENSKABS-formidling

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NordForsk

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NOTE: A full version of this report is available: *Air Quality in the Classroom: 2009 Scandinavian student-based research campaign* (Randall, NILU OR 06/2010). This summary report is also available in Norwegian: *Inneklima i norsk klasserom: Elevbasert forskningskampanje som del av Forskningsdagene 2009* (Randall, NILU OR 13/2010).

Summary Report: Air Quality in the Classroom
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1 Introduction

The 2009 Scandinavian Research Campaign "Air Quality in the Classroom" ran from week 38 to 40 (September 18th – October 7th, 2009) in Norway, Denmark, and Sweden. This year's campaign was designed to repeat the 2003 *Air Quality in the Classroom* student campaign conducted in Norway which measured indoor CO_2, while in addition, the 2009 campaign measured indoor mold. As in the 2003 campaign, the 2009 campaign hoped to raise awareness of indoor air quality issues in the classroom through educating students and teachers on monitoring indoor air, air quality indicators, ventilation routines, and associated health risks.

The primary goals for the campaign as it was designed are as follows:

- Giving students the experience of taking scientific measurements, reading the results, and entering the data.
- Educate the students on specific indicators for air quality.
- An understanding that the indicators used in the campaign can represent more serious components in the air, pointing towards unhealthy situations in the classroom.
- Educate the students that indoor air quality is important to the development of one's health.
- Learn about the Norwegian Educational Statue §9a regarding the requirements of the physical indoor environment for schools, which states "the air should be fresh and good to breathe in, and not contain harmful elements or gasses".

A secondary goal of the campaign is to apply the results to identify schools which can improve their indoor air quality through better ventilating routines or improved ventilation systems – for the benefit of student's health.

CO_2 as an indicator: *CO_2 measurements are often used to analyze indoor air quality. CO_2 in itself is not directly detrimental to human health at the levels found in the campaign, but concentrations of this gas point to how good the air quality is, and if there is a need for better fresh air influx. High CO_2 levels can be a sign that the airflow is poor in relation to the number of people in the room; it can also mean that the air contains high levels of more health damaging pollutions as well.*

Mold as an indicator: *Like CO_2, mold measurements are also often used to assess indoor air quality. Mold is present in our indoor environments, but it is the quantity and species of the molds which determines if they are harmful to human health. Mold growth indicates humidity or moisture problems, which is most often tied to ventilation issues. So if mold quantity and speciation is high, this can in itself be dangerous, and also be indicating other indoor air quality problems due to ventilation issues.*

2 Methodology

The campaign methods were similar to the previous student research campaigns in Norway in that the classes:

1. Registered for the campaign on the www.miljolare.no campaign website (*www.miljolare.no/kampanjer/forskningskampanjen/2009/*) and received the necessary equipment,
2. Performed the CO_2 and mold measurements,
3. Entered the data on their class account on the campaign website.

The students and teachers were also given links on the campaign site to explore addition background material on indoor air quality, and how the campaign is linked to the teaching curriculum goals (in Norwegian): *http://miljolare.no/kampanjer/forskningskampanjen/2009/*

3 Participants

Figure 1 displays a map of all of the participating schools in the 2009 campaign. From Denmark there participated 325 different schools which resulted in 820 unique measurements from 600 different classrooms. From Sweden there participated 132 different schools which resulted in 245 unique measurements from 200 different classrooms. 201 different schools from Norway participated in the campaign, all from varying regions, with a relatively equal distribution by population which means more participants in the southern regions. Approximately 414 Norwegian classrooms were measured for all campaign exercises, with a total of 716 unique CO_2 measurements and 324 unique mold measurements, which totalled over approximately 12,000 students participating in this year's campaign (Table 1). 58 of the 201 participating schools (28%) also participated in the 2003 campaign.

Figure 1: Map of Participating Schools (2009)

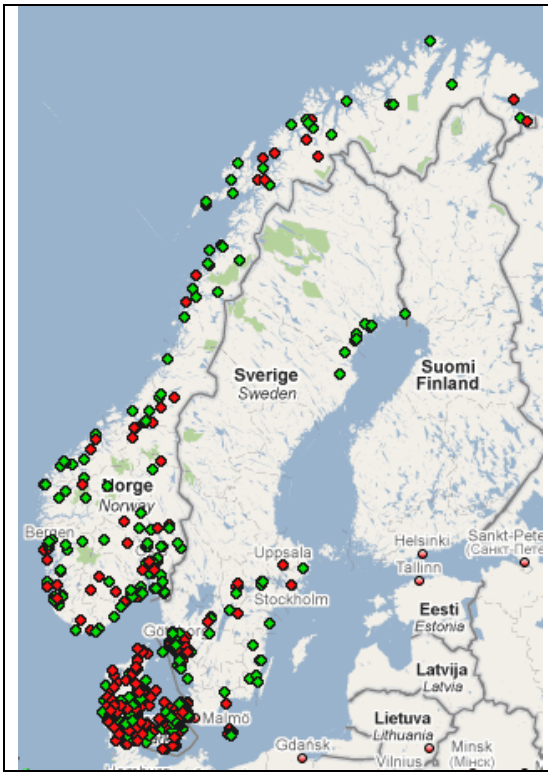


Table 1: Participating Schools in Norway by Region

Region (Norway)	Schools	Classes	Measurements
Akershus	16	36	60
Aust-Agder	2	6	6
Buskerud	5	8	18
Finnmark	8	16	23
Hedmark	9	22	34
Hordaland	24	60	101
Møre og Romsdal	11	20	43
Nord-Trøndelag	7	12	22
Nordland	20	45	70
Oppland	10	25	37
Oslo	11	16	23
Rogaland	16	36	67
Sogn og Fjordane	7	12	25
Sør-Trøndelag	8	13	23
Telemark	11	23	40
Troms	16	34	66
Vest-Agder	6	11	20
Vestfold	6	7	18
Østfold	8	12	20
Total	**201**	**414**	**716**

4 Background - 2003 Results

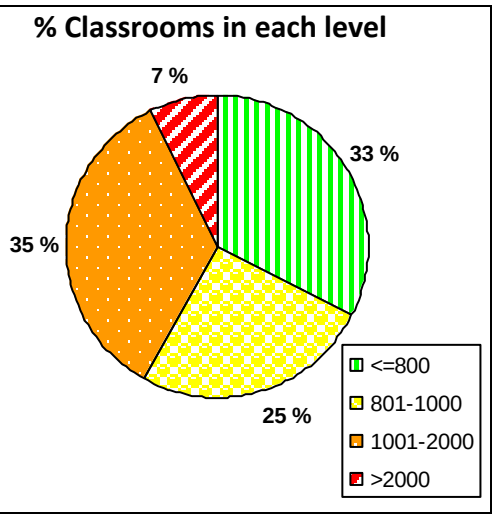
The results from the 2003 campaign in Norway gave the following conclusions (see also Figure 2):

- A majority (58%) of the classrooms had CO_2 concentrations lower or equal to the recommended average and are thus considered "acceptable".
- 35% of the classrooms had indicators for "problematic" air quality, and 7% had indicators for "unacceptable" air quality.
- Like the 2009 campaign, there are considerably better air quality indicators in classrooms with ventilation systems than classrooms without, even though some classrooms with ventilation systems still had "problematic" or "unacceptable" air quality.
- Air quality is potentially correlated to the room volume per person in the classroom (ie. higher density of student results in poorer air quality).
- There is a possible correlation between how the students experience the air quality in the classrooms and the actual measured values.

Due to these 2003 results, NILU recommended that schools with poor air quality indicators focus on utilizing all options available to improve the conditions. These include improving the maintenance routines for the ventilation systems and reducing the amount of students in a given room. In addition, to investigate if whether better manual ventilation routines and reduced occupation time in a given room will give positive results. One of the primary recommendations from the 2003 campaign was to repeat the same campaign within a few years as well.

Figure 2: 2003 CO_2 Results (Norway)

# of schools which registered data:	688
Participation (%):	19
# classrooms:	1085
Avg. CO_2 concentration:	1175
Min CO_2 concentration:	400
Max CO_2-concentration.:	5000
% rooms over 1000 ppm:	42
% rooms with ventilation:	82
# rooms:	
<=800	354
801-1000	275
1001-2000	377
>2000	79



5 2009 Results

A summary of the campaign results for Scandinavia can be broken down into the CO_2 results (Table 2) and the mold results (Table 3).

Table 2: CO_2 Results Summary for Scandinavia (2009)

Country	Schools	Measurements	Rooms	<1000 ppm	> 1000 ppm	proportion over/under 1000 pm
Denmark	326	790	737	45%	55%	
Norway	201	716	414	78%	22%	
Sweden	136	245	222	84%	16%	

Table 3: Mold Results Summary for Scandinavia (2009)

	Schools	Attempts	Rooms	Mold Colonies DG18 (avg)	Mold Species DG18 per dish (avg)	Mold Colonies V8 (avg)	Mold Species V8 per dish (avg)
Denmark	329	805	755	31.2	5.0	29.6	5.0
Norway	157	319	200	7.9	2.6	9.3	2.9

The campaign results show that schools in Norway and Sweden in general have better indoor air quality indications than schools in Denmark. A majority of classrooms (55%) in Denmark are in the "problematic" to "unacceptable" range for CO_2 indicators, where Norway and Sweden contain approximately 20% of classrooms in this poor range. Denmark classrooms also measured 3 times more mold colony growth and 2 times more mold species in comparison to Norway.

The results from the 2009 campaign gave the following conclusions for Norway (see also Figure 3 and 4):

- A majority (78%) of the classrooms had CO_2 concentrations lower or equal to the recommended average and can be considered "acceptable".
- 19% of the classrooms had CO_2 concentration which indicated "problematic" air quality, and 3% indicate "unacceptable" air quality.
- There is considerably better air quality indicators in classrooms with ventilation systems than classrooms without, even though some classrooms with ventilation systems still were "problematic".
- 80% of the classrooms had less than 4 mold species and 77% of the classrooms had less than 10 mold colonies.
- Approximately 20% of the classrooms had over 4 mold species and/or more than 10 mold colonies present, indicating potential "problematic" air quality.

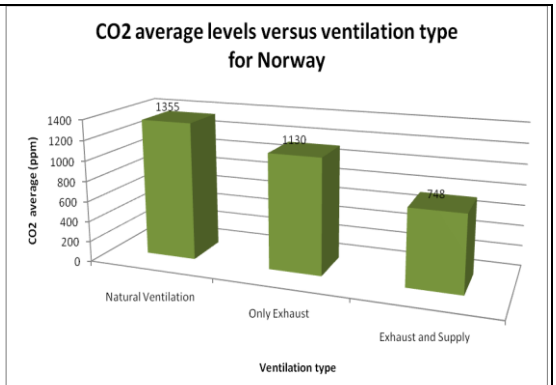
Figure 3: 2009 CO_2 Results (Norway)

# of schools which registered data (CO_2 + mold):	201
Participation of all schools:	6%
# classrooms (just CO_2 data)	286
# CO_2 measurements	495
Avg. CO_2 concentration:	924
Min CO_2 concentration:	350
Max CO_2 concentration:	5000
% rooms >1000 ppm:	22.4%
% rooms w/ventilation system:	80.7%

 # rooms (avg. concentration)*:

<=800ppm	**OK**	167
801-1000ppm	**ACCEPTABLE**	56
1001-2000ppm	**PROBLEMATIC**	55
>2000ppm	**UNACCEPTABLE**	9

**range generated by NILU in the 2003 Campaign report (Innset et al., 2003).*



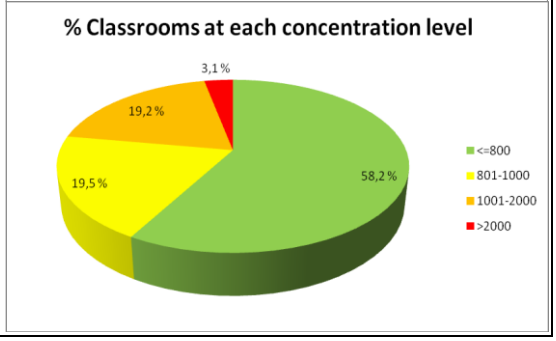
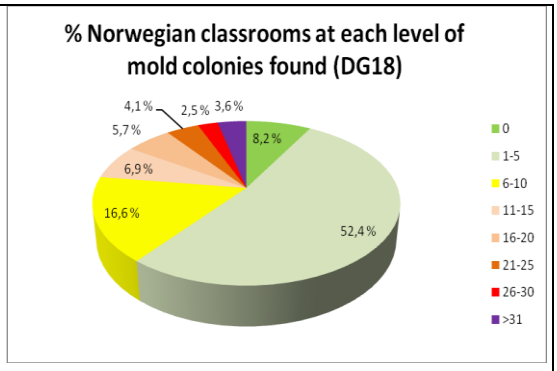
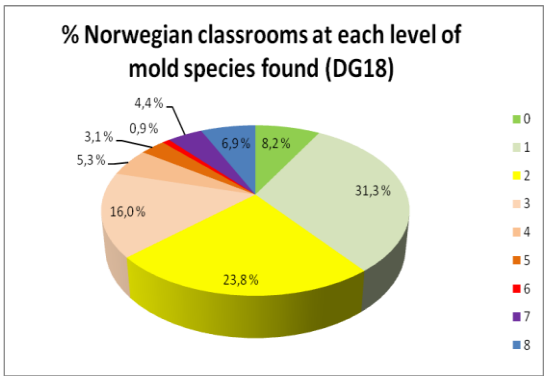


Figure 4: 2009 Mold Results (Norway)

# of schools which registered data (CO_2 + mold):	201
Participation (%):	6
# classrooms (just mold data)	200
# mold measurements	324
Avg. # colonies:	7.9
Avg. # species:	2.6
>=10 colonies	22.8%
>=4 species	20.7%
% rooms w/ventilation system:	80.7%



# samples at each species level:	
0 species	26
1 species	100
2 species	76
3 species	51
4 species	17
5 species	10
6 species	3
7 species	14
8 species	22



6 Discussion and Conclusion

The CO_2 results for Norway show a general improvement over the 2003 campaign results, where almost 20% more classrooms are now below the 1000ppm threshold (Table 4). The CO_2 results also demonstrate that Norwegian classrooms are possibly in better conditions than their Danish counterparts, where 30% more classrooms in Denmark are over the 1000ppm threshold in comparison to Norway. The mold results for Norway do not show any alarming trends at the country level, and like the CO_2 results, these results seem to be better in comparison to Denmark – where Danish classrooms have on average approximately double the amount of mold species present, and three times as many mold colonies found. These differences between the Norwegian and Danish CO_2 and mold results can be attributed to the improved ventilation systems in Norwegian schools and/or manual ventilation routines (Table 5). Other factors which may influence these findings are climatic variations, building standards, and/or differences in cleaning routines. At the country level for Norway, the overall results for indoor air quality in the classrooms are good, but at the individual classroom level, there are still many classrooms which indicate poor air quality. The classrooms

Table 4: Comparison of CO_2 results for Norway

Avg. Concentration CO_2 (ppm)	# of classrooms 2003	# of classrooms 2009	% Difference
<=800	354 (33%)	167 (58%)	+25%
801-1000	275 (25%)	56 (20%)	-5%
1001-2000	377 (35%)	55 (19%)	-16%
>2000	79 (7%)	9 (3%)	-4%

Table 5: Ventilation types and % presence (2009)

Ventilation type	Category	Denmark	Norway
Natural Ventilation	Manual	51%	19%
Only Exhaust	Mechanical	18%	17%
Exhaust and Supply	Advanced Mechanical	31%	64%

with poor air quality indicators need remediation, where some advice is given in the next section.

This year's campaign can be seen as a success, as it was an excellent continuation of the annual campaign event in Norway, and a great web-based learning exercise for the students. It will be interesting to see if this year's campaign results have an impact on improving the indoor classroom conditions in Norway even further, and have an impact on making drastic initial changes in Denmark.

7 Recommendations

The following specific recommendations, in order of importance, can be made based on analysis of the campaign data for Norway. We hope that these recommendations are taken into serious consideration due to the potentiality that some individual classrooms in Norway have indicators for unacceptable air quality, and this may be detrimentally affecting student's health and well-being.

- **Continuous monitoring devices in classrooms**. A CO_2monitoring device is recommended to be installed at the approximate 100 classrooms that measured greater than 1000ppm CO_2 and/or the 30 classrooms with greater than 5 species mold and 20 colonies.
- **Ventilation systems and routines**. For schools with greater than 1000ppm CO_2 and 20 colonies/5 species mold, they should check their ventilation systems and ventilation routines.
    - Those with intake and exhaust ventilation systems, check system efficiency and consider professionally cleaning the system.
    - Those with just exhaust ventilation systems, also check system efficiency and consider cleaning, as well as consider adding intake.
    - Those with just natural ventilation, make sure that strict ventilation routines are adhered to, and consider installing an intake system, or combined intake and exhaust ventilation.
- **Results dissemination targeting students**. A campaign results pamphlet (based on this report) should be sent to all participating schools, notifying them of the results and how these results relate directly to the student - thus stressing the potential health effects of poor indoor air quality.
- **Publishing results at the European/International level**. It is recommended that results from the campaign, and further data analysis be published in an appropriate professional journal and be presented to the greater European scientific and educational community.
- **Professional monitoring campaign**. In order to better quantify the amount of schools with poor air quality in Norway, it is recommended to initiate a professional monitoring campaign.
- **Repeat campaign again.** It would be interesting to repeat this student campaign in Scandinavia/Norway again in 3-4 years for the students to experience the potential air quality trends which could be determined from repeating the campaign three times.

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ABSTRACT
Student research campaigns (forskningskampanjer) have been an annual event in connection to Science Days (Forskningsdagene) since 2003 in Norway. The campaigns invite students from all over the country to participate in a common scientific research event, always connected to a special environmentally related theme – for example Air Quality in the Classroom (2003), Pollution along Roads (2004), Bacteria in Drinking Water (2005), and The Rain Check (2006). This year's campaign repeated the 2003 Indoor Air Quality campaign, while in addition including schools in Denmark and Sweden as well.

The campaign included the hands-on activity of collecting CO_2 and mold data from the student's classrooms. This data was then assembled on the campaign website at miljolare.no. The results from the Norwegian campaign show that Norwegian classrooms show improved indictors in comparison to the 2003 CO_2 results, and that overall the mold results are not too alarming. Norwegian classrooms show much better indicators than their Danish counterparts when analysing the CO2 and mold results. Norwegian classrooms most likely show improved conditions due to advanced ventilation systems and ventilation routines, where improving ventilation is the single best method to improving the indoor air quality.

NORWEGIAN TITLE

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