Air Quality InQuiry (AQIQ):

Adapting air quality sensors for use in high school settings in the United States and Mongolia

Helena Pliszka, Kristen Okorn, Michael Hannigan, Joe Polman, Trang Tran, Daniel Knight, Evan Coffey

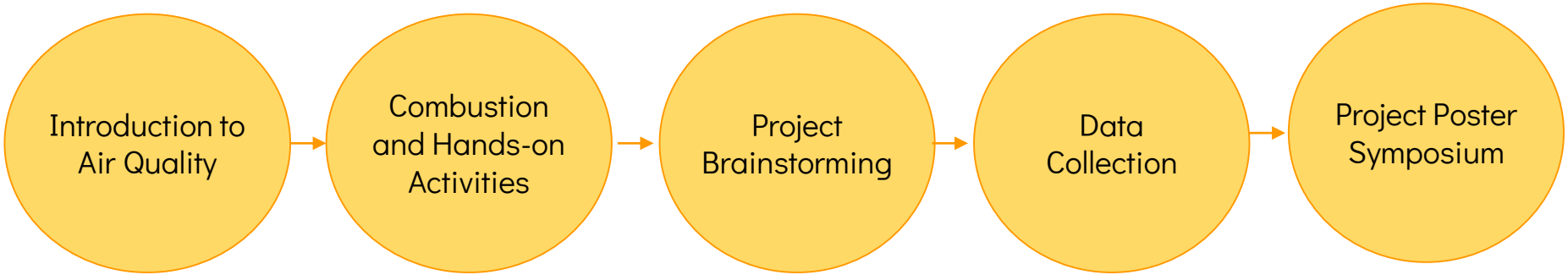
Up on a Rooftop..

- Low-cost air quality monitoring
  - Pre-oil and gas development in North Fork Valley 2012
- Western Slope Conservation Center non-profit set up locations
  - Paonia High was one of them!

...these pods should be *inside* the school

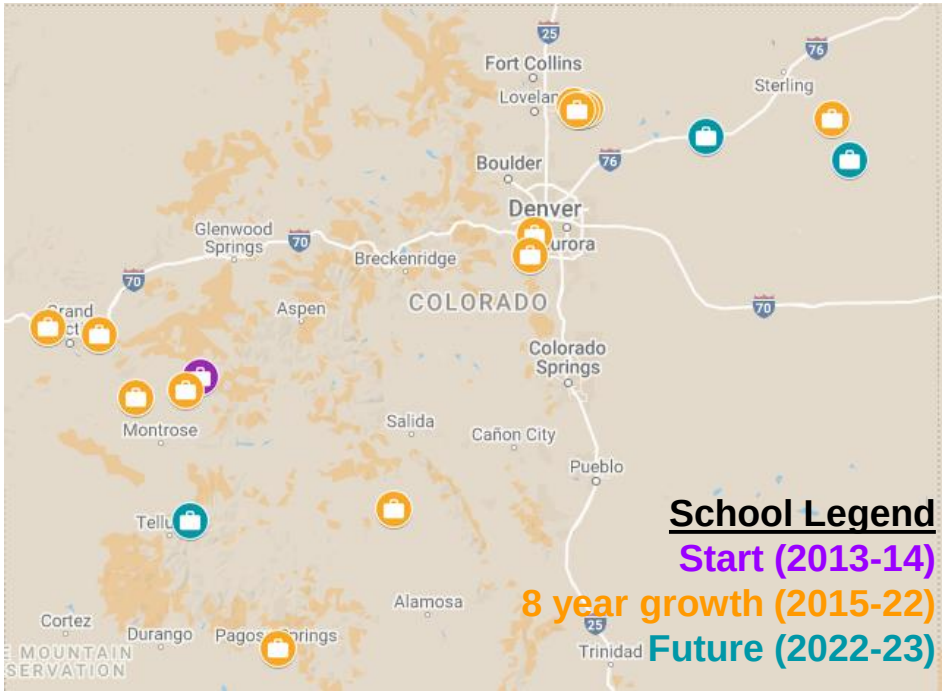
Air Quality InQuiry (AQIQ)

5 Teach Engineering Modules



Guided by CU Boulder mentors throughout the entire process

AQIQ in Colorado



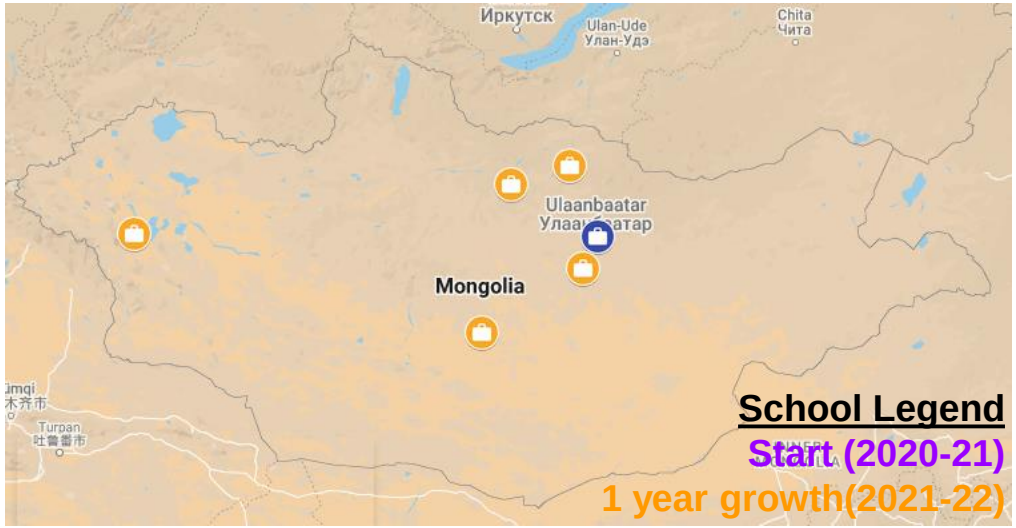
- 8 years later..
  - 15 total schools reached
  - Over 3,000 students
  - 8 school districts
  - Spanning the western slope to front range
- And growing !
  - 3 schools joining in 2022-23 academic year (Ouray, Yuma, Fort Morgan)

AQIQ in Mongolia

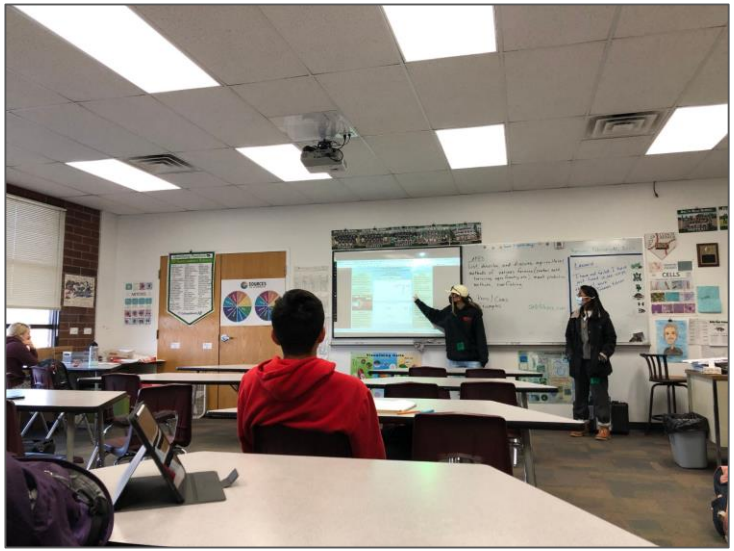
PUBLIC LAB MONGOLIA

CULTIVATING HEALTHY ENVIRONMENT & RESILIENT COMMUNITIES THROUGH OPEN DATA

- Student contact with Public Lab Mongolia NGO and National University of Mongolia
- Severe air pollution
- Start : 3 high schools in capital, Ulaanbaatar
- Current : 5 high schools across various provinces
- Doubled # of involved students



From research to a K-12 environment



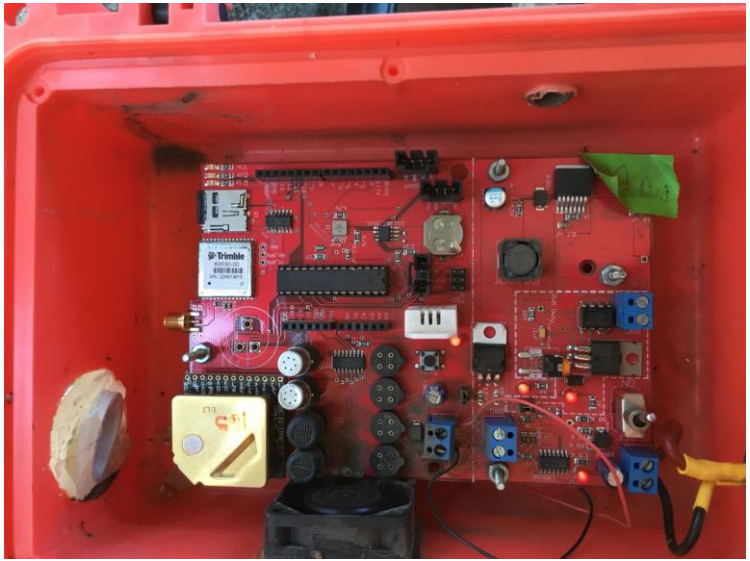
AQIQ Class, Delta High School 2022

Important Constants

- **YPods at center of curriculum**
  - Project-based → learning by doing rather than telling[1]
  - Demystifies science and engineering tools
  - Active engagement - no separation between knowing and doing[2]
- **Low-cost sensors**
  - Increases accessibility
  - Expands on ideas of citizen science[3]
- **Same pods used in research**
  - Authentic tools of the profession (students can adopt role)[2]
    - Used by Hannigan Lab in research settings
  - Allows students to draw ties with higher education/careers

Important Changes

YPod Iterations - 2013



Can measure :

- CO_2
- VOCs (light and heavy)
- NO, NO_2
- Temperature
- Humidity
- Pressure
- Ozone

Other features:

- Janky (disorganized)

Important Changes

YPod Iterations - 2016

Can measure :

- CO_2
- VOCs (light and heavy)
- ~~NO, NO_2~~
- Temperature
- Humidity
- ~~Pressure~~ (discontinued)
- Ozone

Other features:

- ~~Janky (disorganized)~~
- Power cable
- Battery power
- Instructions
- Updated circuit design

Important Changes

YPod Iterations - 2020

Can measure :

- CO_2
- VOCs (light and heavy)
- ~~NO, NO_2~~
- Temperature
- Humidity
- ~~Pressure~~
- ~~Ozone~~
- CO
- PM (1, 2.5, 10)

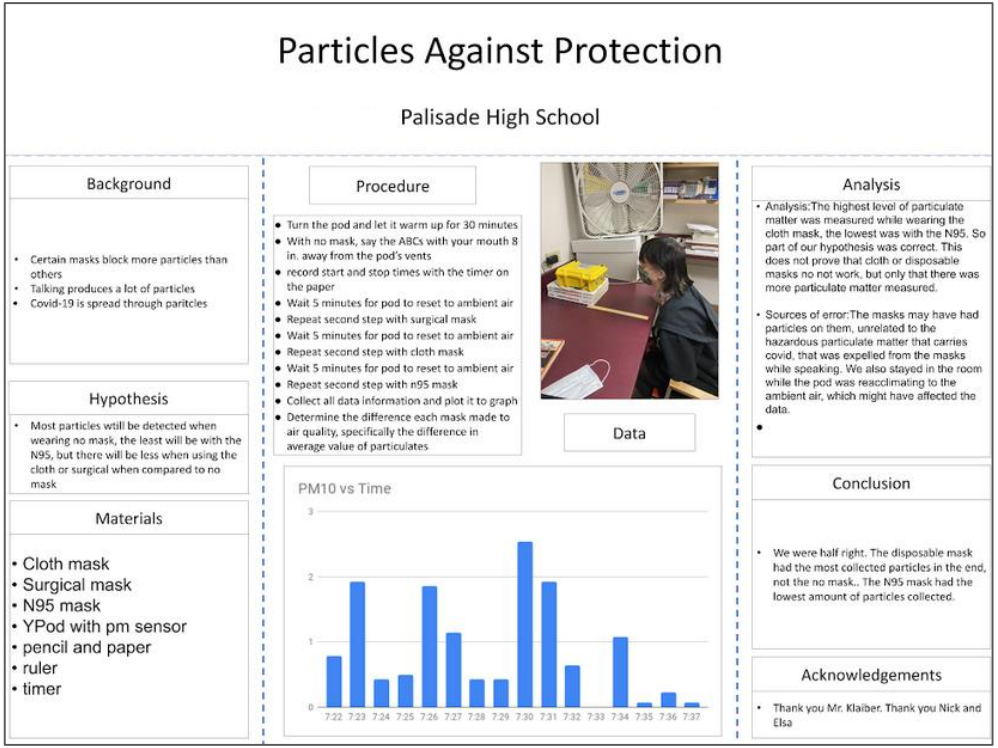
Other features:

- ~~Janky (disorganized)~~
- Power cable
- Battery power
- Instructions
- Updated circuit design
- Choice of gas-only / gas+ particulate

Important Changes

Incorporating PM

- Enhances understanding of air quality
  - AQI and NAAQS (rooted in regulation)
  - Easier for students to visualize
  - Allows to students to measure “Visibility”
  - Expands sources students can study (aerosols, dust, mechanical generation etc.)
- Connects to COVID-19
  - Mask experiment - importance of particle filtration
- Connects to wildfires
  - Place-based, students’ experiences of hazy days
- Over 20% of student projects involved PM in first year!



With these changes, students are able to explore

- Multiple pollutants
- Environmental factors (T, Rh)
- Place-based AQ questions

Tailpipe emissions activity, Ulaanbaatar

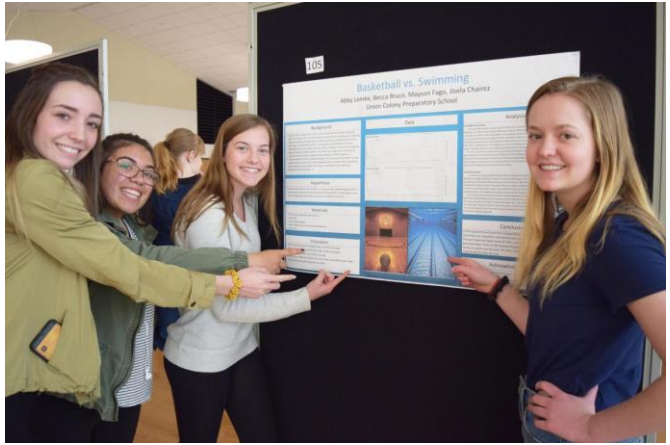
HS student exploring agricultural emissions

Tailpipe emissions activity in Lone Star, 2022

HS student exploring combustion

Past AQIQ Projects

Student AQ Symposium in Mongolia



Student AQ Symposium in Colorado

Pollutants and environmental factors

CO2/Humidity Levels In Music Classrooms

Palisade High School

Background

- We tested the air quality of three different classrooms which performed various musical activities (band, choir, and orchestra), all of which have differing numbers of students and levels of exhalation. We were curious as to which music class would have the highest level of CO2, considering the activity. High levels of CO2 in a poorly ventilated room can cause lethargy, poor attendance in schools, headaches, and even inpaired mental function.

Hypothesis

When musical activity is performed during the class period, then the CO_2 levels will increase because O_2 is needed.

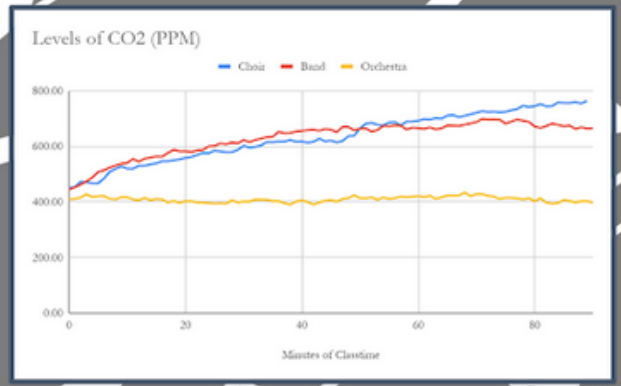
Materials

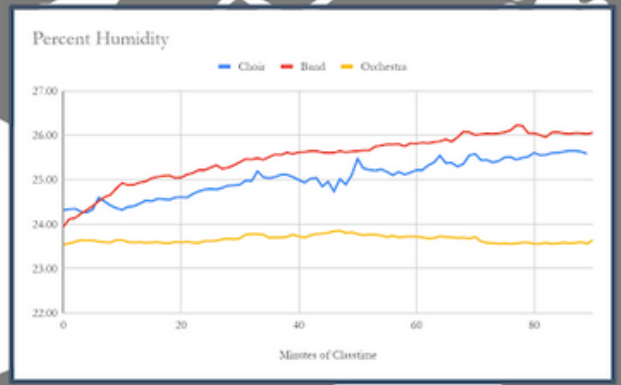
- Y-Pod to measure air quality
- Computer to record data
- Available rooms to test in
- Students involved during testing

Procedure

1. Set Y-pod in each classroom at separate times when the class is active
2. Let the Y-pod test for around 1 ½ hours per class
3. Collect the Y-pod after the time is done
4. Uploaded data to the AQIQ website, and transferred data to Google Sheets to be graphed

Data





Analysis

- Band had the Highest Humidity increase
- Choir had the highest CO2 and temperature increase
- Orchestra was the lowest in all categories
- In all classes, air quality levels grew linearly with the exception of the orchestra room
- Sources of error: On the first day of analyzation, the choir class was not singing, therefore we could not get an accurate data collection. The sizes of the rooms and the number of students also vary greatly between each class

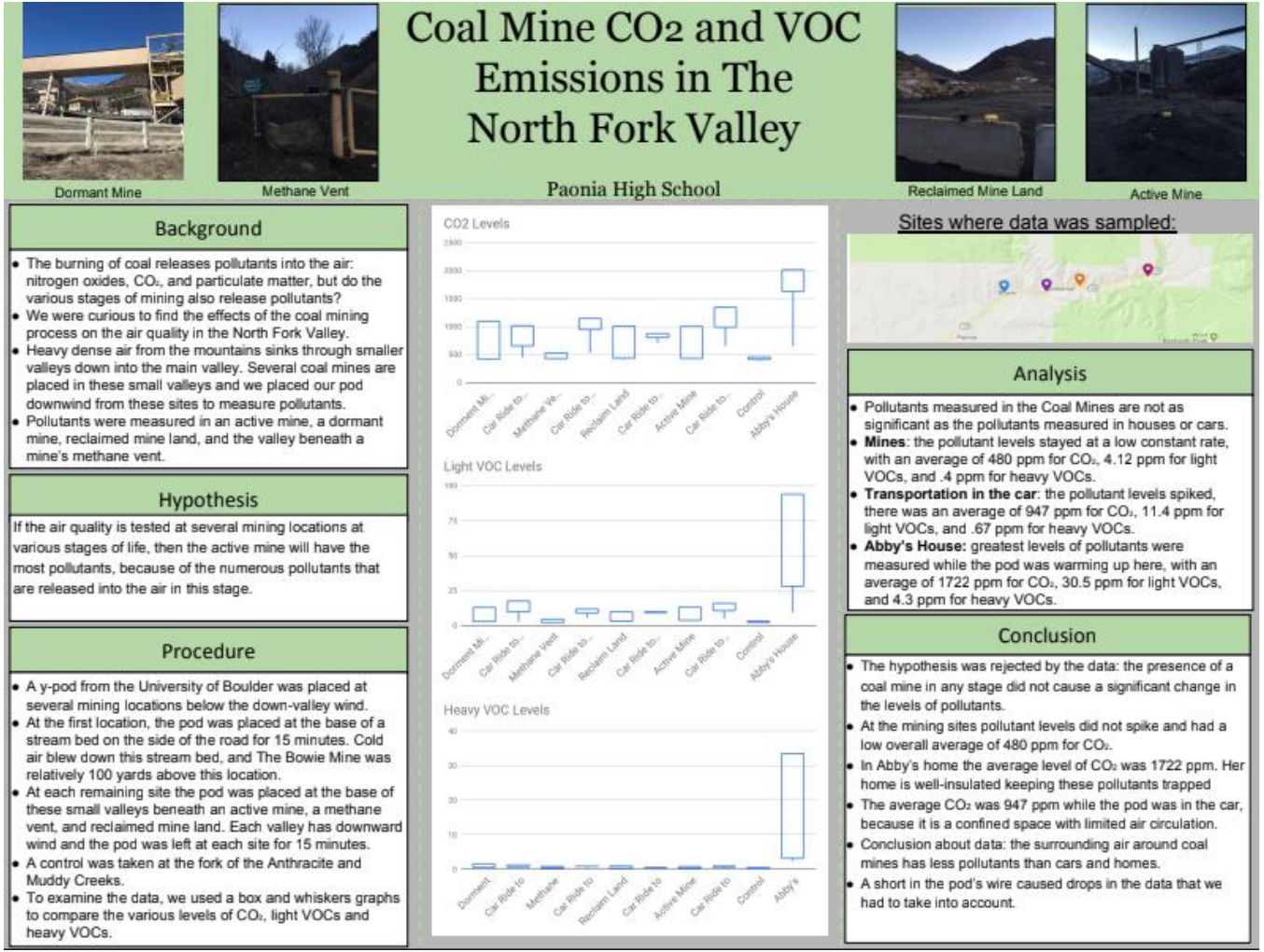
Conclusion

- Choir had the highest increase in CO2 and temperature, which was not expected because it has the least amount of people. Band had the highest humidity levels due to the large amount of students participating compared to the other classes. During the class periods, the CO2 and Humidity levels all increased gradually, and were at their highest at the end of the class period.

Acknowledgements

- We'd like to give a big thank you to Mr. Doty, Mr. Mauck, and Mr. Roper for allowing us to collect data during their classes.
- "How Bedroom CO2 Levels Impact Restful Sleep." *Zehnder America*, 15 May 2018, www.zehndermerica.com/how-bedroom-co2-levels-impact-restful-sleep/.

Place-based and multiple pollutants



Place-based Mongolia and multiple pollutants

AQIQ Mongolia Poster Day Recorded live

Галлагааны үеэр дотоод орчны агаар дахь хийн бохирдуулагчид хэрхэн өөрчлөгддөг вэ?

AQIQ Mongolia Chapter
Агаарын чанарын боловсрол олгох хөтөлбөр

Canada | University of Colorado Boulder | Public Lab Mongolia

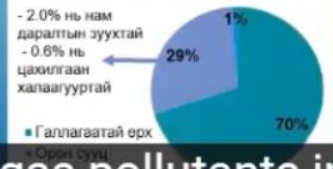
Хураангуй

2021 оны 1 дүгээр сарын 29-ы өдөр Улаанбаатар хотын Хайлааст орчимд 56 м² байшинд туршилтийг хийсэн. Энэхүү судалгаагаар байшинд гал түлэх үед агаар дахь хийн бохирдуулагч хэрхэн өөрчлөгдөж байгааг тодорхойлох зорилготой. Туршилтын үр дүнгээр дотоод орчин дахь нүүрстөрөгчийн дутуу исэл болон дэгдэмхий органик нэгдлүүд нь 15,4%, 2,4%-3.6% тус тус өссөн байна.

Танилцуулга

Агаарын бохирдол гэдэг нь нүүрсний шаталт, үйлдвэрлэл [1] болон тооэжилтоос үүссэн агаар мандалын бүтэц шинж чанарын өөрчлөлт [2] юм.

2019 оны байдлаар Улаанбаатар хотод амьдарч буй иргэд



Таамаглал

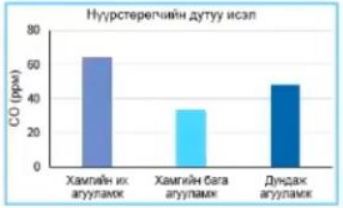
Сайжруулсан нүүрсийг шатаах үед дотоод орчны агаар дахь хийн бохирдуулагчийн агууламж ихсэх байх гэсэн таамаглал дэвшүүлж байна.

Арга аргачлал

Bekas төслийн зууханд туршилтаа явуулаа. Сайжруулсан нүүрс /8кг/ эд шатах үед POD тохооромжийг зуухны амсараас 20см зайтай байршуулж хийн хэмжилт явуулсан. Туршилтийг нийт 12 минут явуулсан бөгөөд үр дүнгийн боловсруулалтыг хийхдээ Microsoft excel program ашиглалаа.

Үр дүн

Судалгааны үр дүн дээр агаар дахь хийн бохирдуулагч бодисын агууламжыг үзүүлэв.



Дүгнэлт

Туршилтын үр дүнгээр дотоод орчны нүүрстөрөгчийн дутуу ислийн агууламж галлагааны үеэр 15.4%-иар ихэссэн байна. Нүүрстөрөгчийн дутуу исэл хамгийн ихдээ 64.5, хамгийн багадаа 33.6, дундажаар 47.9 байжээ.
Туршилтын үр дүнгээр дотоод орчны хүнд дэгдэмхий органик нэгдлийн агууламж галлагааны үеэр 2.4%, хөнгөн дэгдэмхий органик нэгдлийн агууламж 3.6%-иар тус тус өссөн үзүүлэлт гарчээ. Галлагааны үеэр дэгдэмхий органик нэгдэл нь 16:01 цагт хамгийн өндөр хэмжээндээ хүрсэн байна.
Үүнээс үзэхэд бидний дэвшүүлсэн таамаглал батлагдаж байна.

Хэлэлцүүлэг

Алдаа гарч болзошгүй зүйлс:
Хэмжилтийн цаг нь туршилтын цагтай тараагүйн улмаас хийн бохирдуулагчийн нөлөөллийг бүрэн хэмжигдэхгүй

Ашигласан материал

[1] Agaar.mn Агаарын бохирдлын тухай товчхон
[2] Ikon.mn
[3] www.1212.mn Статистикийн мэдээлэл

Талархал

Энэхүү судалгааны хөтөлбөрийг зохион байгуулан, билийг дэмжин, тэтгэсэн

how gas pollutants in the indoor air change during using coal burning stoves

30:39 / 3:55:10

Further Plans

Technical -

- Increase data accessibility
  - E.g. Wifi, cellular, Bluetooth
- Expand measuring capability
- Improve sensor calibration

Educational -

- Long-term impact of AQIQ
- Expand curriculum
  - Sensor function
  - Local sources/industry
  - Environmental justice

Teach Engineering website with AQIQ curriculum

More Information

AQIQ Website - https://www.colorado.edu/aqiq/

AQIQ Data Analysis Tool - https://www.colorado.edu/aqiq/resources

Curriculum - https://www.teachengineering.org/lessons/view/cub_airquality_lesson01

Learning outcomes from previous studies -

A. Collier-Oxandale, et al. “Towards the Development of a Sensor Educational Toolkit to Support Community and Citizen Science.” *Sensors* 2022, *22*, 2543.

A. Collier, D. Knight, K. Hafich, M. Hannigan, M. Polmear and B. Graves, "On the development and implementation of a project-based learning curriculum for air quality in K-12 schools," *2015 IEEE Frontiers in Education Conference (FIE)*, 2015, pp. 1-7.

D. Knight, A. Collier, M. Hannigan and K. Hafich, "Broadening and sustaining an Air Quality K-12 curriculum through a Digital Library and undergraduate service learning course," *2016 IEEE Frontiers in Education Conference (FIE)*, 2016, pp. 1-5.

K. Okorn, T. Tran, J. Polman, D. Knight and M. Hannigan, "Changing learning opportunities and outcomes with varying levels of remote and in-person engineering education outreach," *2021 IEEE Frontiers in Education Conference (FIE)*, 2021, pp. 1-8.

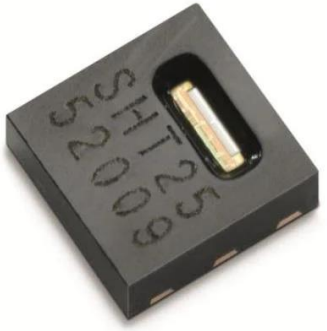
Polman, J. L., Tran, T. C., & Knight, D. W. Place-based air quality inquiry in U.S. rural contexts. In Miller, K. M.. Data Literacy in Context: Culturally Oriented and Place-Based Learning Through Data. Symposium presentation at American Educational Research Association 2022.

Tran, T. C., Polman, J. L., Knight, D. (2022). Organizing outreach for cultural transformation: The design of a STEM education learning pathway. 2022 International Conference of the Learning Sciences. (conference proceedings)

The Sensors

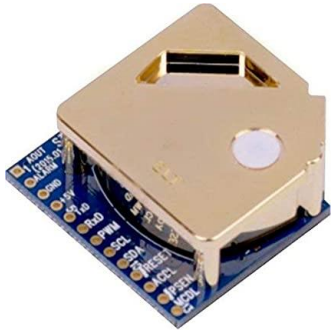
Figaro TGS2600 (sensitive to lighter VOCs)

Figaro TGS2602 (sensitive to heavier VOCs)



Sensirion Surface-Mount Humidity and Temperature

Alphasense CO-B4



ELT S-300 CO_2

Plantower PMS5003 Particulate Matter

References

1. Blumenfeld, D. et al. “Motivating Project-Based Learning: Sustaining the Doing, Supporting the Learning”, *Educational Psychologist*, 1991.

1. Christmas, D. “Authentic Pedagogy: Implications for Education” *European Journal of Research and Reflection in Educational Sciences*, 2014, 2(4).

1. Collier-Oxandale A, Papapostolou V, Feenstra B, Der Boghossian B, Polidori A. Towards the Development of a Sensor Educational Toolkit to Support Community and Citizen Science. *Sensors*. 2022; 22(7):2543.