Berkeley RadWatch & DoseNet

Engaging students and communities in learning about our radioactive world

NSSC Nuclear Science & Security Consortium

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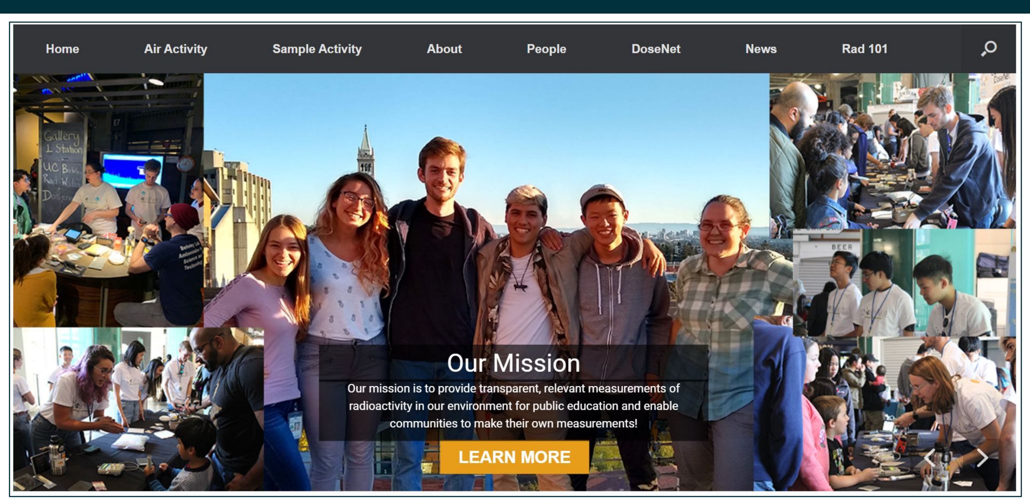
Abstract

The UC Berkeley RadWatch project, founded in 2011 following the Fukushima Da'ichi Nuclear Power Plant accident, focuses on a range of activities designed to improve public understanding of radiation in our environment. This program relies on a team of undergraduate researchers to provide a range of measurements of radiation in our food, water, ground, and air. These students make use of a range of technical methodologies to provide accessible and transparent data for our local communities. RadWatch also launched the DoseNet project several years ago, which involves a network of radiation and environmental sensors connecting schools in the Bay Area and internationally. This network and the technologies involved are also student driven. The sensor systems, including the software and hardware interface and the 3D printed housing, were designed and implemented largely by undergraduates under the guidance of graduate students, and project scientists. The work done by this team of undergraduates provides a model for a hands-on learning environment that has been applied in classrooms and through a summer internship program offered for Bay Area high school students. Highlights from our ongoing RadWatch analyses and the summer analysis work completed by our high school interns is shown.

Introduction



The RadWatch program focuses on maintaining a record of the observed levels of key radioisotopes in our environment, specifically those measurable through gamma-ray spectroscopy. We focus on highlighting levels of known background markers for Uranium and Thorium, such as Bi-214 and Tl-208, as well as K-40, and the most prominent indicators of human activity – specifically Cs-137 and Cs-134, which we track as an indicator of potential recent activity. We have also expanded these capabilities to include looking at heavy metal concentrations in similar biological samples using neutron activation. The purpose of this expanded effort is to put the radiological data we provide within the context of the broader array of potential contaminants we typically find within biological materials.

The RadWatch team is typically is made up of between 4 and 10 undergraduates working on a range of projects. Students are responsible for the general maintenance of our detection systems, and in making ongoing improvements in tools used to produce, analyze, and display the data we make available to the public. Most recently, several of our students have worked to develop a robust set of analysis tools for more rapid processing of the various biological samples we collect.

DoseNet focuses on a set of much less sophisticated sensor systems and understanding what can be learned about radiation in our environment through a network of such systems. This effort was initiated six years ago by a subset of the RadWatch team with radiation sensor installations in two Bay Area schools. Since then, with the help of high school summer interns, the systems have greatly enhanced the range of data collected and grown to include locations around the world.

DoseNet Network Sensor System Highlights

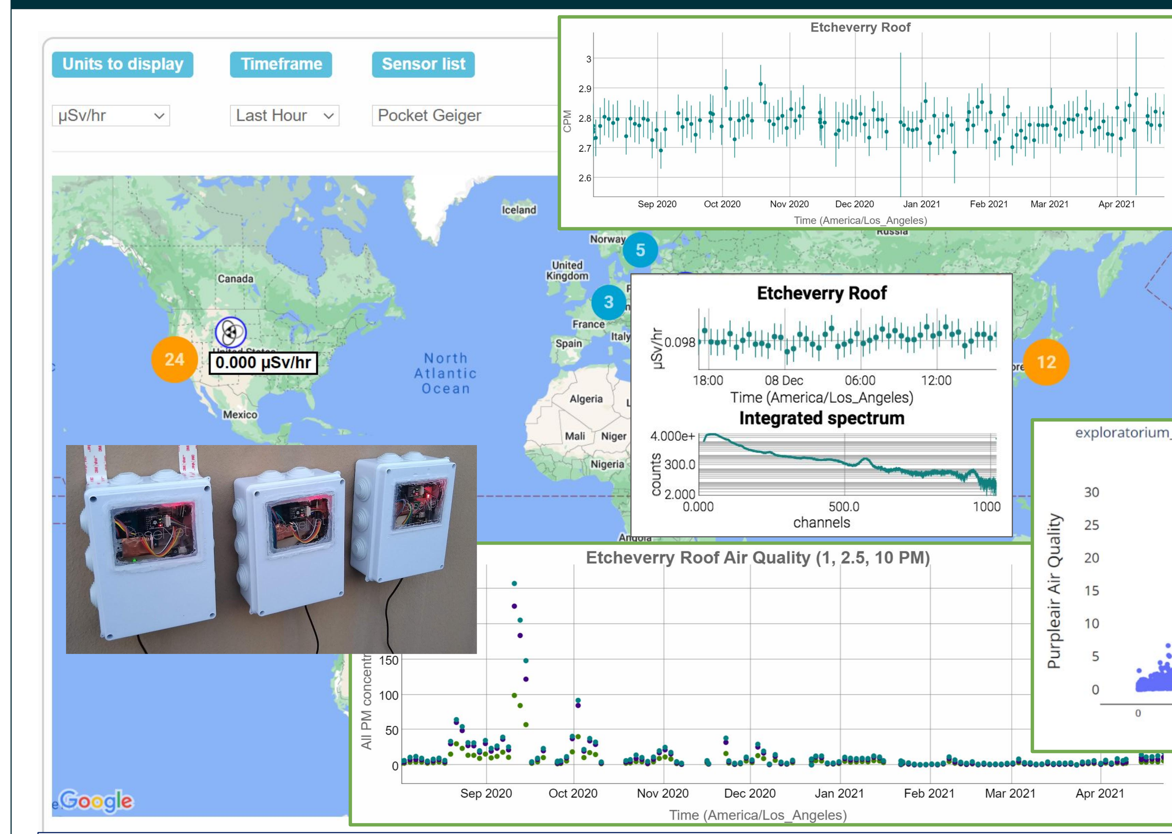


Figure 1: Map of DoseNet sensor locations (main). Example pop-up graphs showing time series data from various sensors: radiation counter (top), radiation spectrometer (middle) and particulate matter air quality sensor (bottom).

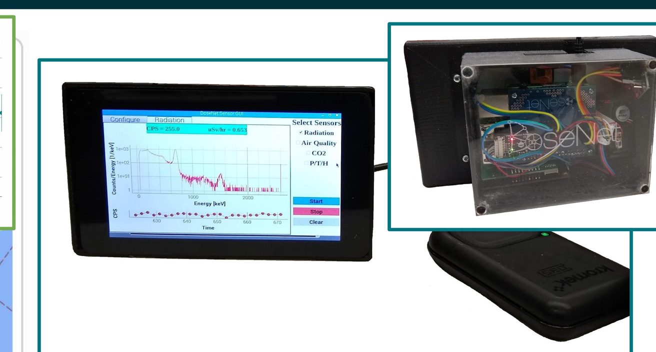


Figure 2: Portable version of sensor system front/back with example display

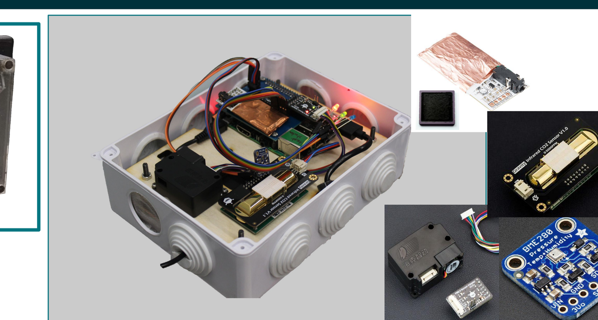


Figure 3: Network sensor system with newest assembly, including radiation counter (top), CO_2 (middle), Air quality (bottom left, and pressure/temperature/humidity (bottom right)

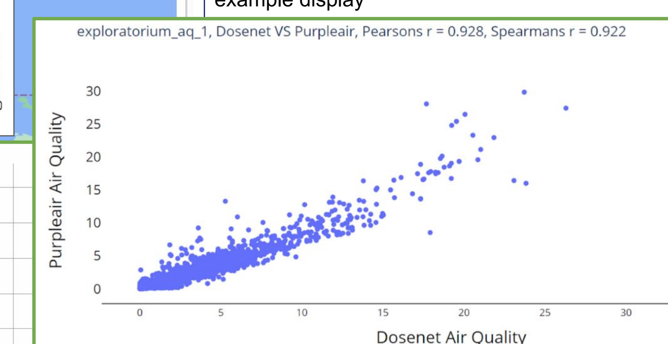


Figure 4: Summer student result showing good agreement between DoseNet air quality sensors and nearby Purple Air sensor

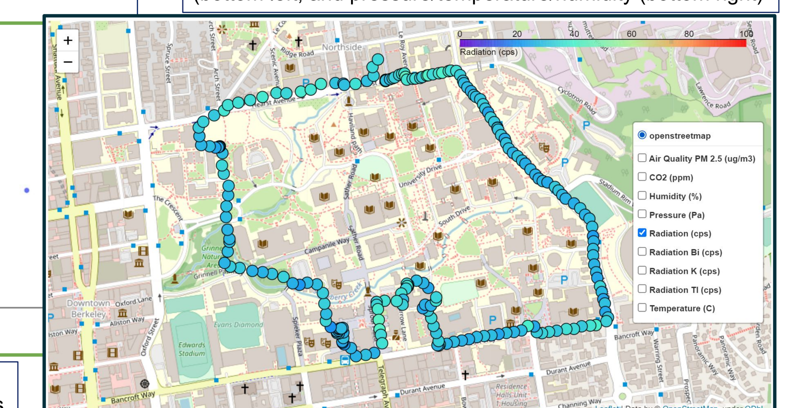


Figure 5: Summer student project result producing graphical interface for collecting and displaying mapped sensor data in real-time.

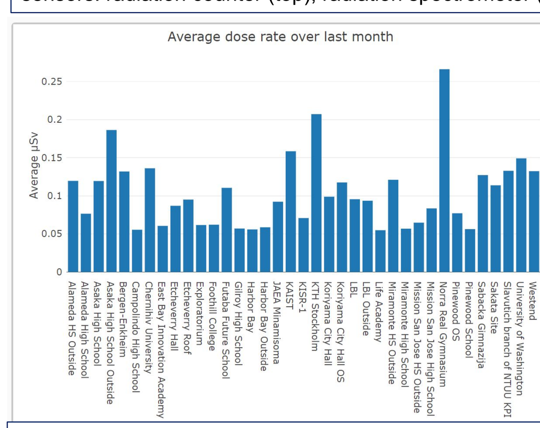


Figure 6: Summer student data visualization combining monthly dose averages across the DoseNet network.

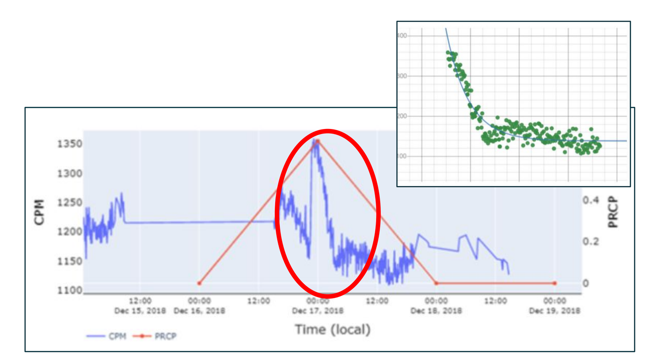
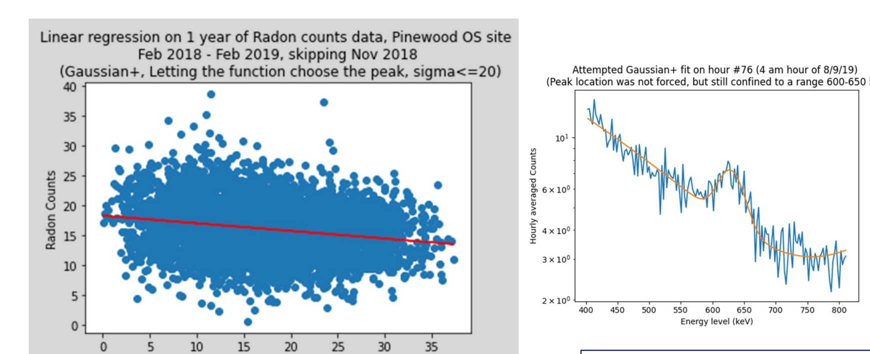


Figure 7: Summer student result looking at variation in radiation resulting from rain and exploring the exponential drop off in counts measured following a rain event.



Site Name	Linear Coefficient	R^2 Value	P-value
Campolindo	-0.0083	0.0001	0.61
Etcheverry Roof	0.197	0.013	2.89e-42
Exploratorium	-0.347	0.132	6.26e-26
Miramonte	0.434	0.205	1.62e-78
Pinewood	-0.182	0.08	1e-99
University of Washington	-0.174	0.072	3.23e-71

Figure 9: Research experience for teachers (RET) student result looking at correlations between specific radon markers (Bi-214) and temperature at various DoseNet network station locations. Top-left shows an example linear regression for data at one location over a year of data, top-right shows an example fit for extracting counts within the Bi-214 peak. The table (bottom) shows the full set of linear regression results for the six locations studied.

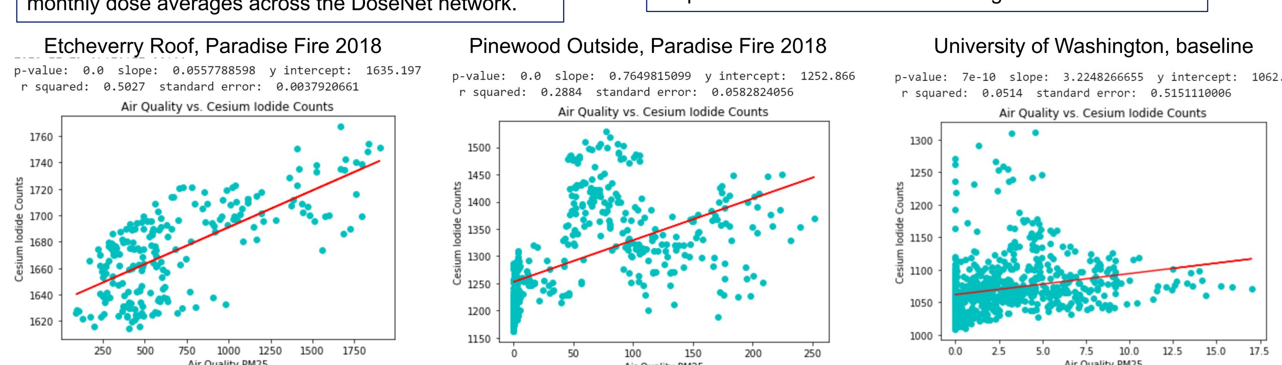


Figure 8: Summer student correlation analysis of radiation count-rate (as proxy for dose-rate versus air quality under normal conditions and during wild-fire related periods of poor air-quality.

A collection of highlighted results are presented in this panel. These focus on exploring the capabilities and sensitivities of the DoseNet sensor system, which includes data from radiation, weather, air quality, and CO_2 sensors, looking at known environmental factors that can lead to variations in dose rates

RadWatch Environmental Sample Results

Students collect samples from fish suppliers around the Bay Area. Samples are analyzed using spectra from a high purity germanium (HPGe) detector with a lead (Figure 2). The same basic setup is used for neutron activation analysis (NAA) samples (previous results are shown in Figure 4). The most recent results for our passive gamma analysis, which highlights K-40, Bi-214, Tl-208 and Cs-137/134 are shown in Figure 1. The current NAA analysis is being finalized, and will include heavy metal concentrations from the same fish samples. These recent results include a major improvements in the automation of the analysis process with the intention of making all steps more accessible to non-experts.

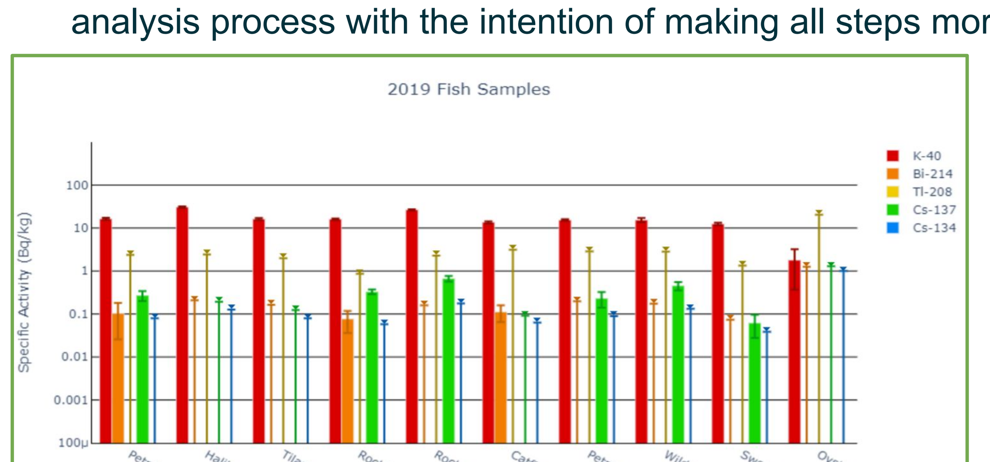
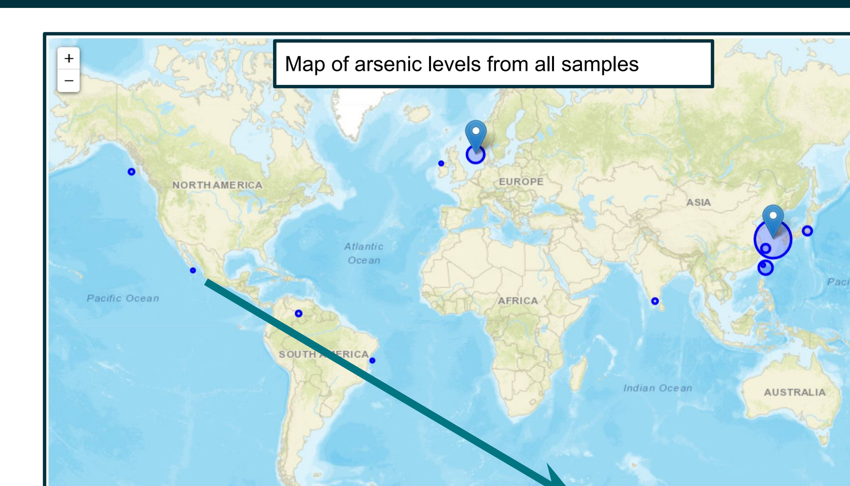


Figure 1: Most recent gamma analysis results

Figure 2: Fish sample in HPGe lead cave

Figure 3: NAA sample



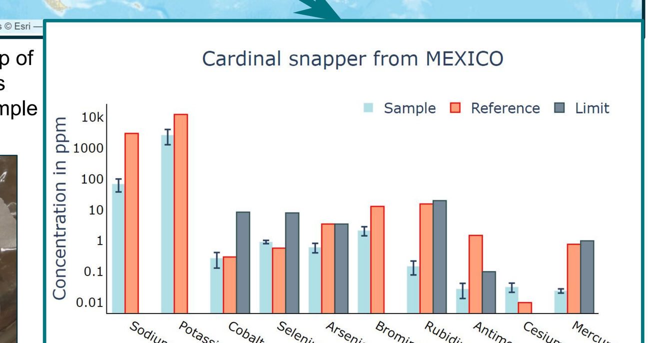


Figure 4: NAA results with map of relative arsenic concentrations (above); all results for an example sample (right).

DoseNet Student Analyses

The DoseNet sensor system includes a set of basic sensor components designed to extract basic radiation and environmental data. This includes: the Radiation Watch silicon chip acting as a radiation counter; in some cases an additional CsI gamma-ray spectrometer; a 1 cm^3 particulate matter sensor using laser light scattering to extract concentrations of 2.5 and 10 micron particulate concentrations; an infrared laser-based analog CO_2 sensor, and a BME280 pressure, temperature, and humidity breakout sensor (see Fig. 3). Our portable devices (Fig. 2) include an additional GPS sensor that allows for the mapping of data collected in real-time (Fig. 5).

We have installations of systems including some subset of these sensors (all include our basic radiation counter) across the Bay Area and internationally (Fig. 1), allowing us to explore the variation in radiation levels across our network (Fig. 6) and explore potential environmental causes for observed variations in dose-rate. We have now used the data collected across this network for a range of basic analyses exploring the accuracy (Fig. 4) and sensitivity (Fig. 7 - 9) of our systems to expected environmental factors that may cause fluctuations in dose-rate. These analyses include looking at how dose varies during wildfires, when there is a marked increase in particulate matter in the atmosphere (Fig. 8), radon washout (Fig. 7), and how temperature might impact radon levels seen in our systems (Fig. 9).

Discussion

The work done by our students has served to establish an independent baseline for background radiation activity in our environment, helping to demonstrate to our communities that radiation is everywhere and to quantify the impact of human activity. Similarly, they have expanded this expertise to include looking at a range of other metrics that may be of interest, such as heavy metal concentrations, while highlighting the power of gamma-ray spectrometry to explore our environment. Most recently, students have worked to make such analysis more streamlined and robust, in anticipation of expanding this work to include a wider range of samples, and to allow for communities to request information from samples collected from their local area.

Within the DoseNet project, our students have explored the sensitivity of basic, affordable, and accessible sensor systems to a range of environmental factors that can lead to observable variations in activity from common radiological markers. This includes looking for sensitivity to expected radon washout resulting from rain, and negative correlations in radon concentration and temperature. In these cases, the limitations of our systems help to highlight the challenges that such networked sensor systems face while expanding student understanding of the factors that can contribute to observed variations in activity from various radiological sources.

Future efforts from our students include building a new radiation sensor with a chip that will allow for increased sensitivity and spectral information without the need for the externally supplied CsI spectrometer, improving data visualization to make our results more accessible to the public, and expanding our system capabilities with additional sensor technologies (e.g. distance, seismic data, etc).

Acknowledgements

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National Nuclear Security Administration