Impact of Cruise Ship Air Emissions in Juneau, Alaska

Monitoring Plan

April 2019

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Introduction

The State of Alaska Department of Environmental Conservation (DEC) Air and Water Divisions are collaborating to address increasing public complaints regarding cruise ship emissions and discharges. Complaints about cruise ship emissions have increased significantly within the last 2 years. The Air Monitoring and Quality Assurance Program (AMQA) has designed a saturation study to investigate air quality impacts from cruise ships and associated activities like increased bus traffic in the downtown Juneau area. The investigation will focus on the 2019 cruise ship season.

Methodology

Because of the many variabilities in the emission patterns during the cruise ship season, AQMA decided to conduct a saturation study to determine the locations of maximum impact in the community and to assess the frequency and severity of the impacts. A saturation study is a type of investigation that utilizes a lot of samplers in a small geographic area over a limited amount of time. Saturations studies are usually the first step in any air quality monitoring assessment with a limited budget. Saturation studies usually employ low cost sampling equipment to determine initially if an air quality problem exists or the problem reaches the levels that warrant a more in depth and costly monitoring project.

Over the course of the season, the community will experience a lot of variability in air quality. The impacts will depend on the local meteorology, the number of ships at the docks and maneuvering around the docs, the ship emissions, which in turn depends on the ships emission sources, their activity and type of fuel, as well as surrounding activities in the community that can contribute to localized pollution. Variability in weather is one of the dominating factors on whether an area is impacted and for how long. The other factor is the emission source.

Because the emission sources are not stationary, but rather move and change daily it is difficult to predict where the maximum impact location or locations are. AMQA will use 20 low cost particulate matter (PM) sensors spread throughout Downtown Juneau and ‘the Flats’ to identify areas of high, medium and low impact. For this study PM is considered a tracer for plumes. Additionally AMQA will establish a network of 10 SO_2 sampling stations. AMQA selected passive SO_2 samplers that do not require electrical power and are a lot less expensive and time intensive to operate than conventional SO_2 analyzers. SO_2 is a common constituent of diesel exhaust.

To better distinguish which diesel source is contributing to the measurements, AMQA has identified 5 meteorological sites around the study area. The data is part of the MesoWest network. MesoWest is operated by the University of Utah Atmospheric Science Department. The data from these sites will be used in the analysis of the air quality measurements, along with the number of ships in the areas at the time and their activity as well as any other information about other potential sources.

Sensor Selection

Particulate Matter

AMQA selected the PurpleAir PA-II PM Sensor (https://www.purpleair.com/sensors). The selected PM sensor has the capacity to transmit the data via telemetry to a website in near real time. The data will be publicly available on the company website. AMQA will also create a website where the hourly averaged data will be displayed on a map.

The PurpleAir sensor uses a fan to draw air past a small laser. The reflections of the light from the particles in the air is counted. The sensor measures particles in six sizes between 0.3µm and 10µm diameter. The sensor measures a one second long particle count approximately every 80 seconds. The second sensor count is offset by 40 seconds allowing for the one second averaged particle measurements. The sensors are calibrated by the manufacturer to associate a particle size with particle mass and estimate total mass for $PM_{1.0}$, $PM_{2.5}$ and PM_{10}. Readings are then uploaded to the cloud every 80 seconds or so where they are stored for download and display on the PurpleAir map.

Low cost sensors are an emerging technology with a large variety of measurement technologies and many new sensors to choose from. EPA has started to perform some testing and is in the process of developing performance guidelines. In the meantime there are no firm standards for these sensors and the quality can vary enormously even though the price or sampling technology between sensors might be similar. To date the PurpleAir sensor has been one of the sensors that has been tested in many different environments and shows fairly good reliability. http://www.aqmd.gov/aq-spec/sensordetail/purpleair).

Air quality has traditionally been measured according to standards established by the EPA using regulatory monitors that are designated as federal reference method (FRM) or federal equivalent method (FEM). These monitors cost in the range of tens of thousands of dollars and require significant infrastructure and trained personnel to operate. In contrast, low-cost sensors may only cost a few hundred dollars, usually require much less maintenance and are simple to operate. Low cost sensors are not as accurate as the regulatory monitors and the data needs to be closely evaluated in the context it was collected. When used in a saturation study the emphasis is on the relational measurements rather than on the absolute accuracy of the measurement. That means the data are used to see variations in concentrations across an area, rather than focusing on the absolute concentration. It is more important to establish a correlation between the sensors than validating them against a federal reference method.

Sulfur Dioxide

AMQA selected the Ogawa passive SO_2 sampler for this saturation study. The sampler does not require any power or internet connection. The samplers are small and their small foot print make them easy to place in the field. A pre-coated collection pad is placed inside a weather proof sampling cartridge and placed outside. As air moves through the sampling cartridge over the pad, the SO_2 molecules react with the chemical on the pad and captured on the pad. After the desired exposure time, the collection pad is removed, the SO_2 extracted into an aliquot of ultrapure water with hydrogen peroxide, prepared for

shipment and analyzed in a lab. Typical exposure times range from 1 week for clean areas to 1 day for more polluted locations (https://ogawausa.com/)

In contrast most federal reference or equivalent method SO_2 analyses are based on the principle of the characteristic fluorescence released by the sulfur dioxide molecule when it is radiated by ultraviolet light. SO_2 absorbs light in the UV region (190-230 nm) of the spectrum without any quenching by air or most other molecules found in polluted air. The decay radiation is passed through a bandwidth filter and into a photomultiplier tube (PMT) that converts the signal into a voltage that can be directly measured. These methods require expensive sampling equipment that require climate controlled shelters, data loggers and telemetry to transmit the data to a computer. The sampler collects minute averaged data, which are usually averaged into hourly averages.

As with PM instrumentation, these analyzers and monitoring sites cost in the range of tens of thousands of dollars and require significant infrastructure and trained personnel to operate. In contrast, the passive samplers cost a few hundred dollars, require much less maintenance and are very simple to operate. Low cost sensors are not as accurate as the regulatory monitors and the data needs to be closely evaluated in the context it was collected. When used in a saturation study the emphasis is on the relational measurements rather than on the absolute accuracy of the measurement. That means the data are used to see variations in concentrations across an area, rather than focusing on the absolute concentration. It is more important to establish a correlation between the sensors than validating them against a federal reference method.

Site Selection

The focus of the study will be in the Juneau downtown area including the area between 9th and 12th Street and Egan Drive and A Street. The samplers will be spread evenly as best as possible given the topography, roads and building alignments. A map with the final site selection will be published here. *(The link will be provided when map has been completed.*)
During a public meeting in January 2019 residents were asked to identify areas that have experienced a high impact. AMQA will attempt to place samplers in these areas.

Timeline

Sampling equipment will be tested in the laboratory in March and April 2019. AMQA will develop a Quality Assurance Plan (QAPP, *the link will be provided once a draft QAPP has been completed.*) prior to deploying samplers.

AMQA will start installing samplers in mid-April with the intent of collecting baseline information before the cruise ship season starts. PM monitoring will continue through the entire season. Depending on the data collections success prior to the season, samplers might be left in the field until the middle of October. SO_2 passive sampling will start in mid-April as well, and focus on the busiest periods of the cruise ship season from May to July.

- PM2.5 data available during the season on web site
- SO_2 lab analysis July/ August

- Data analysis September / November
- Draft report December

Deliverables

- Near real time web site for $PM_{2.5}$
- Draft report
- Potential public meeting to discuss findings
- Final report
- If needed, plan follow up project