SoCal
SETAC News

Society of Environmental Toxicology and Chemistry
Southern California Chapter

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FEATURE ARTICLE

Face Coverings and SARS-CoV-2:

Droplets, aerosols, infectivity and some surprisingly complicated science

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Principal/inventor at Aromatica

The Centers for Disease Control (CDC) and the World Health Organization (WHO) discouraged the use of face coverings by the public during the initial months of the SARS-CoV-2 (coronavirus) pandemic. Jerome Adams, the nation's Surgeon General, tweeted on February 29, 2020:

"Seriously people- STOP BUYING MASKS! They are NOT effective in preventing general public from catching coronavirus, but if healthcare providers can't get them to care for sick patients, it puts them and our communities at risk!"

The National Academies of Sciences, Engineering, and Medicine *Rapid Expert Consultation* requested by the White House concluded that coronavirus is spread not only from sneeze and cough droplets – but also by conversation.[1] Within days of this report CDC recommended that face coverings could be used as a voluntary public health measure.[2]

How is it that we have such mixed messages from well-informed medical experts and scientists? Inconsistent early advice on mask wearing, and now lingering public resistance, may be due to the medical community not fully understanding the nature of aerosol behavior and transmission.

First, this coronavirus is novel, meaning that we had no experience with or immunity to the virus. At the start of an epidemic, we learn by analogy from previous epidemics. Since every virus is different, analogy only gets us part of the way to understanding. The early stages of a pandemic are like "the fog of war". Second, we suddenly experienced supply-chain challenges delivering personal protective equipment (PPE)[3] needed by those who must work in proximity with COVID-19[4] patients. Finally, there is the matter that the underlying aerosol science is complicated and not widely understood.

Much of the medical literature on respiratory disease transmission dichotomizes infection as coming either in droplet or airborne (aerosol) vehicles with a cut-off of 5-10µm.[5] Particles larger than the cut-off are considered "droplets" and those smaller are "airborne". This distinction is artificial and is not based on the physicochemical properties, composition, size or behavior of infectious particles. Social distancing recommendations come from an expectation that cough and sneeze droplets are primarily responsible for respiratory infections. It's assumed that these droplets fall by gravitational settling -- therefore do not travel far enough to infect another person.[6]

When that dichotomy was established nearly a century ago our knowledge of aerosol science was still rudimentary – yet the paradigm remains in use and is the source of inconsistent official recommendations, misinformation, and public confusion during this pandemic.

Here is where aerosol science comes in.

An aerosol is a liquid or solid particle suspended in air.[7] Aerosols include dusts, combustion particles, fog, mists, fumes and infectious bioaerosols. They range in diameter from submicrometer to several hundred micrometers and are of occupational and

President's Corner

Erika Holland, CSU Long Beach

What an interesting 2020 we have all had and how unfortunate that we were not able to celebrate another great year with the Chapter in person. I hope everyone and their families remain in good health as this pandemic continues. I am sure we are all missing summer travel and overall summer activities. I really missed the fourth of July celebration and summer BBQs and like all of us am hoping for a slightly more normal 2021. I also missed visiting with our membership and the ability to plan in-person meetings for the remainder of the year due to all the uncertainty. With that, I have to say, I have been humbled by the continued

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Table 1. Stokes settling velocity and VT approximations for a unit density (1g/cm^3) spherical particle in perfectly still air at standard conditions.[10]

Aerodynamic particle diameter, µm	Terminal Settling Velocity, VTS cm/sec	Time to fall 2 meters
1	0.003	18 hours
5	0.075	44 minutes
10	0.300	11 minutes
25	1.875	1.78 minutes
50	7.500	27 seconds
100	30.000	7 seconds

environmental health concern (see sidebar).

Aerosols resides outside the region defined by Newton's Laws of motion and classical mechanics. Instead, the Navier-Stokes equations describe the physical behavior of aerosols.[8] Stokes' Law, by linearization and simplification of the complex Navier-Stokes equations, provides a close approximation for the terminal settling velocity (V_{TS}) of an aerosol under the influence of gravity.[9] V_{TS} is reached rapidly and increases as the square of particle diameter.

The nonlinear monotonic function of gravitational settling has no clear particle size on which to dichotomize droplet vs. airborne behavior (Table 1). Only the larger aerosols fall out of still air in less than a minute. Any air currents can keep these particles suspended for extended periods of time. Additionally, this simplified and constrained model does not account for the propulsion and turbulence of a vapor cloud generated by a cough or sneeze. Recent work by Lydia Bourouiba from the *Fluid Dynamics of Disease Transmission Laboratory* at MIT shows that a "payload of pathogen-bearing" particles from cough or sneeze can travel 7-8m.[10]

Setting a cut-off diameter of 5-10µm and focusing only on aerosols above that break is arbitrary, is not physically grounded, and does not capture the complexity or behavior of aerosols that range in size from nanoparticles to temporarily-suspended particles up to 500µm.

What then do we know about the size of respiratory aerosols?

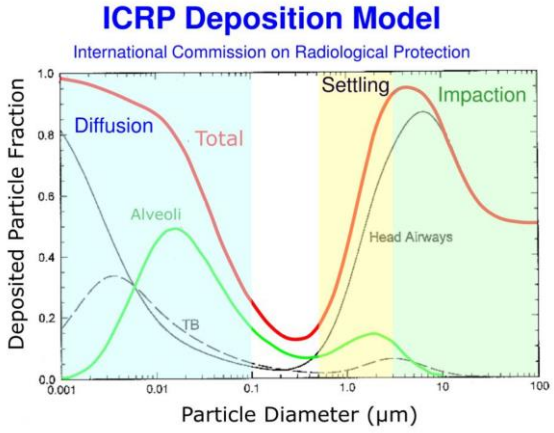
In a review of 26 studies, Grafton et al. found that breathing, talking, coughing and sneezing all released particles from 0.1µm-100µm.[11] As for aerosol production during breathing and talking, the authors speculate that particle atomization can occur through the vibration of vocal cords and from breaking of surface tension when opening alveolar sacs during tidal breathing. They state that bioaerosol infectivity is influenced by deposition of pathogen-carrying particles in the respiratory tract, type of infection, and pathogen load. We know little about these characteristics for SARS-CoV-2. **That brings us to the role of face coverings in our battle to bring down rates of infection and the spread of COVID-19.**

Face coverings are all about risk reduction. A University of Washington model shows that deaths could be reduced by 1/3 if 95% of the public wore masks.[12] A meta-analysis of 172 observational studies concluded that face coverings have a large effect on reducing the risk of infection.[13]

A simple cloth mask captures the bulk spray from a sneeze or cough of an infected individual; it also reduces the amount of virus you might inhale. We do not know the infectious dose - amount of virus needed to cause infection – for COVID-19. However, the larger the virus inoculum the greater a head start the virus has on the body's normal immune defenses. Therefore, those who wear face coverings and subsequently test positive, are more likely to be asymptomatic.

Support for this comes from an animal experiment showing lower

Environmental Aerosol Exposure



Occupational and environmental scientists have long focused on aerosol exposures and their effects on human health. Research over the past 35-40 years has largely focused on particles <10µm that can enter the lower tract and cause or exacerbate chronic bronchitis, pneumoconiosis, asthma, pneumonia, emphysema, lung cancer, heart disease, and premature mortality. There are anthropogenic and natural sources of these aerosols. Aerosols larger than 10µm are mostly captured in the nasopharynx and can exacerbate asthma but do not reach the lower respiratory tract. Much of what is known about aerosol deposition comes from the International Commission on Radiological Protection (ICRP), with strong representation from nuclear and health physicists. https://www.icrp.org/

Feature Article (continued)

infection rates from the SARS-CoV-2 virus when breathing air, containing the virus, and filtered through mask material. If the animals breathing filtered air became ill, the disease was milder.[14] This experiment, with intentional coronavirus exposure, could not ethically be conducted on humans.

Observational evidence of this effect comes from a study reporting on two hair stylists, both of whom had COVID-19. The stylists were tested because they felt ill, but it took a week to get back positive results; in the meantime, they served 139 clients. Customers and stylists wore masks and none of the clients subsequently developed symptoms. Of the sixty-seven clients who were tested for COVID-19, all were negative; while six non-client close contacts of one of the stylists subsequently came down with COVID-19.[15]

In the Proceedings of the National Academy of Sciences, Mario J. Molina[16] and his group state clearly:

Our analysis reveals that the difference with and without mandated face covering represents the determinant in shaping the trends of the pandemic. This protective measure significantly reduces the number of infections. Other mitigation measures, such as social distancing implemented in the United States, are insufficient by themselves in protecting the public. Our work also highlights the necessity that sound science is essential in decision-making for the current and future public health pandemics.[17]

We still have much to learn about this virus. Physical scientists, including chemists, toxicologists and exposure scientists, are needed to improve understanding of exposure and infection pathways. Until we have a cure or vaccine, our efforts need to focus on restricting the spread of disease -- so that public health measures can work to "crush the curve" of infection.[18] In the absence of countermeasures such as social distancing and face coverings, SARS-CoV-2 spreads exponentially. Therefore, these measures are essential if we hope to contain the virus.[19]

At the individual level that means wearing a face covering, maintaining social distance, and frequent handwashing. We are all in this together.

Endnotes

1. https://doi.org/10.17226/25769
2. https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/cloth-face-cover-guidance.html
3. https://www.adb.org/publications/shortage-ppe-covid-19-supply-chains-bottlenecks-policy
4. The disease caused by the SARS-CoV-2 virus
5. https://www.who.int/csr/bioriskreduction/infection_control/publication/en/
6. https://doi.org/10.1093/oxfordjournals.aje.a118097
7. William C. Hinds, 1999, Aerosol Technology: Properties, behavior, and measurement of airborne particles, Second Edition, Wiley-Interscience ISBN: 978-0-471-19410-1
8. https://www.grc.nasa.gov/www/k-12/airplane/nseqs.html. Navier-Stokes is one of seven unsolved equations in the Millennium Prize Problems challenge, sponsored by the Clay Mathematics Institute.
9. G. G. Stokes, "On the Effect of Internal Friction of Fluids on the Motion of Pendulums," Transaction of the Cambridge Philosophical Society, Vol. 9, Part 2, 1851, pp. 8-106.
10. doi:10.1001/jama.2020.4756
11. https://pubmed.ncbi.nlm.nih.gov/21094184/
12. www.healthdata.org/infographic/covid19-mask-usage-meta-analysis
13. https://doi.org/10.1016/S0140-6736(20)31142-9
14. https://*doi*.org/*10.1093/cid/ciaa644*
15. http://dx.doi.org/10.15585/mmwr.mm6928e2
16. Dr. Molina received the Nobel Prize in 1995 for his work with Professor Sherwood Rowland at UC Irvine. The prize was awarded for their discovery of the role of CFCs in destruction of the protective stratospheric ozone layer. Their research resulted in global cooperation to cease production of the most damaging CFCs.
17. https://www.pnas.org/content/117/26/14857
18. DOI: 10.1056/NEJMe2007263
19. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7224694/

Announcing SoCal SETAC 2021 Student Research Grant Applications!

To support the wonderful environmental chemistry and toxicology work done by students at Southern California schools, SoCal SETAC is soliciting applications from graduate students (for an award up to $2000) and undergraduate students (for an award up to $1000). These awards are intended to be used for proposed research (e.g. laboratory supplies, analyses costs, etc.). These research grants are available to any student researcher in the Southern California Region whose research falls under the scientific interests of the society.

Complete proposal packages are due 11:59 pm on September 20, 2020

See link below for more information:

https://www.socal-setac.org/student-grants

PRESIDENT'S CORNER (continued)

involvement of the Board, Officers, and members as everyone continues to help the Chapter thrive through these challenges.

Starting off I wanted to extend a huge thank you to Mary Woo, an Academic Board member from CSU Channel Islands, along with several Officers, for organizing an extraordinary student networking event through Zoom. The online "Chat with an Expert" event took place in June and aimed to connect students with professionals from different sectors of toxicology. We had an overwhelming number of professionals from government, the private sector, and academia volunteer to talk with students regarding their career, aspects of their job, and of course finding and applying for job opportunities. Literally within hours of sending out a call for volunteers, Misty's email was full of professionals eager to share with students. Then, thanks to Mary's leadership and stellar organization, together with our Officers who helped moderate, the meeting went seamlessly. The professional and student attendees had overwhelmingly positive feedback and we unanimously agreed that this event should be an ongoing offering to support our student body. We will look for an appropriate time moving forward to include another round for the student-professional networking opportunity.

The Board and Officers have also been working to plan an extended networking event for the Fall dinner meeting. We had hoped to hold this event in person, perhaps outside, but with the continued caseload in the State, we came to yet another hard decision. In-person gatherings need to be avoided to ensure the health of our entire membership and we have decided that the Fall meeting will also be virtual. This will be yet another opportunity to support our students and hear about their research. We have gathered a lot of great ideas from other SETAC Chapters that held successful virtual meetings that are both informative and effective. There are still a lot of details to discuss regarding timing and formatting but the virtual offering should offer us all a chance to see what the rest of the chapter is up to and hopefully a way to stay in touch. Stay tuned for more information in the future!

So even in a pandemic, the Chapter has strived to stay active to inform SETAC members in the Southern California area and I have enjoyed acting as President for the 2019-2020 cycle. This was our 25th year as a Chapter (thanks for the fun fact Chris) and while we were not able to celebrate this milestone, we will no doubt commemorate the occasion next time we can meet in person! Here is hoping that will be our annual meeting in 2021. So, as we come to the end of another year I am excited to step up as a Co-Past President, where Chris Stransky, our current Past President, has agreed to stay on for one more year as to share the spotlight and joy of planning our next annual meeting. Nick Hayman will step into the President role and I am confident he will be a great leader. He has played a huge role in the success of the Chapter since joining the Board (2018-2019) and as our current Vice President. As President, I have been so fortunate to have benefited from the great people acting as Officers and Board members. Chris has been such a great mentor and I am in awe at all the hard work of our other Officers (Nick, Alvina, Misty, Joe, and Violet) and Board members (Karin, Mary, Varenka, Jun, Ashley, Kate, Amanda, and Nicol). This year Karin, Jun, Mary, and Nicol will be rotating off the Board and I am grateful for all their contributions over their two-year terms. We are fortunate that Karin Wisenbaker, has agreed to step into the Vice President role this year. As a member of the Board, Karin has constantly volunteered to help organize events, evaluate student research, and plan annual meetings. She will no doubt make a strong contribution as our new VP!

Last but not least, I want to extend a huge thank you to the sponsors that have continued to support the Chapter this year, despite the loss of our annual meeting: Aquatic Bioassays, Anchor QEA, Enthalpy, Pacific EcoRisk, Physis, Weck Labs, and Wood E&I. The funds went to support general Chapter expenses and above all allowed us to continue our support of student research grants and travel or registration awards to the 2020 National SETAC Annual Meeting.

It has been an honor acting as President this year and I feel lucky to be part of this vibrant regional Chapter. The Chapter continues to be a model of success for other SETAC Chapters all due to our great Officers, Board members, and membership at large. I look forward to continued involvement this year and beyond and urge others to get involved, such a great group to work with! Take care and I hope to see everyone in person soon!

Erika

MEET THE BOARD

Kate Buckley

Wood Environment & Infrastructure Solutions, Inc

Kate catching Spotted Sand Bass in San Diego Bay for bioaccumulation testing

I could not be more excited to be a private sector representative on the SoCal SETAC board! My interest in SETAC began while attending the University of California, Davis and has continued to serve as a relevant and important aspect of my educational and professional career.

Growing up in San Diego, California, I developed a strong interest in the marine environment from an early age. I began to foster this interest by volunteering at the Birch Aquarium, educating campers about local marine life and leading hands-on activities including surfing, snorkeling, and tide-pooling.

I then enrolled at UC Davis, where I was confident in my decision to study science but torn between human biology and environmental studies. Luckily, the university offered an environmental toxicology major, which was the perfect intersection between these two interests. While in school, I also volunteered in the Tjeerdema Aquatic Toxicology and Environmental Chemistry lab assisting graduate students in their research on the environmental fate of antibiotics, particularly Azithromycin- one of the most widely used antibiotics in the world. While at UC Davis, I was first introduced to SETAC and was one of the few undergrad students to participate in the Northern California chapter events.

My favorite part of my academic career at UC Davis was participation in a study abroad program at the University of Queensland, Australia. In this program, we collaborated with other students on research topics, gained experience designing and presenting research, and learned new methods for collecting and analyzing data. Specifically, I studied the effects of sedimentation on coral *Pocillopora damicornis* on Heron Island in the Great Barrier Reef and how temperature affects feeding behavior of crab *Metopograpsis frontalis* on corals. It was a marine scientist's dream!

After school, I moved back to San Diego and spent one year volunteering at the Hamdoun Lab at Scripps Institution of Oceanography (SIO) assisting graduate students with their research on the interactions between persistent organic pollutants (POPs) and ATP Binding Cassette (ABC) transporters in sea urchin embryos. While at SIO, I was introduced to staff at Wood Environment & Infrastructure Solutions, Inc. (previously Amec Foster Wheeler) and landed a job in the environmental consulting industry.

My academic background and experience have well-equipped me to work in the private sector as an Aquatic Scientist for Wood. As an environmental consultant, I have the opportunity to support a wide variety of projects that include the monitoring of water, sediment, and biotic communities as well as reporting these studies to ensure regulatory compliance. This includes toxicity studies, particularly those required by National Pollution Discharge Elimination System (NPDES) permits. Occasionally, I also work in the Wood Aquatic Toxicology Laboratory to assist in compliance toxicity tests and special studies. Outside of work, I also participate in a volunteer scientific diving program called Reef Check (pictured) and enjoy staying active through running, surfing, swimming, hiking, and biking.

Performing a Reef Check dive survey in Catalina, surrounded by invasive algae Sargassum horneri

STUDENT CORNER

Student Member Spotlight: Alice Coleman

PhD Student at University of Southern California

Hello! My name is Alice Coleman and I am a second-year student in the Marine Biology and Biological Oceanography Ph.D. program at USC. I am a member of Dr. Suzanne Edmands' lab, which primarily studies conservation and population genetics with the supralittoral copepod *Tigriopus californicus*. My current research assesses the existing US EPA methods for choosing organisms during the development of water quality criteria, the enforceable national standards that represent the maximum concentration of a toxicant expected to not present significant health risks to the majority of aquatic life. To ensure the protection of the broad taxonomic and phylogenetic diversity of aquatic organisms, the US EPA set minimum data requirements which describe the minimum set of species that must have available data in order to develop a criterion. Combining evolutionary, statistical and ecotoxicological techniques, my work explores the relationship between the taxonomic composition of toxicity data and criteria and assesses whether the minimum data requirements are sufficient for providing the intended level of protection. I am also studying the phylogenetic patterns of toxicity tolerance at large to help understand when tolerance in one species will be a good proxy for tolerance in a related species. Phylogenetic approaches are increasingly being used to generate toxicity data for data-deficient species but the extent to which tolerance is phylogenetically restricted across aquatic organisms is unclear. For the remainder of my Ph.D., I am keenly interested in exploring the roles of local adaptation and phenotypic plasticity in the physiological responses to the acute and chronic toxicant exposure observed in fishes and aquatic invertebrates.

How to Create a Focused Graduate School Application

Amanda Russell, SoCal SETAC Student

So, you've made the decision to apply to graduate school! You've started working on your personal statement, obtaining letters of recommendation, and reaching out to potential advisors, and want to make your application the best it can be. It can be a daunting task, but there are certain steps you can take to streamline the process. Here are four tips that can help focus your application and discern which program is right for you:

1. Start Early and Check Deadlines

Applying to graduate school is a time-consuming process that requires significant planning. Different programs often have different deadlines and timelines, and it is important to plan ahead and give yourself plenty of time. It might be beneficial to even start the planning process six months before the application deadlines. Pay special attention not only to school deadlines, but also to deadlines for grants, scholarships, and financial aid. For many students, FAFSA is an important source of funding, and many schools have special aid or grants set aside for incoming students. Advanced planning will allow you to spend your time and energy on your personal statement and researching programs and laboratories.

2. Know Why You Are Applying

Although you don't need to have every detail of your ten year plan decided, you should have a clear answer for the question "Why do you want to attend graduate school?". Make sure that you know why you are applying and what you hope to get out of this experience, and let those answers guide your decision-making process. It's normal and expected for goals and ideas to change along the way, but graduate school is a significant commitment, and having clear motivations will help you select the program with the best fit for you. There is absolutely nothing wrong with taking a year (or two!) to get some work experience to figure out which program will work best for you.

3. Talk to current graduate students

The best way to understand the inner workings and details of a graduate program is to talk to the students who are already in the midst of it. Current graduate students are often willing to share their thoughts and personal experiences, and can be a fantastic

STUDENT CORNER (continued)

resource. This can be a great way to ask more detailed or personalized questions about the graduate program, overall school experience, and specific laboratories. These students have been through the same process, and likely dealt with similar challenges and questions. This step is especially critical in understanding how the program dealt with Covid-19 related challenges such as online learning, in-person laboratory experiments, and changes in funding. To understand what the next year might look like in graduate school, ask the students that lived through it last year.

4. Don't give up

There will be times when the process may feel overwhelming, but you are not alone. Be persistent, stay inspired, and get motivated. Let your passion and goals remind you why you want to pursue a graduate degree, and keep moving forward. Not every laboratory accepts students every year, and positions may be dependent on funding, school policies, or factors out of your control. Even from one year to another, your application may look different as you gain experience and skills or shift your focus. Rejection is a common and unavoidable part of the process, so it is crucial to continue researching programs and sending inquiry emails.

Navigating the application process is a tough but important first step into your graduate school journey. Every student has a unique background and experiences, and with careful planning, clear motivations, and strong focus, you can begin to understand which programs are the best fit for you and how to highlight your strengths. As one of your SoCal SETAC student representatives and current master's student, you are welcome to reach out to me with questions about the application process or graduate school concerns at arussell3483@gmail.com. Good luck!

Have you checked out the revamped Student Resources Page on the SoCal SETAC Website?

During these unprecedented times, we have built this page to help students find resource to continue to learn and engage with community and prepare for the next step. Check it out and please email vrenick@ocsd.com if you have any additional resources or tips to share!

https://www.socal-setac.org/student-resources

CALENDAR OF EVENTS

August

Ecological Society of America 2020 Annual Meeting

Aug 3-6, virtual

National Environmental Monitoring Conference 2020

Aug 3-21, virtual

17th Annual EPA Drinking Water Workshop

Aug 31-Sep 3, virtual

September

StormCon: The Surface Water Quality Conference & Exp

Sep 9-10, virtual

35th Annual Water Reuse Symposium

Sep 14-16, virtual

CASQA Annual Conference

Sep 15-16, virtual

October

15th International Conference on Monitoring, Modelling and Management of Water Pollution

Sep 30-Oct 2, virtual

WEFTEC Connect 2020

Oct 5-9, virtual

November

SciCon2: SETAC North America 41st Annual Meeting

Nov 15-19, virtual

SOCAL SETAC OFFICERS AND BOARD MEMBERS

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