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MICROORGANISMS DETECTION

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INTRODUCTION

Our particles sensor can detect a range of diameters between **0.1 and 10µm**.

The research is separated into three parts; fungi and protozoa, bacteria and viruses, due to the difference in size between them. In the case of spherical microorganisms, the diameter was taken as a parameter for comparison. In the case of micro-organisms with two dimensions (cylindrical: diameter and length, or others: height and width), the larger of the two dimensions was taken as the parameter for comparison.

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FUNGI AND PROTOZOA

The smallest protozoa are at least 1 to 10 µm in size (Citation: Yaeger, R.G., 1996. Protozoa: Structure, classification, growth, and development. Medical Microbiology. 4th edition. Available at: http://www.ncbi.nlm.nih.gov/books/NBK8325/ [Accessed March 20, 2022]).

Fungi have a maximum diameter of 2 to 10 µm (Citation: Anon, Fungi. Fungi - an overview [ScienceDirect Topics. Available at: https://www.sciencedirect.com/topics/earth-and-planetary-sciences/fungi [Accessed March 20, 2022]).

Therefore, it is concluded that 100% of fungi and protozoa would be detected by our PM sensor.

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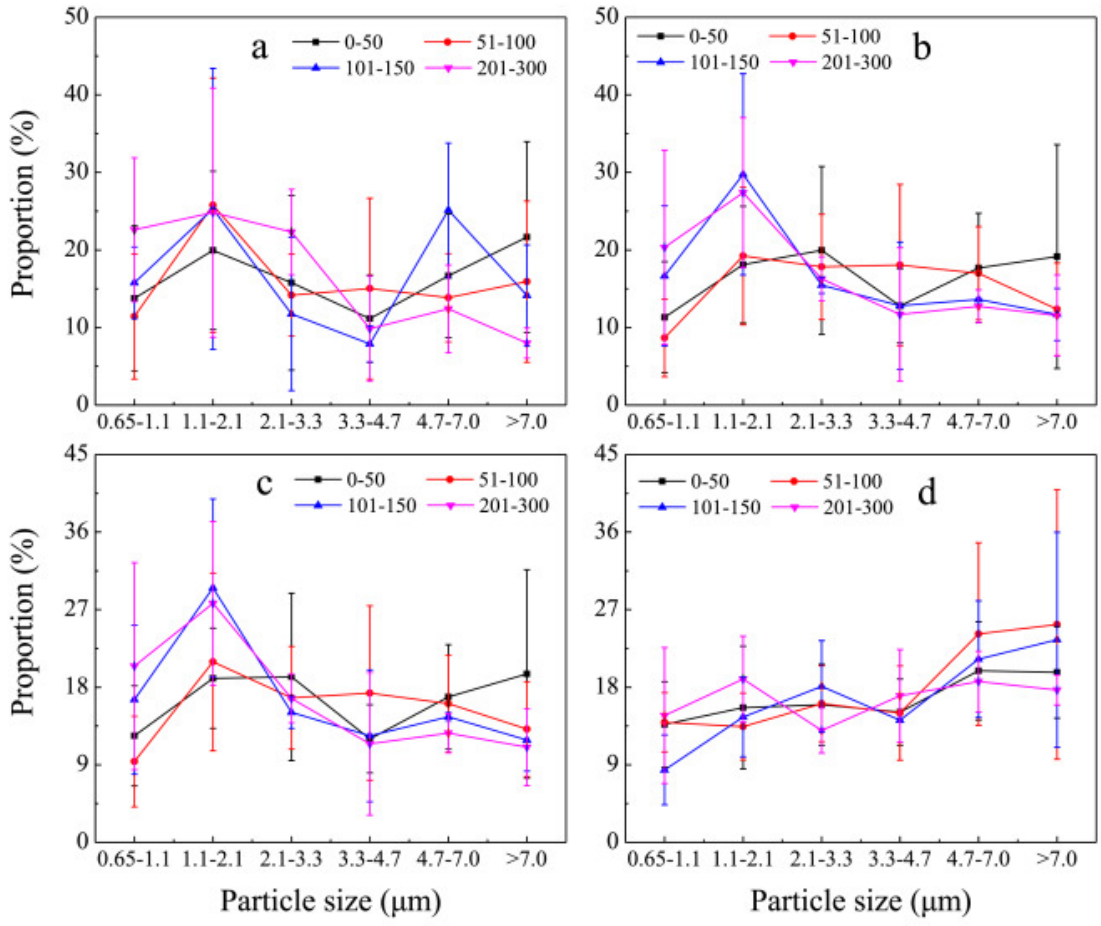
BACTERIA

The graph below shows the size distribution of bacteria in the air under different atmospheric conditions:



(Citation: Gong, J. et al., 2019. Concentration, viability and size distribution of bacteria in atmospheric bioaerosols under different types of pollution. Environmental Pollution. Available at: https://www.sciencedirect.com/science/article/pii/S0269749119338436?via%3Dihub [Accessed March 20, 2022]).

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The graph demonstrates that the smallest bacteria have a minimum size of 0.65 µm, and that therefore **100% of the bacteria in the air would be detected by our PM sensor.**

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VIRUS

We have not found any global distribution of virus sizes. However, we have found size distributions of the most frequent viruses, in red those we could not detect and in green those we could detect:

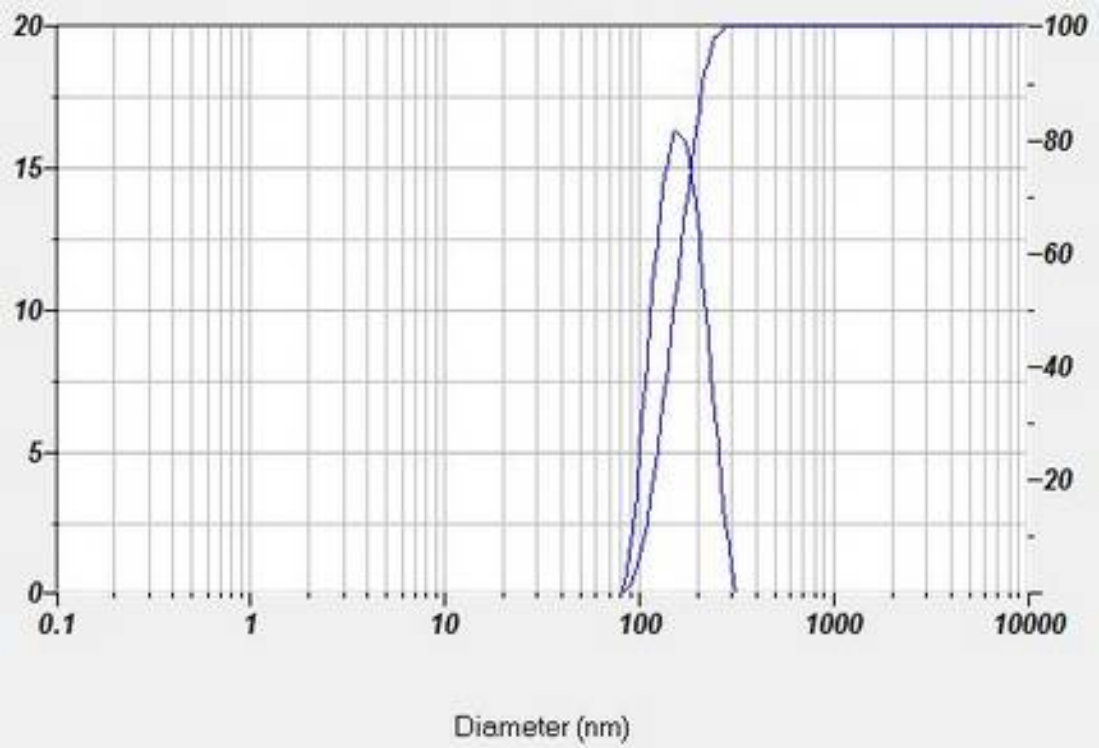
- Coronaviridae: 0.08 - 0.22 µm (Citation: Anon, 2016. Coronaviridae. Fenner's Veterinary Virology (Fifth Edition). Available at: https://www.sciencedirect.com/science/article/pii/B9780128009468000246 [Accessed March 20, 2022])

- SARS-COV-2 (Covid19): 0.1 µm (Citation: Bar-On, Y.M. et al., 2020. SARS-COV-2 (COVID-19) by the numbers. eLife. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7224694/#:~:text=SARS%2DCoV%2D2%20is%20an,produced%20by%20coughing%20and%20sneezing. [Accessed March 20, 2022])

- Rhinovirus: 0.015 - 0.03 µm (Citation: E;, D.S.D.C.A.A.C.G., The cold case: Are rhinoviruses perfectly adapted pathogens? Cellular and molecular life sciences : CMLS. Available at: https://pubmed.ncbi.nlm.nih.gov/17131060/#:~:text=Rhinoviruses%2C%20which%20cause%20common%20cold,genome%20(about%207%20kb). [Accessed March 20, 2022])

- Influenza virus: 0.8 - 0.12 µm (Citation: WM;, S., The size of influenza virus. The Journal of experimental medicine. Available at: https://pubmed.ncbi.nlm.nih.gov/19871369/#:~:text=It%20is%20concluded%20that%20influenza,diameter%20of%20about%2070%20mmicro. [Accessed March 20, 2022])

In addition, most of the size distribution of influenza viruses is above 0.1 µm, as shown in the graph below. (Citation: Anon, Virus and virus like particle particle size analysis. HORIBA. Available at: https://www.horiba.com/es/scientific/products/particle-characterization/applications/pharmaceuticals/viruses-virus-like-particles/ [Accessed March 20, 2022]):



- Varicella-Zoster, Herpes-Zoster virus: 0.15 - 0.2 µm (Citation: Canada, P.H.A.of, 2012. Government of Canada. Canada.ca. Available at: https://www.canada.ca/en/public-health/services/laboratory-biosafety-biosecurity/pathogen-safety-data-sheets-risk-assessment/varicella-zoster-virus.html [Accessed March 20, 2022])

- Measles virus: 0.15 - 0.3 µm (Citation: Enders, G., 1996. Paramyxoviruses. Medical Microbiology. 4th edition. Available at: https://www.ncbi.nlm.nih.gov/books/NBK8461/#:~:text=All%20paramyxoviruses%20are%20enveloped%20particles,an%20RNA%2Ddirected%20RNA%20polymerase. [Accessed March 20, 2022])

- Mumps virus: 0.1 - 0.8 µm (Citation: Brgles, M. et al., 2016. Identification of mumps virus protein and lipid composition by mass spectrometry - virology journal. BioMed Central. Available at: https://virologyj.biomedcentral.com/articles/10.1186/s12985-016-0463-0#:~:text=Mumps%20virions%20are%20pleomorphic%20particles,host%20cell%2Dderived%20lipid%20envelope. [Accessed March 20, 2022])

- Hantavirus: 0.08 - 0.12 µm (Citation: Muyangwa, M. et al., 2015. Hantaviral proteins: Structure, functions, and role in hantavirus infection. Frontiers in microbiology. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4661284/ [Accessed March 20, 2022])

- HSV (Herpes Simplex virus): 0.16 µm (Citation: Anon, Herpes simplex virus. Herpes Simplex Virus - an overview | ScienceDirect Topics. Available at: https://www.sciencedirect.com/topics/medicine-and-dentistry/herpes-simplex-virus#:~:text=HSV%20is%20a%20nonenveloped%20virus,%2C%20double%2Dstranded%20DNA%20genome. [Accessed March 20, 2022])

- Ebolavirus: 0.8 - 1 µm (Citation: SIB Swiss Institute of Bioinformatics Disclaimer, Ebolavirus. SIB Swiss Institute of Bioinformatics Disclaimer. Available at: https://viralzone.expasy.org/207 [Accessed March 20, 2022])

- VIH: 0.1 µm (Citation: German Advisory Committee Blood (Arbeitskreis Blut), Subgroup 'Assessment of Pathogens Transmissible by Blood,' 2016. Human immunodeficiency virus (HIV). Transfusion medicine and hemotherapy : offizielles Organ der Deutschen Gesellschaft fur Transfusionsmedizin und Immunhamatologie. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4924471/ [Accessed March 20, 2022])

Our PM sensor could detect the following microbes:

- Staphylococcus aureus: 0.5 - 1 µm
- E coli: 1 - 2 µm
- Bacillus subtilis: 2 - 6 µm
- Staphylococcus aureus R (MRSA): 0.5 - 1 µm
- Streptococcus: 0.5 - 2 µm
- Listeria: 0.5 - 4 µm
- Candida albicans: 2 - 4 µm

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- Black mould/chartarum: 9 - 14 µm
- H5N8/Avian influenza virus: 0.2 - 0.3 µm
- Hepatitis A: 0.027 - 0.032 µm
- H1Ni/Swine flu: 0.2 - 0.3 µm
- Norovirus: 0.027 - 0.038 µm
- Legionella: 2 - 20 µm

We conclude that we can detect a very high percentage of the most common viruses present in the air.

One might think that there are many more viruses than bacteria in the air, because the size of the former is much smaller than that of the latter. However, it has been shown that the ratio of viruses to bacteria indoors is less than 1, with bacteria outnumbering viruses indoors (Citation: Prussin, A.J., L.C., 2015. Total virus and bacteria concentrations in indoor and outdoor air. Environmental science & technology letters. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4515362/ [Accessed March 20, 2022]).

Regarding the percentage of viruses not detected by the PM sensor, we could make a correction to the algorithm to simulate the detection of these viruses, although we do not consider it necessary.

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