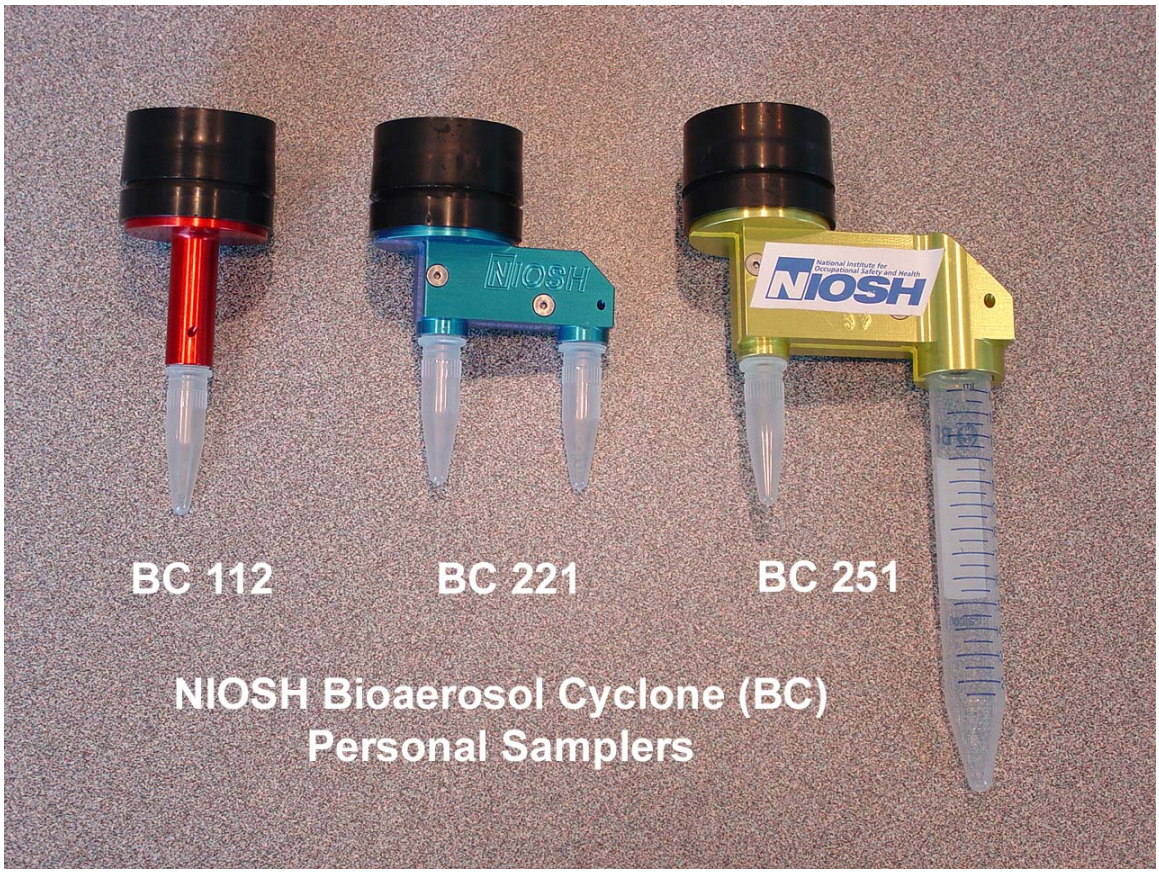
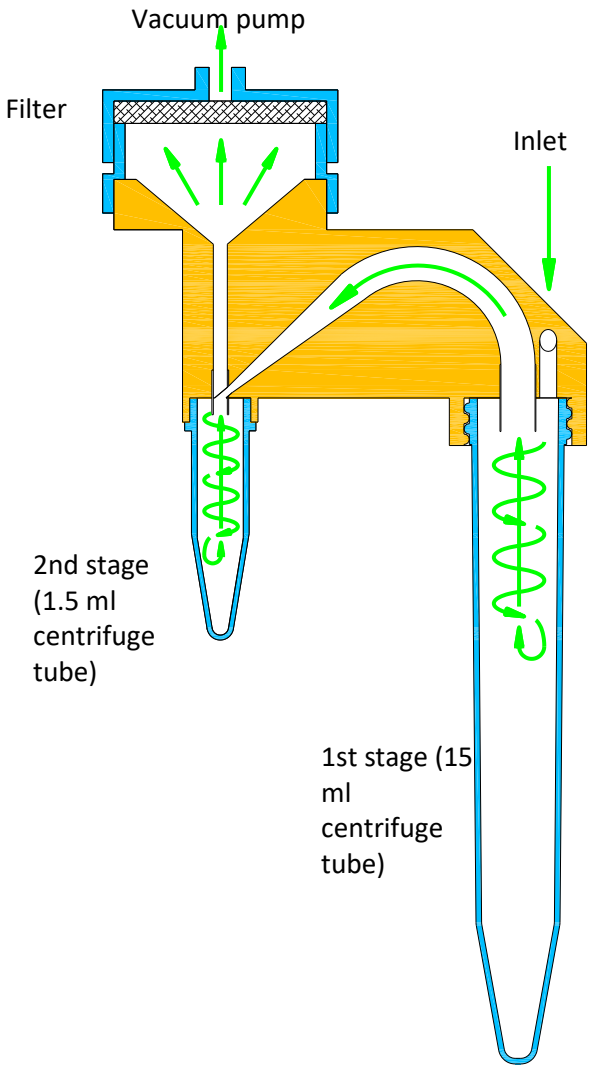
November 10, 2020

NIOSH cyclone samplers for personal bioaerosol collection



Bioaerosol samples can now be analyzed using molecular and immunological techniques such as enzyme-linked immunosorbent assays (ELISA) and polymerase chain reactions (PCR). These techniques are faster and less labor-intensive than culture or microscope-based methods, and provide high levels of sensitivity and specificity. To facilitate the processing of samples, NIOSH has developed a series of one- and two-stage cyclone-based personal bioaerosol samplers that collect airborne material in standard disposable plastic centrifuge tubes. Our one-stage bioaerosol cyclone sampler (BC 112) collects aerosol particles in a 1.5 ml centrifuge tube and on a back-up filter. Field trials of this sampler have shown that it efficiently collects fungal spores and that it compares well to conventional samplers. The two-stage BC 221 sampler collects aerosols in two 1.5 ml tubes and on a backup filter. The BC 221 is able to separate airborne fungal spores from fungal fragments, which is of great interest in the evaluation of fungal aerosol exposure. Our most recent two-stage cyclone sampler, the BC 251, collects aerosols in a 15 ml centrifuge tube, a 1.5 ml tube and on a backup filter. At 3.5 l/min, the BC 251 conforms to the ACGIH/ISO criterion for separation of respirable and non-respirable airborne particles, which is widely used in health-related aerosol measurements. The BC 251 has been successfully used to collect airborne influenza virus in healthcare facilities and from the coughs of influenza patients. All of the samplers can be operated with commercially-available personal air sampling pumps. This design could also be adapted to make larger samplers for atmospheric and indoor air quality sampling. The NIOSH bioaerosol cyclone personal samplers are covered by US Patent # 7,370,543 B2 issued May 13, 2008.

How a cyclone aerosol sampler works



A cyclone sampler works by pulling air into a round chamber and swirling it around like a cyclone. Particles in the air are thrown against the wall of the chamber by centrifugal force, where they collect. In the NIOSH sampler, air and particles are first pulled in to the sampler through the inlet on the right. Large particles (4 µm and larger) collect on the wall of the first tube. The air and uncollected particles flow out and into the second tube. Because the second tube has a smaller radius and smaller inlet nozzle (resulting in faster air flow), smaller particles (1 to 4 µm) will collect here. The smallest particles (<1 µm) pass through this tube and collect on the filter.

Collection efficiencies for the NIOSH cyclone personal samplers

Sampler	*flow rate (liters /min)*	*1st stage 50% cut-off size (µm)*	*1st stage sharpness (geometric standard deviation)*	*2nd stage 50% cut-off size (µm)*	*2nd stage sharpness (geometric standard deviation)*
one-stage BC 112	1	3.7	1.45	--	--
	2	2.5	1.67	--	--
	4	1.5	1.42	--	--
two-stage BC 221	2	2.7	1.43	1.5	1.74
	3.5	1.9	1.37	1.0	1.56
two-stage BC 251	2	4.9	1.48	1.7	1.68
	3.5	4.1	1.51	1.0	1.59
	10	2.1	1.44	0.41	1.56

NIOSH samplers in use

Two NIOSH samplers are shown on a tripod in a healthcare facility. The black case on the floor contains two sampling pumps that pull air through the samplers.

NIOSH sampler worn by a healthcare worker. The sampling pump is in the backpack behind the worker. The black box on the left shoulder turns the pump on and off. The yellow button pauses the pump for 60 seconds and then automatically starts it again. This feature is used by healthcare workers when they need a very quiet environment such as when using a stethoscope.

Publications using NIOSH samplers

One-stage BC 112 sampler:

Chen, BT, GA Feather, A Maynard and CY Rao (2004). Development of a personal sampler for collecting fungal spores. *Aerosol Sci Technol* 38(9):926-937.

Macher, J, B Chen and C Rao (2008). Chamber evaluation of a personal, bioaerosol cyclone sampler. *J Occup Environ Hyg* 5(11):702-12.

Macher, J, B Chen and C Rao (2008). Field evaluation of a personal, bioaerosol cyclone sampler. *J Occup Environ Hyg* 5(11):724-34.

Two-stage BC 221 sampler:

Lindsley, WG, D Schmechel and BT Chen (2006). A two-stage cyclone using microcentrifuge tubes for personal bioaerosol sampling. *J Environ Monit* 8: 1136-1142.

Blachere, FM, WG Lindsley, JE Slaven, BJ Green, SA Anderson, BT Chen and DH Beezhold (2007). Bioaerosol sampling for the detection of aerosolized influenza virus. *Influenza Other Respir Viruses* 1(3):113-120.

Singh, U, L Levin, SA Grinshpun, C Schaffer, A Adhikari and T Reponen (2011). Influence of home characteristics on airborne and dustborne endotoxin and beta-d-glucan. J Environ Monit 13(11): 3246-53.

Yamamoto, N, D Schmechel, BT Chen, WG Lindsley and J Peccia (2011). Comparison of quantitative airborne fungi measurements by active and passive sampling methods. *J Aerosol Sci* 42(8): 499-507.

Two-stage BC 251 sampler:

Blachere, FM, WG Lindsley, TA Pearce, SE Anderson, M Fisher, R Khakoo, BJ Meade, O Lander, S Davis, RE Thewlis, I Celik, BT Chen and DH Beezhold (2009). Measurement of Airborne Influenza in a Hospital Emergency Department. *Clin Infect Dis* 48:438-440 .

Lindsley, WG, FM Blachere, KA Davis, TA Pearce, MA Fisher, R Khakoo, SM Davis, ME Rogers, RE Thewlis, JA Posada, JB Redrow, IB Celik, BT Chen, and DH Beezhold (2010). Distribution of airborne influenza and respiratory syncytial virus in an urgent care medical clinic. *Clin Infect Dis* 50:693-698.

Lindsley WG, Blachere FM, Thewlis RE, Vishnu A, Davis KA, Cao G, Palmer JE, Clark KE, Fisher MA, Khakoo R and Beezhold DH (2010). Measurements of airborne influenza virus in aerosol particles from human coughs. *PLoS ONE*. 5(11): e15100.

D Verreault, GM Rousseau, L Gendron, M Veillette, D Massé, WG Lindsley, S Moineau, and C Duchaine (2011). Detection of airborne lactococcal bacteriophages in cheese plants. *Appl Environ Microbiol*. 77(2): 491-7.

Blachere, FM, G Cao, WG Lindsley, JD Noti and DH Beezhold (2011). Enhanced detection of infectious airborne influenza virus. *J Virol Methods* 176: 120-4.

Cao, G, JD Noti, FM Blachere, WG Lindsley and DH Beezhold (2011). Development of an improved methodology to detect infectious airborne influenza virus using the NIOSH bioaerosol sampler. *J Environ Monit* 13(12): 3321-8.

Noti, JD, WG Lindsley, FM Blachere, G Cao, ML Kashon, RE Thewlis, CM McMillen, WP King, JV Szalajda and DH Beezhold (2012). Detection of Infectious Influenza Virus in Cough Aerosols Generated in a Simulated Patient Examination Room. *Clin Infect Dis.* (epub ahead of print)

For more information about the NIOSH bioaerosol cyclone personal samplers, please contact:

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