



Physico-Chemical Characterization of Naturally and Anthropogenically Weathered Basalt & Sandstone, and their Contribution to Forming Crustal Aerosols of Bhopal, India

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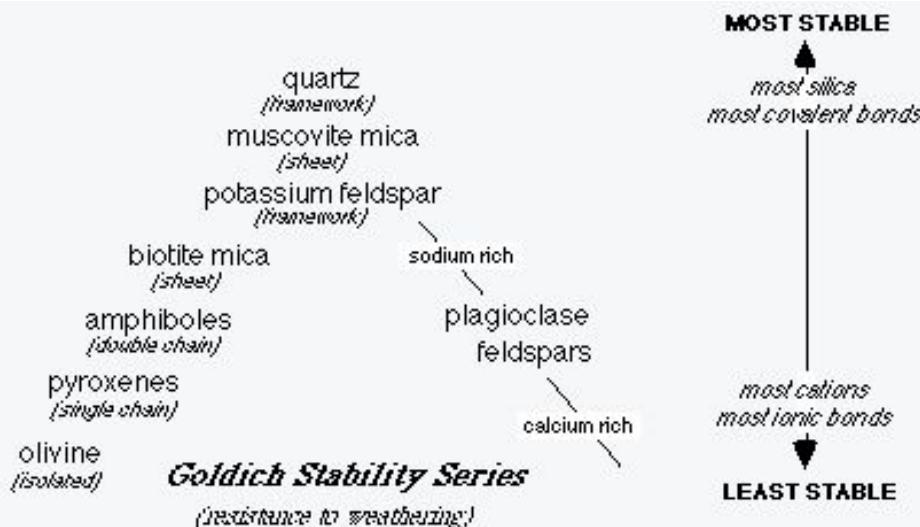
Introduction and Motivation

- Two most predominant & cardinal representatives of the crustal geology of the Indian Subcontinent: Basalt and Sandstone
- Bhopal Sandstones: 710 Mya, Deccan Basalts: 66 Mya
- Commonly used as construction and aggregatory materials even in urban areas
- Weathering Rates: Influence crust-air interface dynamics
- Crustal Aerosols: Atmospheric aerosols originating from mechanical processing of regolithic minerals & soils from the earth's crust
- Crustal aerosols contribute about 10-20 % of the fine particulate matter ($PM_{2.5}$) of the total tropospheric aerosol burden.
- They restrict visibility through haze formation and increased atmospheric turbidity

Introduction and Motivation

- Naturally sourced: Formed by naturally facilitated aerosolization of unconsolidated crustal minerals through various natural processes of weathering
- Anthropogenically sourced: Formed by construction-related mining and blasting activities, and other earth-moving operations
- Quantification of weathering-related physico-chemical characteristics:
 - Morphology
 - Packing
 - Grain-size distribution
 - Mineralogy
 - Elemental & ionic abundances
 - Rate of weathering
 - Aerosolization potential
 - Emission Factor
- The major lithophilic elements (Al, Si, K, Ca, Ti & Fe) and their relative fractions help determine the natural and anthropogenic emissions factors of the crustal rock-types.

Introduction and Motivation



- Si/Al ratio: Effective indicator for determining the abundance of most crustal aerosols.
 - Al_2O_3 : Fairly constant in most igneous rocks
 - SiO_2 : Generally higher in plutonic & sedimentary rocks than in volcanic rocks
 - Most ambient crustally derived aerosols are produced under natural conditions
 - Average Si/Al ratio for Earth's Crust: 2.7-3.4

Objectives

- To study the driving factors that promote the natural and anthropogenic generation of crustal dust.
- To analyze the modal composition of the sub-212 micron particle size fractions of naturally weathered regolith complexes (Basalt, Sandstone and their mixed derivatives) by mass and to correlate the results for sub-45 micron particle sizes to the mineralogy and aerosolization potential of the resuspended crustal aerosols facilitated via a resuspension chamber.
- To chemically characterize the size-classified weathered crustal rock material and compare these abundances with the ambient aerosol chemical characteristics in the study area. The quantification and comparison of Si/Al ratio will fall under this domain.

Objectives

- To assess the influence of anthropogenic activities such as rock blasting and other earth-moving construction operations on the physicochemical characteristics (including the Si/Al ratio) of the natural re-suspendable crustal material.
- To generate aerosol source apportionment-ready (e.g., US EPA CMB 8.0) reference chemical source profiles for aerosol mass apportionment in the study region.

- Location: Abbas Nagar
- Disconformity: 20°N
- Surface Area: 1.675 km^2
- Average distances:
 - a. Bhopal Air: 3.5 km
 - b. Bhopal Jn.: 7 km
 - c. IISERB: 9.5 km
- Major institutions: RGPV, IT Park, MIMS, RKDF University
- Altitude Measurements:
 - a. Bhopal mean: 500 m
 - b. BLT: 500 - 520 m
 - c. SST: 500 - 560 m
- Vegetation:
 - BLT: Dense arboural
 - SST: Shrubs & grass

Study Area





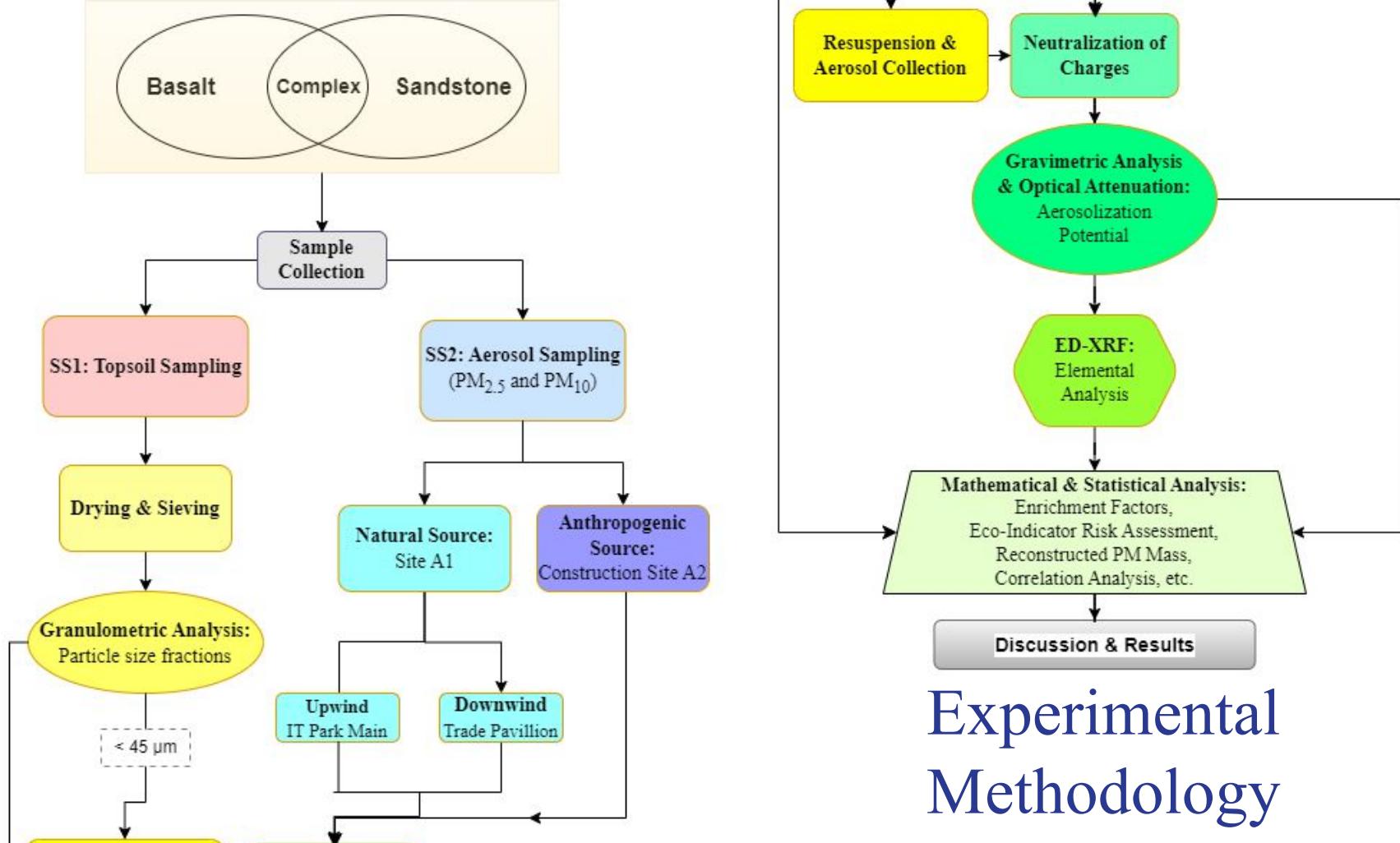
Sandstone Observations

- Kaimur Sandstone from the Upper Vindhyan Supergroup
- Neo-proterozoic Era (710 mya)
- Mineralogy:
 - 95% quartz with traces of ultramafic minerals
 - Micaceous Shale → fluvial depositional paleoenvironment
 - Quartz arenite
- Higher relative specific gravity → Scarcity of intergranular spaces → Low porosity → Deep burial → Metamorphosis into quartzite (increase in temperature & pressure) → isostatic adjustments → resurfaced rock → increase in bulk volume → formation of shear compression fracturing → Shear/exhumation conjugate joints
- 3 sets of joint planes:
 - Bedding plane → 5°N - 20°N → Sedimentary Dip
 - Conjugate / exhumation joint planes
 - Cross-bedding → Shallow-marine / fluvial depositional paleoenvironment → Paleocurrent directions

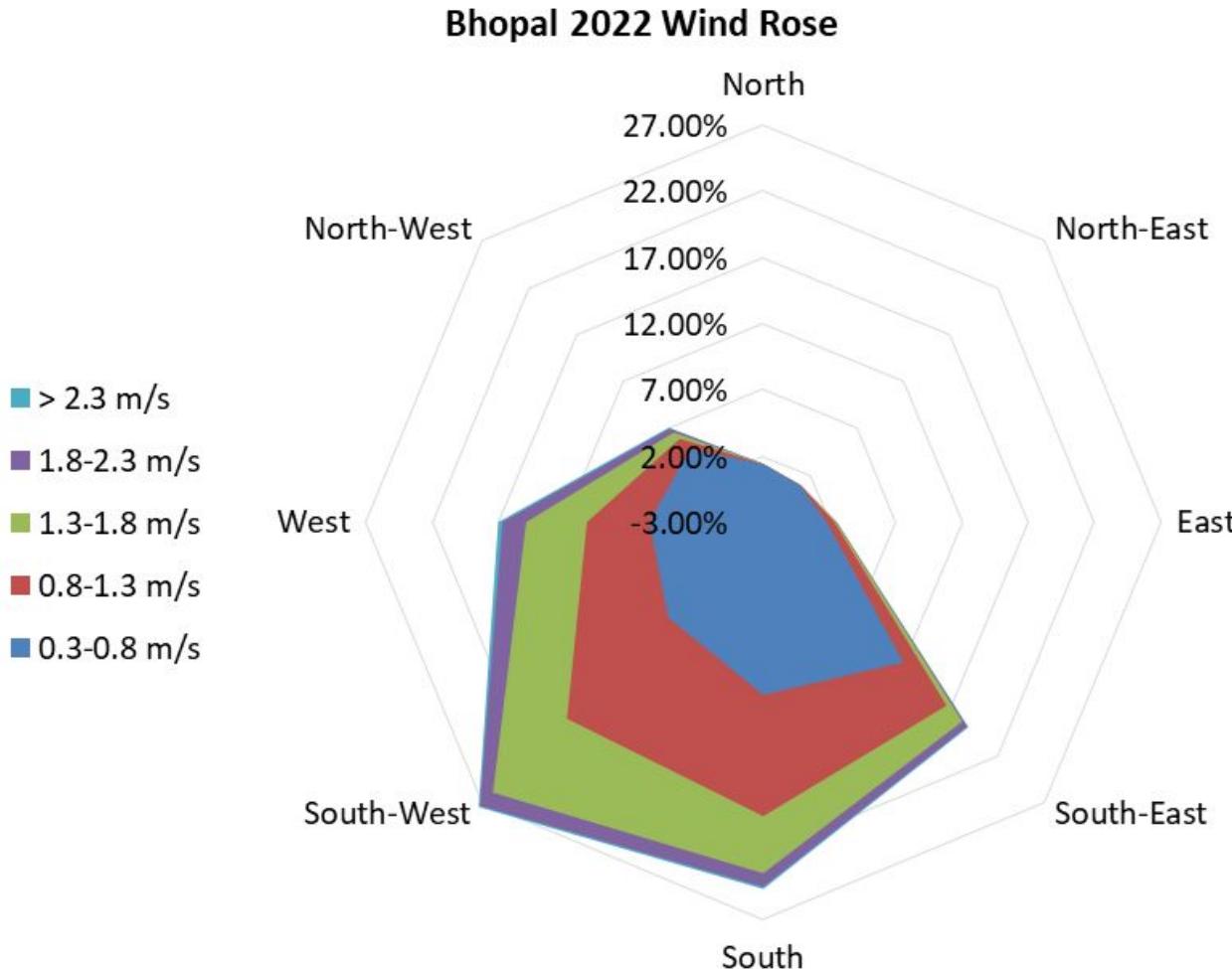
- Deccan Basaltic Provinces → End-Cretaceous Period (66 mya)
- Deccan traps → Reunion hotspot volcanism
- Flood basalts: Tholeiitic composition
- Mineralogy: Clinopyroxene, plagioclase feldspar
- Characteristic spheroidal weathering → Hydrolysis of Plagioclase



Basalt



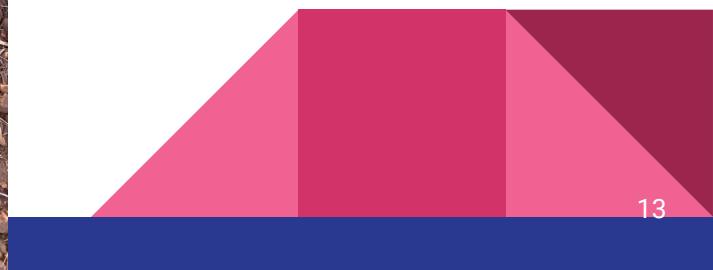
Wind Rose



- Wind speed and direction data for 2022
- Central Control Room for Air quality Management, Central Pollution Control Board (CPCB)
- 0.3 - 1.3 m/s towards N - ME

SS1: Top-Soil Sampling

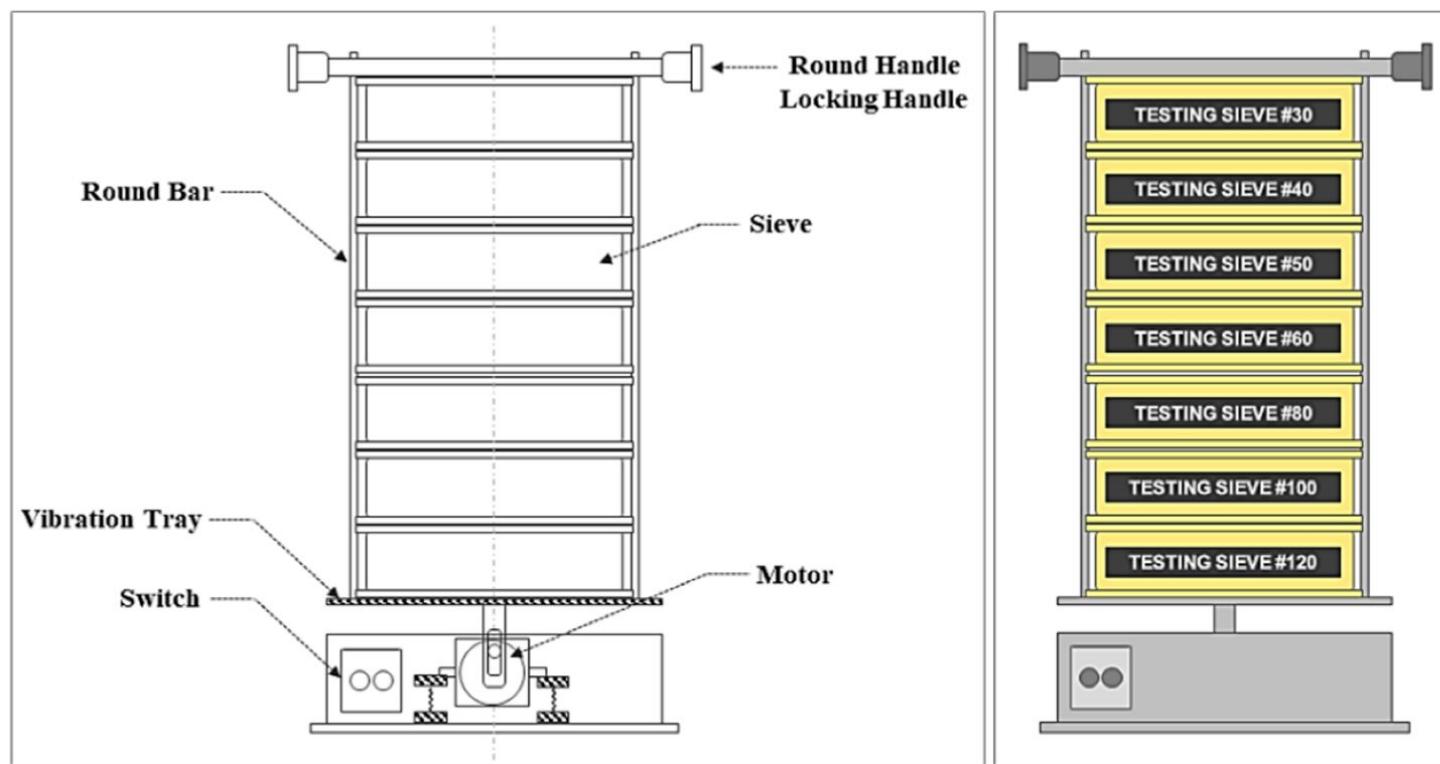
- Study Area: $1630 \times 1030 \text{ m}^2 = 1.675 \text{ km}^2 = 414 \text{ acres}$
- Conducive sampling conditions:
 - Precipitation: < 5% per day along with 2 days break after heavy showers
 - Soil moisture content: < 70%
 - Collection Site: Vegetation and leaf litter-free, undisturbed by human activities and homogenous representative of the zone
- Grid based sampling:
 - Advantages: Easy to implement, uniform pattern sampling, whole field spatial information
 - $9 \times 9 \text{ grid} = 81 \text{ zones}$
 - Zone: $180 \times 115 \text{ m}^2 = 0.0207 \text{ km}^2 = 5 \text{ acres}$
 - 20/81 topsoil exposures found = 10 composite samples (triplicates of each)
 - Composite Sample: 1.5 - 2 kg each
- Tools were cleaned using ethanol (insitu) and water & blow dried
- Sample Storage: Zip-lock bags in laboratory conditions



SS2: Aerosol Sampling

- Teflon filters (PM_{2.5})
- Flow-rate: 5 lpm
- Construction-source sampling:
 - Sample Size: 15 samples
 - Sampling duration: 6 hours
 - Avg. horizontal distance from source: 50 m
 - Downwind sampling
- Ambient Sampling
 - Sample Size: 5 samples of downwind and upwind each
 - Sampling duration: 24 hours
 - Sampling location: IT Park Sutherland Main Building (Upwind), Trade Pavilion Technotask Building (Downwind)



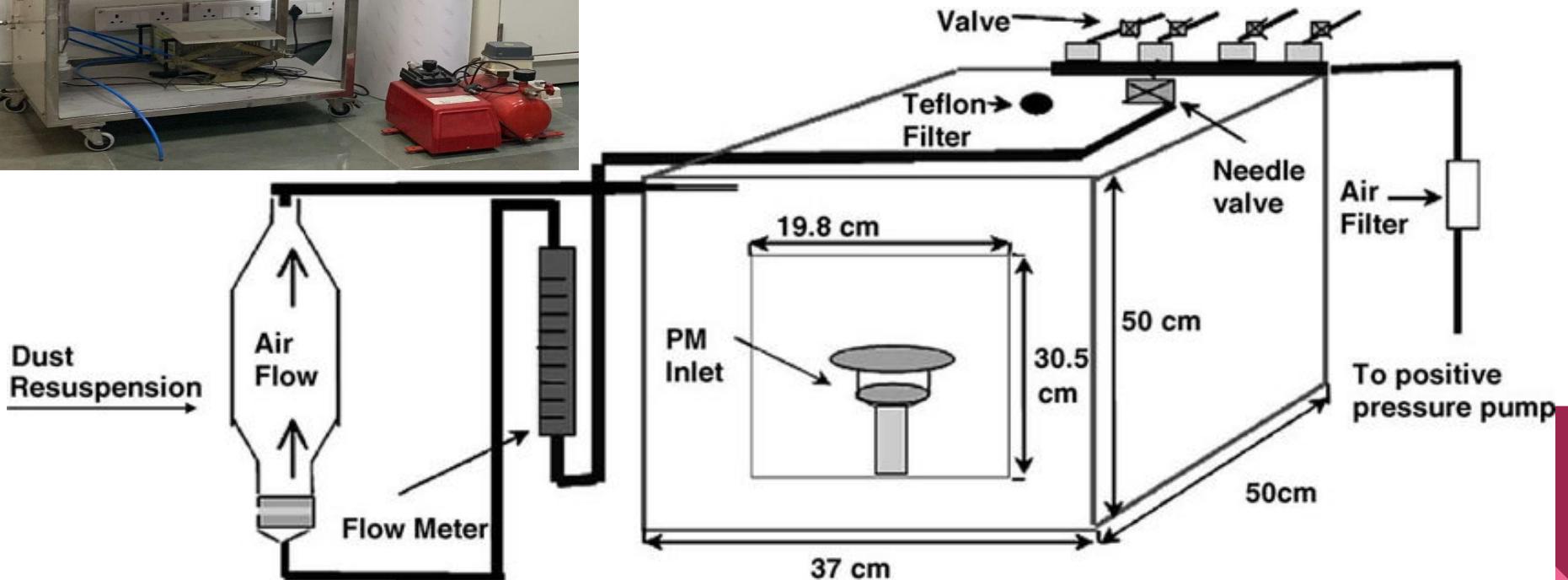


Sieve Sizes: 70, 100, 140, 170, 200, 230, 270, 325, 500



Drying & Sieving

Aerosol Resuspension Chamber



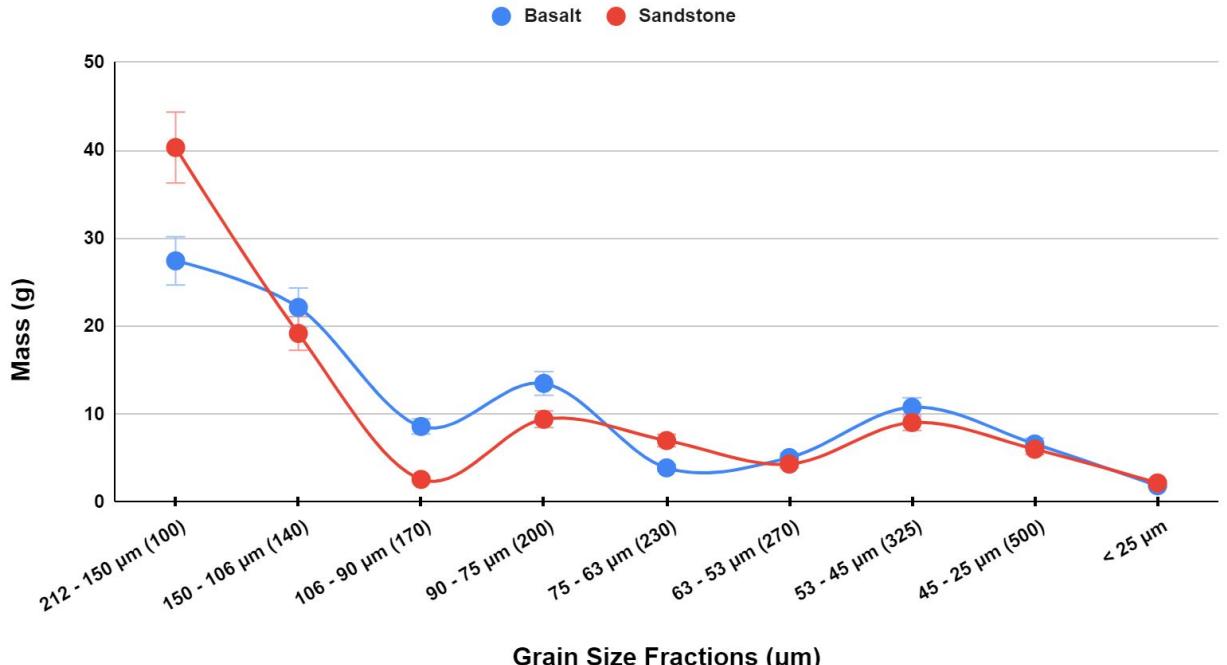
Physico-Chemical Analysis

- Top-Soil Samples
 - Granulometric Analysis: Distribution of particle size fractions by mass
- Aerosol Samples
 - Mass concentration calculations
 - Optical Attenuation: OT - 21
 - Elemental Analysis: Energy Dispersive X-ray Fluorescence

Results & Discussion

- Trimodal Distribution
- Si/Al (UW) = 2.139
- Si/Al (DW) = 1.759
- Si/Al (SS) = 1.701
- Si/Al (RS_BLT) = 1.618
- Si/Al (RS_SST) = 1.686
- OT - 21 (SS): (UV, IR) = 51, 20
- OT - 21 (UW): 18, 2
- OT - 21 (DW): 38, 12

Granulometric Analysis



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A dark blue background featuring a geometric pattern of overlapping triangles in various shades of blue. The triangles are oriented at different angles, creating a dynamic and modern look.

Thank You

