8th International R&D Conference on Global Trends in Water Resources, Power & RE Sectors

# Continuous suspended sediment measurement for mitigation of wear in hydropower plants

Navam Shrivastava *(Presenter)*
Research scholar, NIT Warangal

Dr. Anant Kumar Rai
Assistant professor, NIT Warangal

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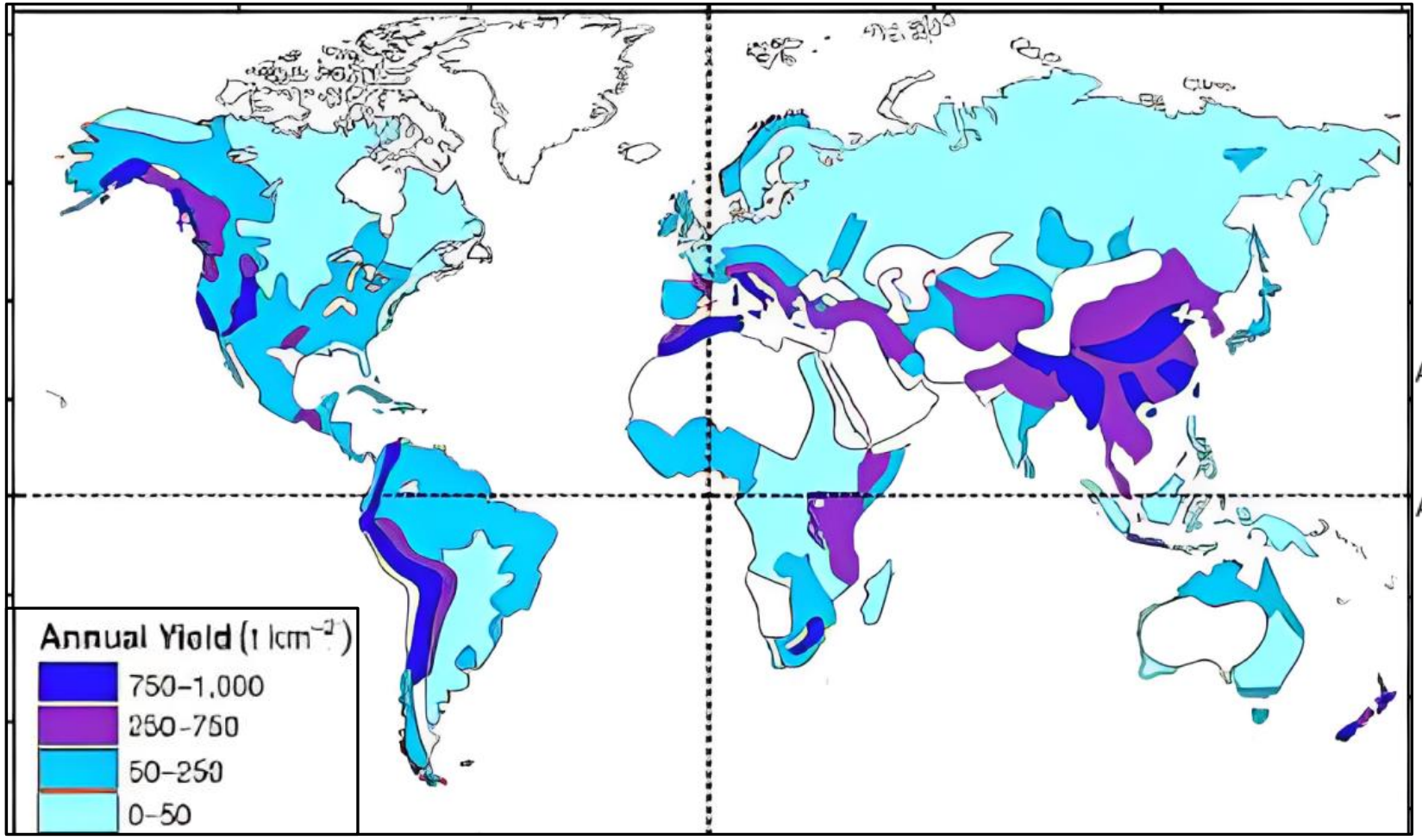
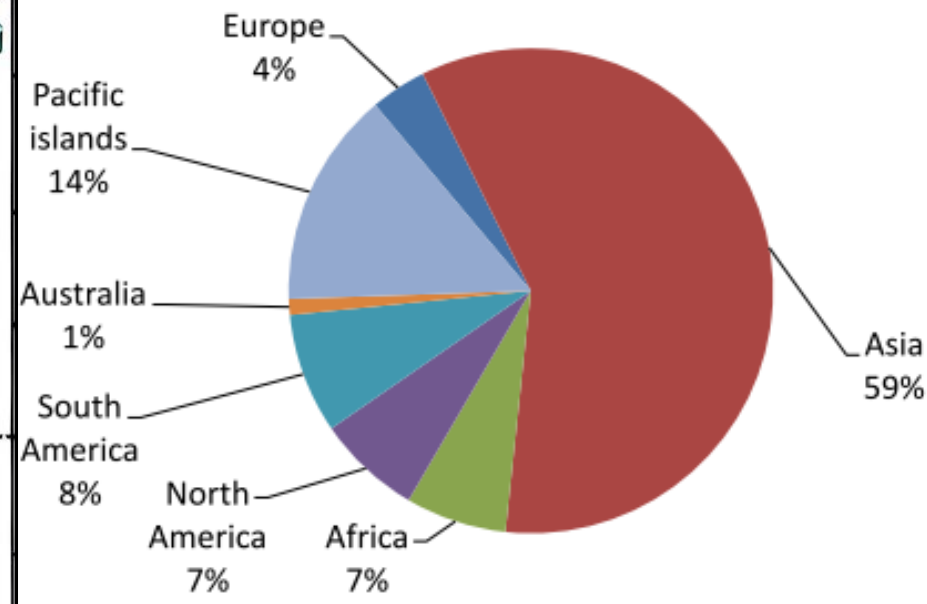
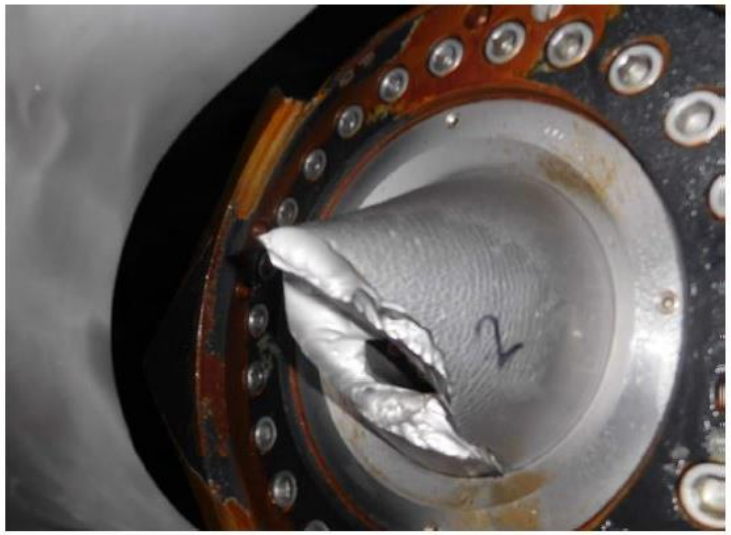
# Introduction – Global sediment yield



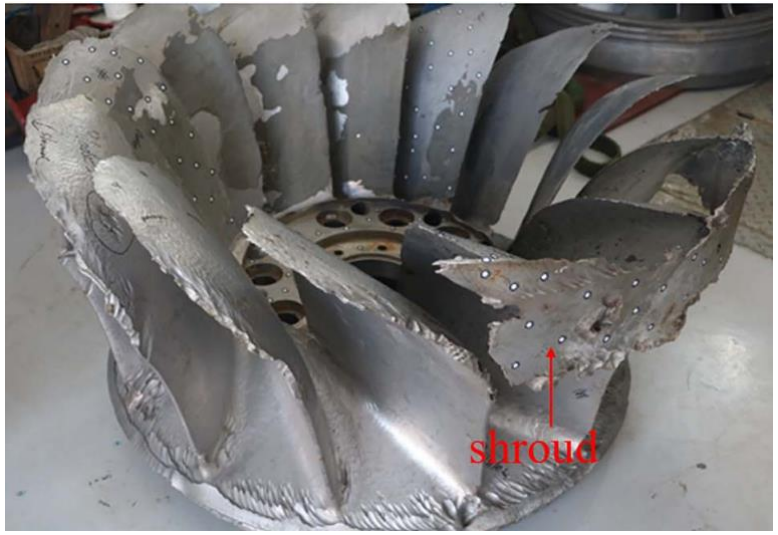

(Flemming, 2011)




(Dedkov and Gusarov, 2006)

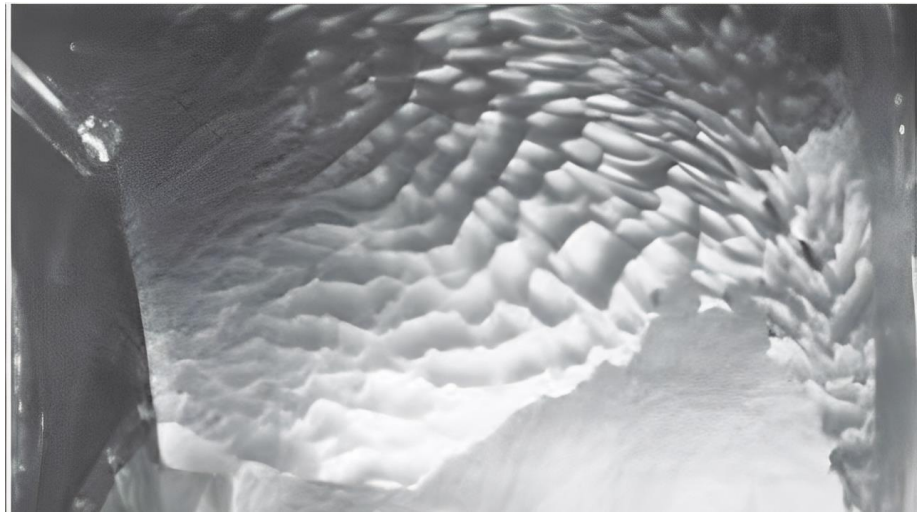


Eroded needle and bucket of Kashang Pelton turbine




Eroded runner of Trishuli Francis turbine

(Zhao et al., 2021)

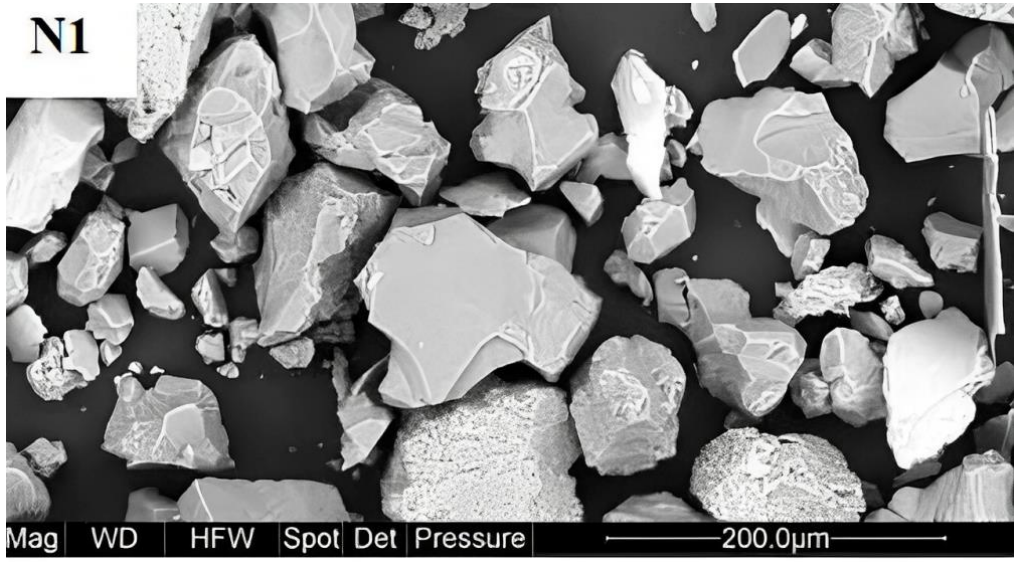


Eroded blade of Chilla Kaplan turbine

(Sangal et al., 2018)

# Parameters affecting hydro-abrasive erosion

- Sediment parameters
  - Size
  - Size distribution
  - Concentration
  - Shape
  - Hardness
- Operating parameters
  - Plant head
  - Discharge
- Design parameters
  - Nozzle angle
  - Needle angle
  - Bucket curvature
  - Guide vane orientation
  - Bend angle of penstock
- Turbine material

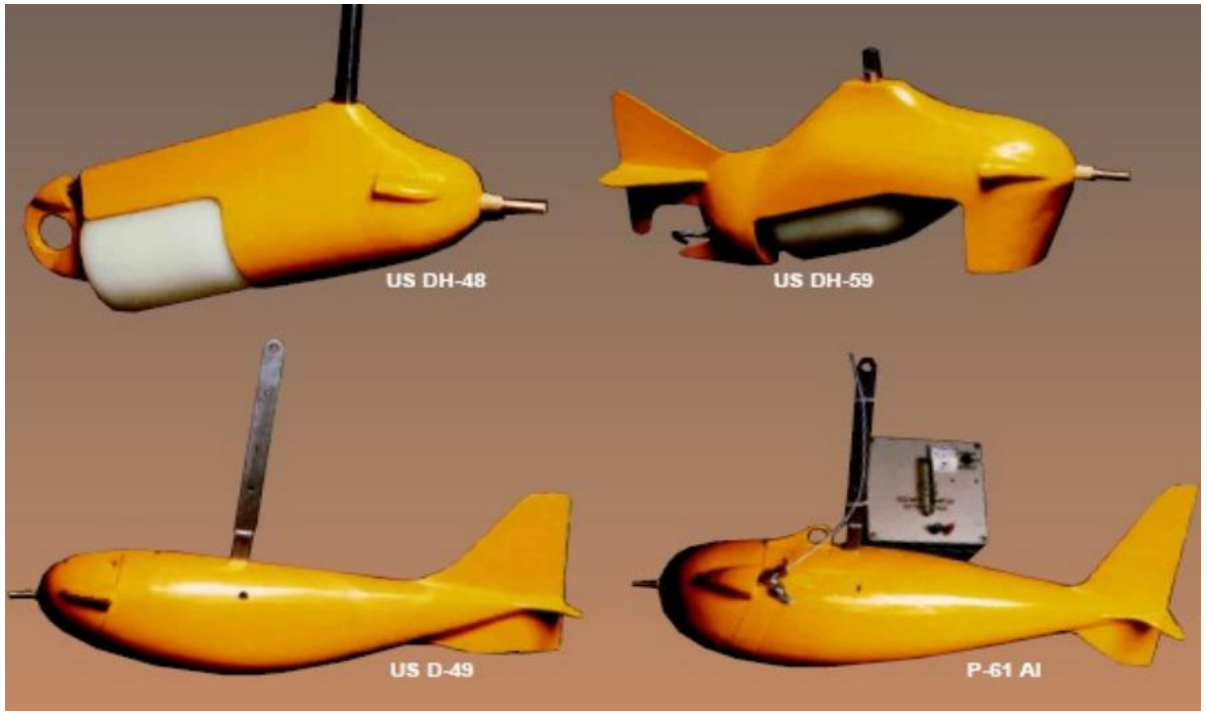



(Felix, 2017)

# Traditional sediment measurement

Sample collection → Laboratory measurement

- Sediment concentration
  - Evaporation
  - Filtration
- Particle size distribution (PSD)
  - Sieve method
  - Hydrometer




Samplers

(Msadal et al., 2010)

# Limitations of traditional methods

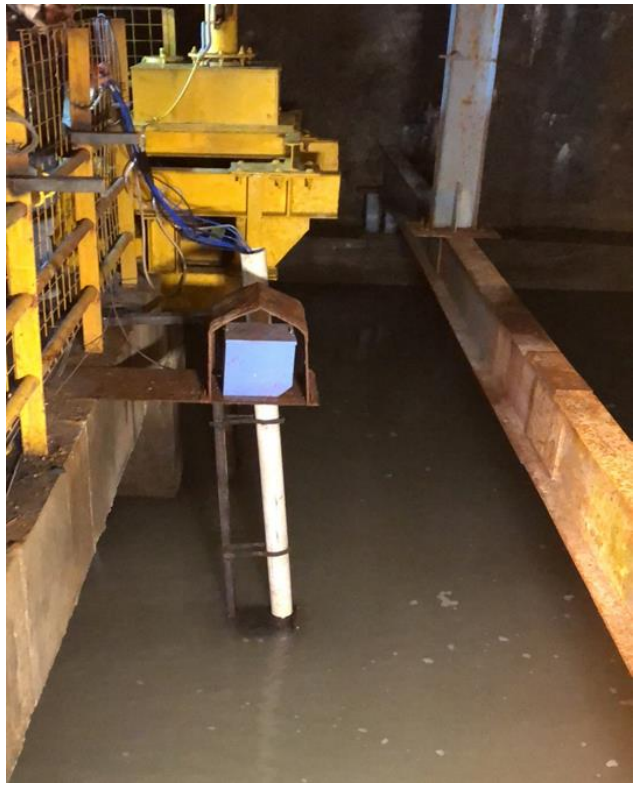
- Laborious and time intensive
- Difficulty in accessing remote or hazardous areas
- Challenging to record the significant temporal and spatial fluctuations in sediment
- Difficult in sampling during monsoon season
- Limited Depth Profiling

# Continuous sediment measurement – in situ technologies

Based on turbidity
- Concentration

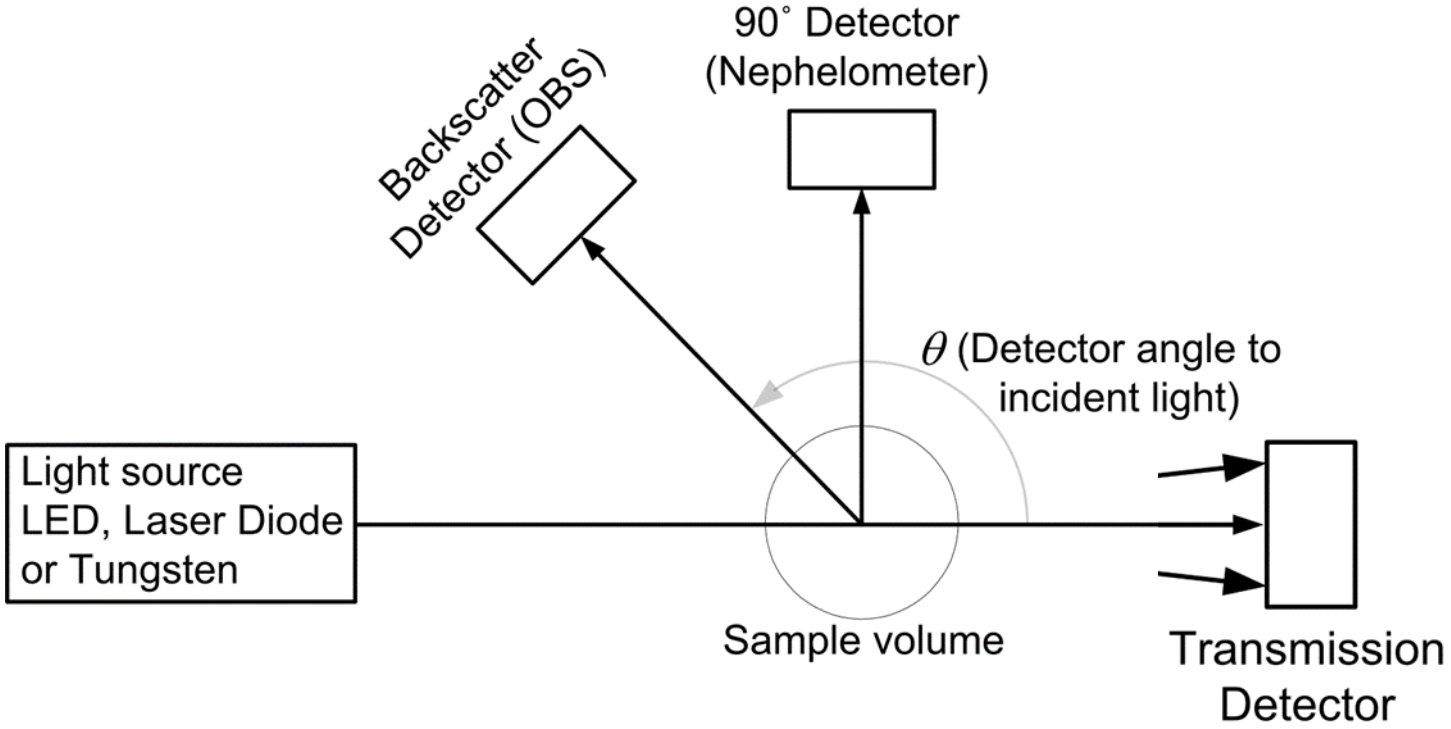
Based on acoustic backscattering
- Concentration
- PSD

Based on laser diffraction
- Concentration
- PSD



Continuous sediment monitoring at Allain Duhangan HPP

# Turbidimeter



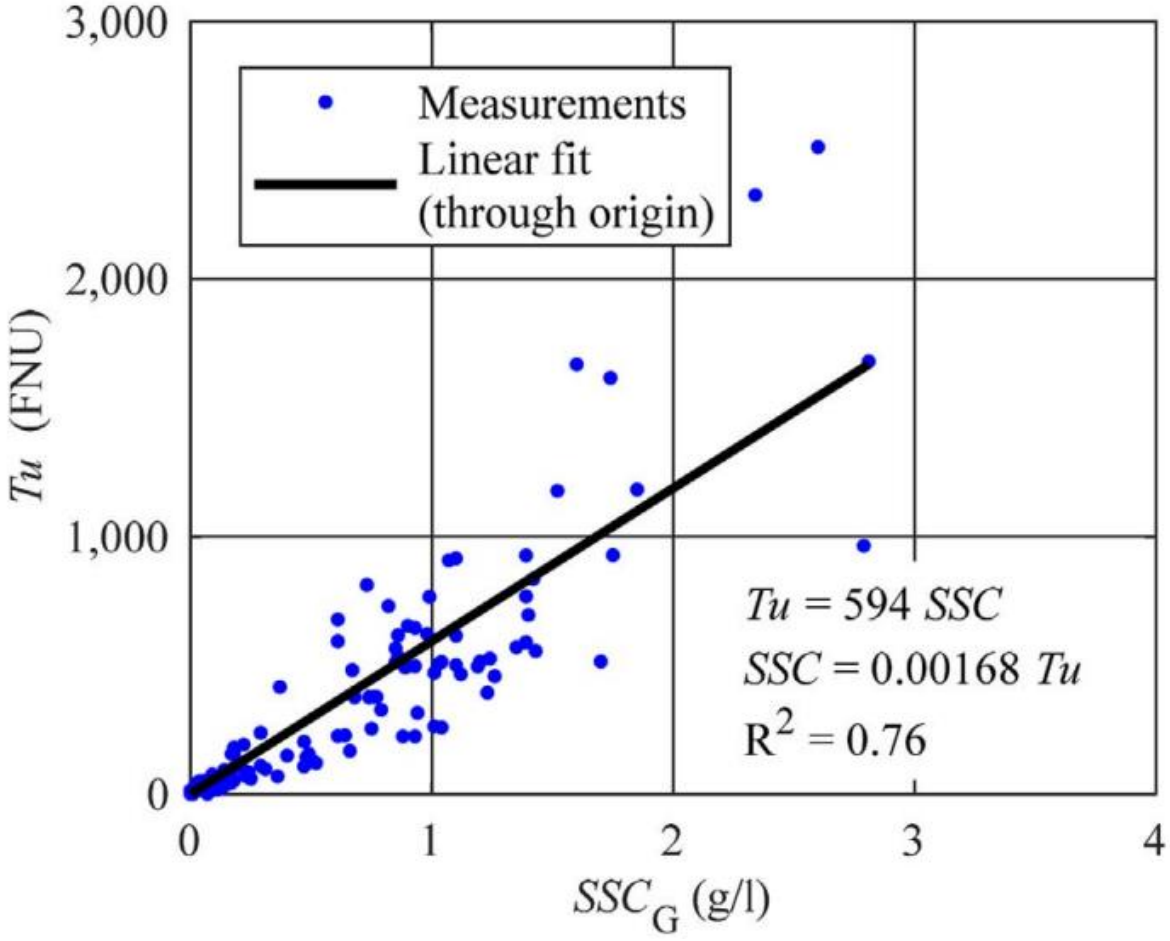

Turbidimeter working principle

- Most economical
- Preferer in areas with lesser variation in sediment properties like watershed

$$\text{Turbidity (NTU)} = a(\text{SSC})^b$$

(Rai and Kumar, 2015)

# Turbidimeter (Contd…)




(Felix et al., 2018)

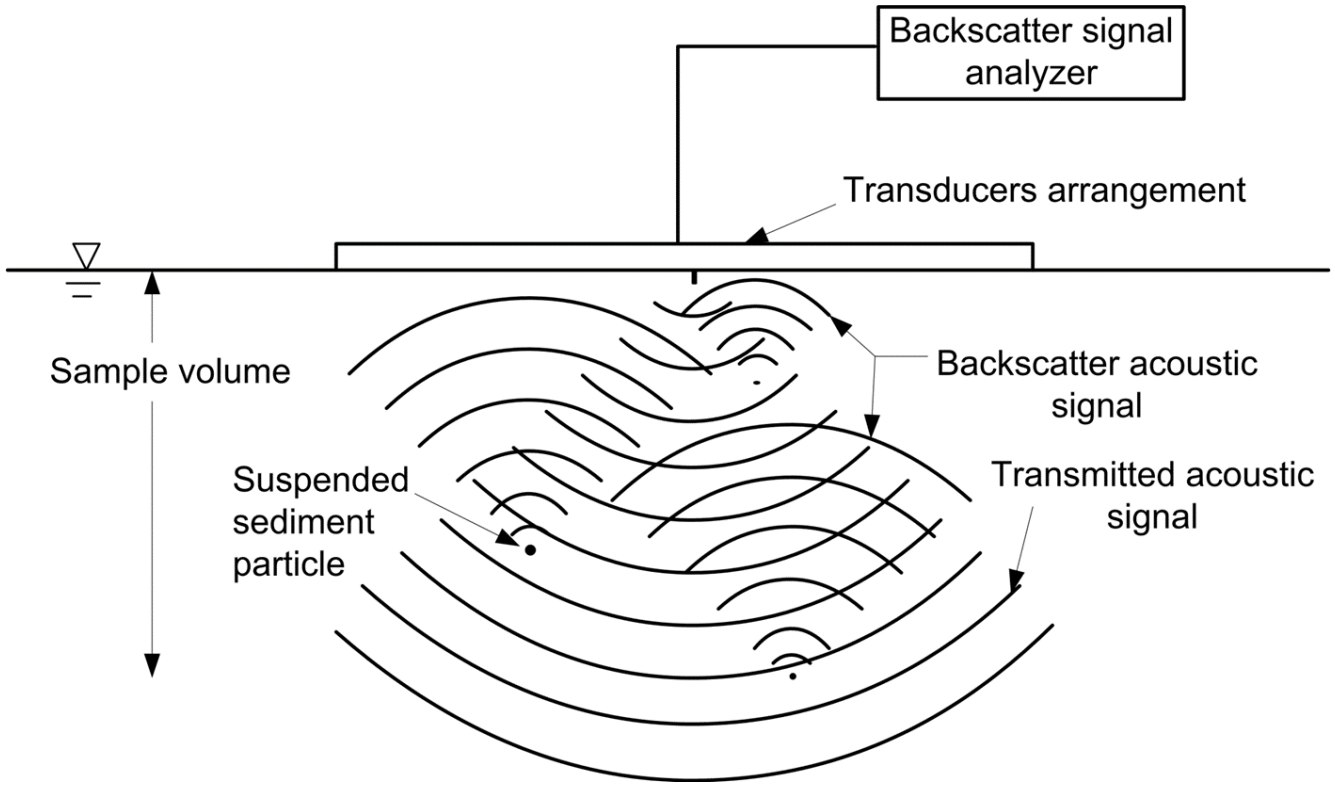
Turbidity (NTU) = $a(SSC)^b$

b ≈ 1 (for SSC < 1000 ppm)

b > 1 (For SSC > 1000 ppm)

Portable Online Turbidity and suspended solids Sensor (Solitax)

# Acoustic backscatter



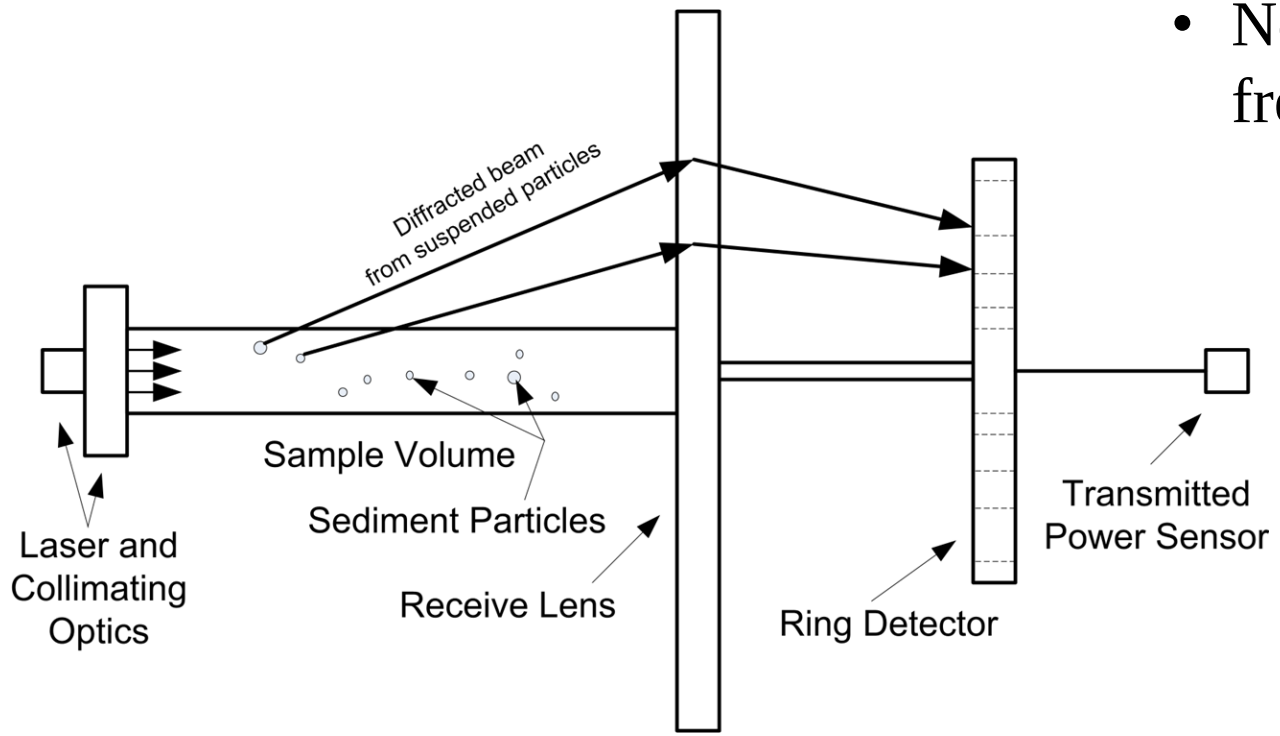

(Rai and Kumar, 2015)

- Less sensitive to by biological fouling
- Not reliable for high variation in PSD

Online multi-frequency acoustic sensor (AquaScat)

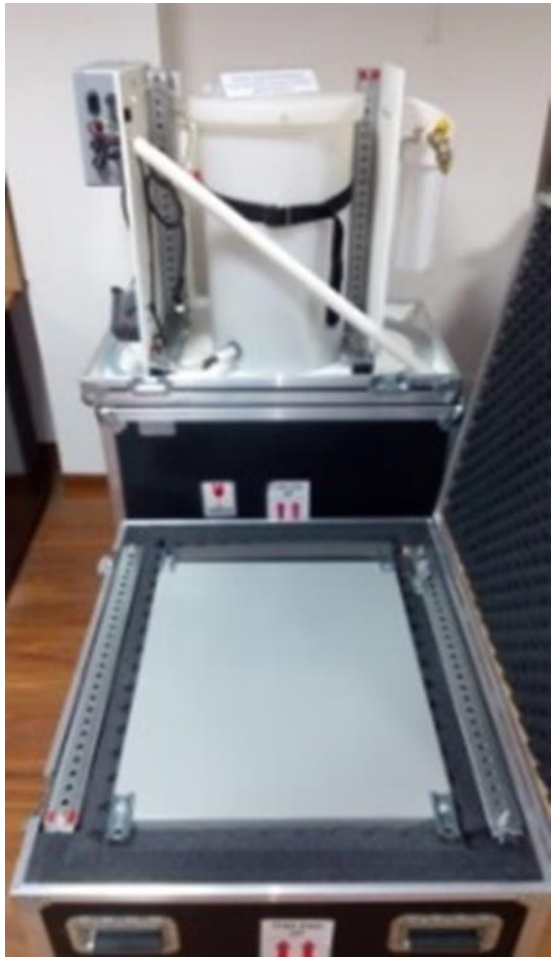
# Laser diffraction based instrument

Particle size ↑ Scattering angle ↓




(Rai and Kumar, 2015)

- Most accurate
- Reliable in varying PSD conditions also
- Not required frequent calibration



Online Laser Diffraction Sediment Sensor (LISST)

# Mitigation strategies

- Installing desilting basin at intake
- Continuously SSC monitoring - shutting down HPP on reaching cut-off SCC
- Regular repairment and replacement of eroded parts to reduce secondary damage
- Surface and bulk modification of turbine materials
- Design optimization using numerical studies

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# Thank You