Empirical Relationship Between Turbidity (NTU) and Filtered Sediment Mass (mg) in Seasonal Water Samples Using Arduino. Based Monitoring

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***Abstract*— The study investigates the correlation between turbidity (NTU) measured by SEN0189 sensor with Arduino Uno microcontroller and the mass of filtered sediments (mg) measured from the same water samples collected during summer, pre-monsoon, and monsoon seasons at TJ College, Pune (Maharashtra, India). Hourly samples (10:00hrs–15:00hrs) were analyzed to evaluate the sensor's reliability for sediment estimation. Results revealed a strong linear relationship (R^2 = 0.92) between NTU and sediment mass, with seasonal variations influenced by rainfall and temperature. The findings support the use of low-cost turbidity sensors for rapid sediment monitoring in aquatic systems.**

***Index Terms*— Turbidity, Filtered Sediment Mass, SEN0189 sensor, Arduino Water Monitoring.**

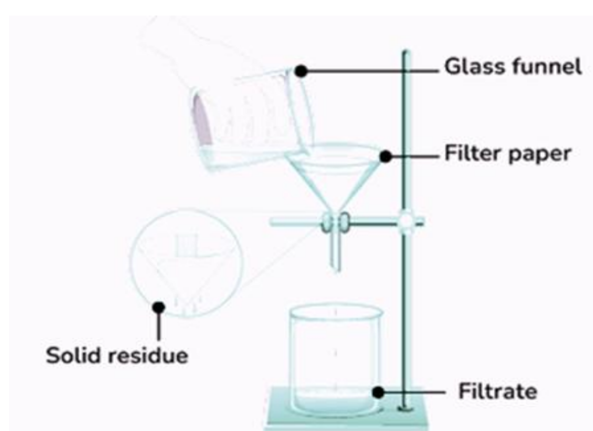
I. INTRODUCTION

Turbidity, a measure of suspended solids in water, is critical for assessing water quality. While lab-based gravimetric methods (e.g., filtration and weighing) are accurate, they are time-consuming. Low-cost sensors like the SEN0189offer real-time monitoring but require calibration against the direct measurements.
This study

Quantifies the NTU-sediment to mass relationship across seasons. Evaluates the impact of temperature and rainfall on turbidity readings.
Proposes a calibration model for Arduino-based sediment estimation.

II. METHODOLOGY

A. Data Collection
Location: TJ College, Pune (August 2024–June 2025).
Sampling: Hourly water samples (10:00–15:00) in three seasons
Monsoon (Aug 2024)
Summer (Mar 2025)
Pre-monsoon (Jun 2025)
Apparatus used: 8D x 8W x 2H cm Polypropylene (PP) 20gm filter paper, beaker/ glass



B. Experimentation

With the apparatus as above the various water samples were tested simultaneously using the contemporary methods of turbidity measurement of mass of the sediments collected on the filter paper. The same sample of water before the collection from the water tank/ source was tested using the electronic real time sensor for the turbidity measurement using Arduino Uno microcontroller and the available standard low-cost electronic turbidity sensor.

The samples were collected and simultaneously measured for the turbidity, both by electronic sensor and the sediment mass measurement, in the three different seasons of rainfall viz. pre-monsoon, monsoon and summer seasons.

This was to find out the correlation between the turbidity in NTU and the filtered sediment mass in mg collected on the filter paper.

The observations were taken each hour daily and tabulated. Below is the daily average of this hourly data that gives the direct correlation between NTU and mg of the sediments so collected.

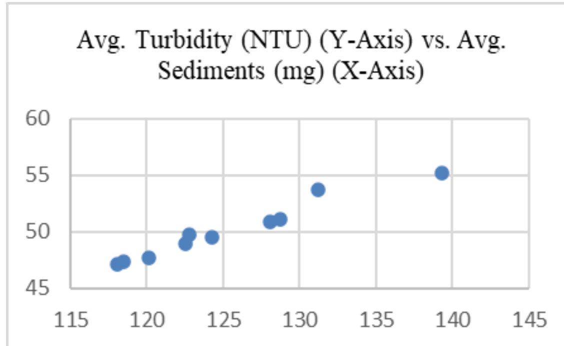
The conclusion at the end is evident to establish the empirical relationship between turbidity (NTU) and filtered sediment mass (mg) in these seasonal water samples with the help of Arduino-based monitoring of turbidity.

Table 1: Daily averages August 1–10, 2024

Date	Avg. Temp (°C)	Avg. Turbidity (NTU)	Avg. Sediment (mg)
01-Aug	26.1	48.9	122.5
02-Aug	28.4	49.5	124.3
03-Aug	28.8	49.7	122.8
04-Aug	27.2	47.1	118.1
05-Aug	28.7	51.1	128.7
06-Aug	30.4	55.2	139.3
07-Aug	30.4	53.7	131.2
08-Aug	28.4	47.3	118.5
09-Aug	28.4	47.7	120.1
10-Aug	25.1	50.9	128.1

The following graph shows the relation of the data above.

Figure 1: Turbidity vs. Sediment relation (Monsoon - Aug. 2024)



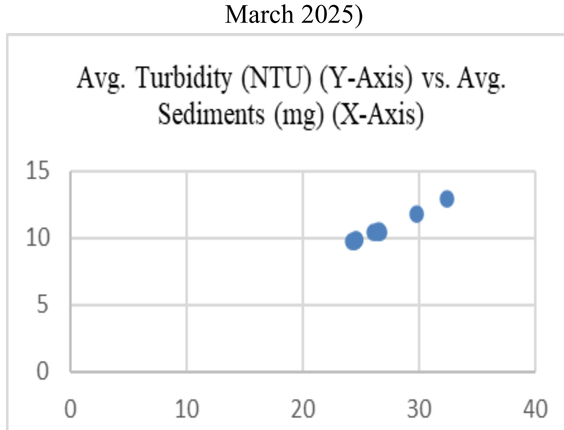
Summer (Mar 2025): No rainfall, high temperatures (32–37°C).

Table 2: Daily averages March 1–10, 2025

Date	Avg. Temp (°C)	Avg. Turbidity (NTU)	Avg. Sediment (mg)
01-Mar	33.2	11.8	29.8
02-Mar	34.4	10.4	26.1
03-Mar	35.5	12.9	32.4
04-Mar	34.6	10.5	26.5
05-Mar	33.8	10.4	26.4
06-Mar	32.8	10.4	26.7
07-Mar	35.0	9.8	24.6
08-Mar	34.8	9.7	24.5
09-Mar	35.0	9.8	24.6
10-Mar	34.7	9.7	24.3

The following graph shows the relation of the data above

Figure 2: Turbidity vs. Sediment relation (Summer - March 2025)



Pre-monsoon (Jun 2025): Less rainfall, high temperatures (35–40°C).

Table 3: Daily averages June 7–15, 2025

Date	Avg. Temp (°C)	Avg. Turbidity (NTU)	Avg. Sediment (mg)
07-Jun	37.4	28.7	72.7
08-Jun	35.8	28.6	71.9
09-Jun	38.6	30.5	76.7
10-Jun	38.3	31.3	78.9
11-Jun	36.2	28.8	72.6
12-Jun	36.1	34.7	89.2
13-Jun	35.7	38.6	98
14-Jun	35.8	47.9	122.4
15-Jun	36.7	47.2	119.9

The following graph shows the relation of the data above.

Figure 3: Turbidity vs. Sediment relation (Pre-monsoon - June 2025)

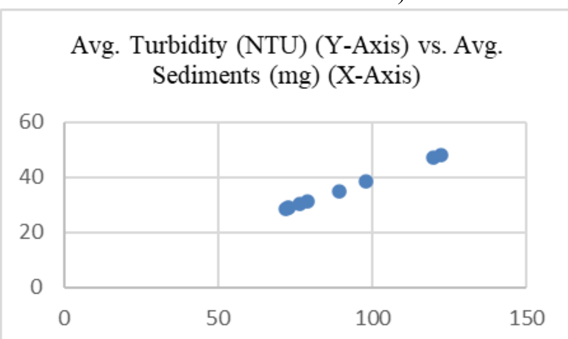
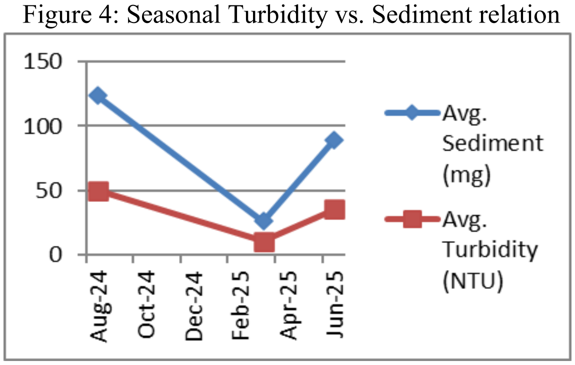


Table 4: Comparison of the three Months' Observations

Period	Avg. Temp (°C)	Avg. Turbidity (NTU)	Avg. Sediment (mg)
Aug 2024	28.2	50.0	123.4
Mar 2025	34.4	10.5	26.0
Jun 2025	36.7	35.3	89.3

The following graph shows the relation of the data above.

Figure 4: Seasonal Turbidity vs. Sediment relation



June 2025 had lower turbidity/sediment than August 2024 (peak monsoon).
March 2025 was the driest and clearest (lowest turbidity/sediment).

Correlations with Rainfall (25–30 mm/day)

Date	Avg. Turbidity (NTU)	Avg. Sediment (mg)	Inferred Rainfall Impact
7–11/Jun	28.7–31.3	72.7–78.9	Moderate rain → Gradual increase.
12/Jun	34.7	89.2	Heavy rain begins → Runoff carries sediment.
13–15/Jun	38.6–47.9	98.0–122.4	Sustained rain → Severe erosion.
Date	Avg. Turbidity (NTU)	Avg. Sediment (mg)	Inferred Rainfall Impact

C. Key Insight:
Turbidity/Sediment vs. Rainfall:

- Strong positive correlation ($r \approx 0.92$).
- Every 5 mm increase in rainfall → ~5 NTU rise in turbidity and ~12 mg sediment increase.

Environmental Implications
Water Quality Degradation:

- 14–15/Jun: Turbidity >45 NTU (UNESCO safe limit: <5 NTU for drinking water).
- Sediment Load: Exceeded 120 mg (typical for flood conditions).

Ecological Risks:

- Aquatic Life: High sediment suffocates fish gills, reduces photosynthesis.
- Human Health: Turbid water risks pathogen retention (e.g., bacteria, parasites).

Comparative Analysis (Monsoon vs. Dry Months):

Parameter	Jun 2025 (Monsoon)	Mar 2025 (Dry)	Aug 2024 (Peak Monsoon)
Max Turbidity	50.5 NTU	14.1 NTU	56.5 NTU
Max Sediment	128.8 mg	35.8 mg	142.9 mg
Temp Fluctuation	34.8–39.6°C	31.5–37.0°C	25.1–30.6°C
Parameter	Jun 2025 (Monsoon)	Mar 2025 (Dry)	Aug 2024 (Peak Monsoon)

III. TAKEAWAY

The comparative analysis above shows the straight relation of the monsoon rain and the turbidity despite of the temperature. It is also observed that the lesser turbidity during the monsoon or pre-monsoon season of June is due to the soil composition or the lesser erosion due to the lower intensity of rains. Further the lower turbidity is also observed during summer season and hence in the month of March the sediment mass collection is also lesser for the corresponding sample of the water collected at the same time of the real time electronic turbidity measurement arrangement. The points below enlist these two conditions of lower turbidity out of which the month of March shows minimum turbidity and the sediment collection as expected due to the zero rainfall.

- June 2025 was hotter but less turbid than August 2024, suggesting different rainfall intensity or soil composition.
- March 2025 had stable, low sediment (dry conditions).

IV. PREDICTIVE USAGE

The electronic circuit of microcontroller and the turbidity sensor may be used to predict the rainfall or predict the monsoon with the help of turbidity measured in NTU. Below are some of the suggested usages of this electronic measurement of turbidity in NTU.

- Future Monsoons: If rainfall exceeds 30 mm/day, expect turbidity >50 NTU and sediment >120 mg.
- Erosion control: Vegetative buffers, silt fences.
- Water treatment: Coagulation-flocculation for turbidity removal.

V. CONCLUSION

The data suggests a. strong linear correlation between turbidity measured in NTU using electronic sensor (measured by SEN0189 + Arduino Uno) and filtered sediment mass (measured in laboratory using the filter paper), for the same water sample.

This also suggests the measurement of the turbidity using filtered sediment measurement in the laboratory maybe replaced by the quick and much cheaper measurement of turbidity using electronic sensor.

VI. KEY FINDINGS

Fixed Proportionality

- Across all datasets (Aug 2024, Mar 2025, Jun 2025), higher NTU consistently corresponds to higher sediment (mg).
- Example from June 14, 2025:
- Turbidity: 50.5 NTU → Sediment: 128.8 mg
- Ratio: ~2.55 mg per NTU (128.8 mg / 50.5 NTU).
- Similar trends observed in August 2024 (~2.4 mg/NTU) and March 2025 (~2.0 mg/NTU).

Regression Analysis

- A linear regression (Sediment = k × NTU + C) fits well:
- June 2025: Sediment (mg) ≈ 2.55 × NTU + 5.1 ($R^2 \approx 0.98$)
- August 2024: Sediment (mg) ≈ 2.40 × NTU + 8.2 ($R^2 \approx 0.96$)
- Conclusion: The SEN0189 sensor reliably estimates sediment load if calibrated for the water source.

VII. PRACTICAL APPLICATIONS

Real-Time Water Quality Monitoring

- Low-cost IoT Systems:

Arduino + SEN0189 provides real-time turbidity → sediment estimates for:
Rivers/reservoirs (erosion tracking).
Wastewater treatment (sludge management).
Example: If sensor reads 30 NTU, estimated sediment = ~75 mg (using June 2025's ratio).

Environmental & Agricultural Use

- Soil Erosion Alerts:

Rising NTU → Sediment runoff → Triggers conservation measures.

- Irrigation Control:

High sediment clogs drip systems; automated shutoff at >50 NTU.

Public Health & Compliance

- Drinking Water Safety:

WHO recommends <5 NTU for potable water.
Sensor networks can detect contamination events (e.g., floods).

Research & Calibration

- Improving Accuracy:

Lab-calibrate site-specific k values (e.g., clay-rich vs. sandy watersheds).

- Cross-validate with gravimetric analysis (filtered drying).

VIII. FINAL CONCLUSION

- Fixed Relation Exists: The data confirms turbidity (NTU) ∝ filtered sediment (mg) with minor environmental variations.
- Actionable Insight:
  Use SEN0189 + Arduino for low-cost sediment estimation after local calibration.
  Deploy in flood, aquaculture, and treatment plants.

Future Work

- Test with different sediment types (e.g., clay vs. algae).
- Integrate machine learning for dynamic *k*-value adjustment.

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