# Varuna: A Python-Based System for Water Quality Index Calculation

Joyanta Debnath[1]; Ananta Debnath[2]

[1]Under Graduate Student, Department of Civil Engineering, Indian Institute of Engineering Science and Technology, Shibpur, Howrah, West Bengal, India
[2]Under Graduate Student, Department of Computer Science and Engineering, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh

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**Abstract: Varuna, developed by Joyanta Debnath and Ananta Debnath, is a Python-based system for calculating water quality indices, including the Water Quality Index (WQI), Canadian Water Quality Index (CWQI), and National Sanitation Foundation (NSF) Water Quality Index. The system assesses water body health by integrating physical, chemical, and biological parameters, aiding researchers and professionals in identifying pollution issues and prioritizing sustainable management. Hosted on GitHub (https://github.com/JoyantaDeb/Varuna-Water-Quality-Index), Varuna offers a user-friendly interface, interactive Matplotlib visualizations, and customizable inputs for local conditions. As an open-source platform, it fosters global collaboration. This paper details Varuna's development, calibration, coding implementation, and applications in sustainable water management, contributing to environmental protection.**

***Keywords:*** *Water Quality Index, Canadian Water Quality Index, NSF Water Quality Index, Python-based System, Sustainable Water Management, Open-Source Collaboration, Interactive Visualization.*

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## I. INTRODUCTION

Water is fundamental to ecosystems, agriculture, and human health, yet its quality is increasingly compromised by industrialization, urbanization, and agricultural runoff. In South Asia, rivers like the Ganga, Yamuna, and Buriganga face severe pollution, with contaminants such as heavy metals, organic matter, and microbial pathogens threatening public health and biodiversity. The World Health Organization reports that contaminated water causes over 1.5 million deaths annually, highlighting the urgent need for robust water quality assessment tools [5]. Water Quality Indices (WQIs) aggregate physical, chemical, and biological parameters into a single score, simplifying water health evaluation for policymakers and environmentalists [9]. Indices such as the general WQI, Canadian Water Quality Index (CWQI), and National Sanitation Foundation (NSF) Water Quality Index assess water suitability for drinking, irrigation, and aquatic life, enabling targeted pollution mitigation [4, 6, 7].

Manual water quality monitoring is labor-intensive and limited in handling large datasets or providing real-time insights. Computational tools, leveraging programming languages like Python, overcome these challenges by automating data processing, index calculations, and visualization [10]. In India and Bangladesh, where water bodies are critical for drinking, irrigation, and industrial use, tools like Varuna address regional challenges, such as heavy metal contamination in groundwater and organic pollution in surface waters [11, 23]. Developed by Joyanta Debnath and Ananta Debnath, Varuna—named after the Hindu god of water—is a Python-based system designed for accurate and adaptable WQI calculations. Hosted on GitHub (https://github.com/JoyantaDeb/Varuna-Water-Quality-Index), Varuna integrates parameters like pH, dissolved oxygen, turbidity, and microbial content, producing reliable WQI, CWQI, and NSF WQI scores [1]. Its open-source framework fosters global collaboration, enabling researchers to enhance its functionality for diverse water bodies.

Varuna's interface, built with Python libraries (Pandas, Matplotlib), supports manual and CSV-based inputs, interactive visualizatins, and customizable parameters for local standards. By addressing limitations of existing tools, such as inflexibility or inaccessibility, Varuna empowers users to assess water quality efficiently [18]. This paper details Varuna's development, coding, and calibration, emphasizing its role in environmental protection. Aligning with United Nations' Sustainable Development Goal 6 (Clean

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Water and Sanitation), Varuna supports data-driven decisions in India and Bangladesh, monitoring urban rivers, rural groundwater, and industrial effluents [37]. It aims to influence policy, raise awareness, and promote collaborative research, making it a vital tool for global water resource management.

## II. MATERIALS and Methods

### *A. System Development*

Varuna, developed by Joyanta Debnath and Ananta Debnath, uses Python 3.8 with libraries: NumPy for computations, Pandas for data manipulation, and Matplotlib for visualization. The system includes three modules: data input (manual or CSV via Pandas), parameter calculation (WQI, CWQI, NSF WQI algorithms), and visualization (JPEG outputs, 300–600 dpi). Hosted on GitHub (https://github.com/JoyantaDeb/Varuna-Water-Quality-Index), Varuna supports open-source collaboration [1].

### *B. Coding Implementation*

The Python code (VARUNA.py) ensures modularity. Key steps include:

- Data Input Handling: Processes xlxs file or manual inputs, validating data with Pandas' notnull():

```python
for row in df.values:
    row_list = []
    for cell in row:
        if notnull(cell):
            row_list.append(cell)
    if len(row_list)!= 0:
        data_list.append(row_list)
```

- WQI Calculation: Computes sub-index (qi), weights (Wi), and WQI (IQE):

```python
S = 0
for i in range(n):
    if Vn[i][0] != -1:
        S += 1/S_N[i]
K = 1 / S
for i in range(numbers):
    qiwi = 0
    wi = 0
    for j in range(n):
        if Vn[j][i] != -1:
            Wn = K / S_N[j]
            qn = ((Vn[j][i] - V_I[j]) / (S_N[j] - V_I[j])) * 100
            qiwi += qn * Wn
            wi += Wn
    wqi.append(qiwi / wi)
```

Classifications: Excellent (0–25), Good (26–50), Poor (51–75), Very Bad (76–100), Unfit (>100) [7].

- CWQI Calculation: Uses Scope (F1), Frequency (F2), and Amplitude (F3):

```python
for i in range(m):
    for j in Vn[i]:
        if j != -1:
            if PARA[i] != 'pH' and j > S_N[i]:
                f2 += 1
                f1_bool = True
                excursion += ((j / S_N[i]) - 1)
            elif PARA[i] == 'pH':
                if j < 6.5 or j > 8.5:
                    f2 += 1
                    f1_bool = True
                    excursion += max(((S_N[i] / j) - 1), ((j / S_N[i]) - 1))
F1 = (f1 / m) * 100
F2 = (f2 / (m * numbers)) * 100
nse = excursion / (m * numbers)
F3 = nse / (0.01 * nse + 0.01)
CWQI = 100 - (math.sqrt(F1**2 + F2**2 + F3**2) / 1.732)
```

Classifications: Excellent (95–100) to Poor (0–44) [6].

- NSF WQI Calculation: NSFWQI = Σ (wi * qi), with sub-indices from curves [3].

- Data Visualization: Uses "Tabulate" library to display the output in a tabular form in the terminal.

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| Parameters | Observed Value | Standard Values | Wi | WQI | Water Quality | Grade |
|---|---|---|---|---|---|---|
| Electric Conductivity(mS/cm) | 8 | 2.25 | 0.505753 | | | |
| Dissolved Oxygen(mg/L) | 9 | 6 | 0.189657 | | | |
| Color(NTU) | 0.0098 | 15 | 0.0758629 | 1102.5336377325673 | Unfit for Drinking | E |
| Turbidity(NTU) | 200 | 5 | 0.227589 | | | |
| Total Dissolved Solids(mg/L) | 3 | 1000 | 0.00113794 | | | |

| Parameters | Observed Value | Qi | NSFWQI | Water Quality |
|---|---|---|---|---|
| pH | 7 | 90.2186 | | |
| BOD | 23 | 8.42019 | | |
| DO | 56 | 48.3007 | | |
| TDS | 323 | 58.5793 | 30.594583913570037 | Poor |
| Temperature | 10 | 42.795 | | |
| Fecal Coliform | 5678 | 11.6625 | | |

Fig 1: Data Visualization

### *C. Calibration Methodologies*

- **WQI:** Calibrated against WHO and Malagasy standards [5].
- **CWQI:** Nine parameters weighted; excursions calculated [6].
- **NSF WQI:** Uses predefined curves for nine parameters [3].

## III. RESULTS AND DISCUSSION

Varuna, developed by Joyanta Debnath and Ananta Debnath, was validated with datasets, e.g., pH 7.5, dissolved oxygen 8 mg/L, turbidity 5 NTU, yielding WQI 42 (Good) and CWQI 85 (Good). Visualizations (Figure 2, https://github.com/JoyantaDeb/Varuna-Water-Quality-Index) aided interpretation. The GitHub-hosted system enabled contributions, enhancing adaptability for India and Bangladesh water bodies [23, 51]. Limitations include data quality dependence and computational overhead. Future enhancements may include machine learning for predictive analysis [18].

## IV. CONCLUSION

Varuna, created by Joyanta Debnath and Ananta Debnath, advances water quality assessment with an accurate, open-source WQI calculation tool. Hosted on GitHub (https://github.com/JoyantaDeb/Varuna-Water-Quality-Index), it supports sustainable water management, aligning with global sustainability goals.

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