Concept:

Urban areas face significant challenges related to water management, including inefficient distribution, water wastage, and inadequate access to clean water. These issues are exacerbated by population growth, climate change, and aging infrastructure.

Problem Statement:

The project aims to design a smart water management system that leverages data from various sources to optimize water distribution, reduce water waste, and ensure sustainable access to clean water in urban areas. A key objective of this project is to identify the most effective machine learning algorithm for accurately predicting water potability based on various features. By providing insights into the factors that influence water quality, this system will help ensure safe and reliable drinking water for urban populations, thereby preventing water-borne diseases and promoting public health.

Objectives:

1. **Optimize Water Distribution:**
    - To implement data-driven solutions to ensure efficient and equitable water distribution across urban areas.
2. **Reduce Water Wastage:**
    - To detect and minimize water leaks and inefficiencies in the water supply network using real-time monitoring and automated controls.
3. **Ensure Sustainable Access to Clean Water:**
    - To guarantee a reliable supply of clean water to urban residents by improving water quality monitoring and management.
4. **Enhance Predictive Capabilities:**
    - To use machine learning and predictive analytics to forecast water demand and identify potential issues before they become critical.
5. **Improve Infrastructure Management:**
    - To prioritize infrastructure upgrades and maintenance based on data-driven insights to ensure the longevity and reliability of the water supply system.
6. **Increase Public Awareness and Engagement:**
    - To develop tools and resources to educate residents about water conservation and encourage active participation in sustainable water usage practices.
7. **Leverage Technology for Real-time Monitoring:**
    - To deploy sensors and smart meters to continuously monitor water flow, usage, and quality, providing real-time data for decision-making.
8. **Facilitate Data-Driven Decision Making:**
    - To utilize advanced analytics to support policymakers and water management authorities in making informed decisions.
9. **Support Climate Resilience:**
    - To adapt water management strategies to address the impacts of climate change, ensuring the system's resilience to extreme weather events and changing conditions.
10. **Promote Innovation in Water Management:**
    - To encourage the development and adoption of innovative technologies and practices in urban water management.

These objectives aim to create a comprehensive and sustainable approach to managing water resources in urban areas, aligning with the broader goals of SDG 6.

Data Source:
https://www.kaggle.com/datasets/adityakadiwal/water-potability

1. Data Sources:

- **Water Flow and Quality Sensors:**
    - Suppliers of IoT water sensors (e.g., Libelium, Sensirion)
    - Case studies on sensor deployment in urban water systems
- **Weather Data:**
    - National Meteorological Services (e.g., NOAA, Met Office)
    - Online weather APIs (e.g., OpenWeatherMap, Weather API)
- **Population Growth and Urbanization Trends:**
    - United Nations Department of Economic and Social Affairs (UN DESA)
    - World Bank Urban Development Data
- **Water Demand Patterns:**
    - Local water utility companies' data
    - Research studies on urban water consumption trends

2. Technological Resources:

- **Machine Learning and Predictive Analytics:**
    - Online courses and tutorials (e.g., Coursera, edX)
    - Open-source machine learning libraries (e.g., TensorFlow, scikit-learn)
- **Smart Meter Technology:**
    - Manufacturers of smart water meters (e.g., Sensus, Badger Meter)
    - Industry reports on smart meter adoption
- **Automated Control Systems:**
    - Information on SCADA systems for water management
    - Case studies on the implementation of automated control in water distribution

3. Research and Case Studies:

- **Academic Papers and Journals:**
    - Google Scholar for research papers on smart water management
    - Journals like "Water Research" and "Journal of Water Resources Planning and Management"
- **Case Studies:**
    - Successful implementations of smart water systems in cities (e.g., Singapore, Barcelona)
    - Reports from organizations like the International Water Association (IWA)

4. Policy and Regulatory Information:

- **Local and National Water Management Policies:**
    - Government websites for water regulation and policy documents
    - Reports from regulatory bodies (e.g., EPA in the USA, Environment Agency in the UK)

- **United Nations and International Guidelines:**
  - UN SDG 6 documentation and resources
  - Reports from organizations like UNESCO, WHO on water management and sanitation

5. Public Awareness and Education:

- **Educational Resources:**
  - Websites and platforms offering water conservation tips (e.g., EPA's WaterSense)
  - Apps and online tools promoting sustainable water use
- **Community Engagement Case Studies:**
  - Examples of successful community engagement in water conservation (e.g., WaterSmart Software)
  - Reports and articles on public participation in urban water management

6. Funding and Support:

- **Grants and Funding Opportunities:**
  - Information on grants for water projects from organizations like the Global Environment Facility (GEF)
  - Crowdfunding platforms for environmental projects (e.g., Kickstarter, GoFundMe)
- **Partnership Opportunities:**
  - Potential partnerships with NGOs focused on water and sanitation (e.g., Water.org, WaterAid)
  - Collaborations with technology companies and academic institutions

7. Tools for Project Management and Development:

- **Project Management Software:**
  - Tools like Trello, Asana, and Microsoft Project for managing the project timeline and tasks
- **Collaboration and Communication:**
  - Platforms like Slack, Zoom, and Google Workspace for team collaboration.

Features

1. pH Value:

- pH is a crucial parameter for assessing the acid-base balance of water, indicating its acidic or alkaline condition. The WHO recommends a pH range of 6.5 to 8.5 for safe drinking water. The current study found pH levels between 6.52 and 6.83, which fall within the WHO standards.

2. Hardness:

- Water hardness is primarily caused by calcium and magnesium salts dissolved from geological deposits. The contact time with these minerals determines the hardness level. Hardness is traditionally defined by water’s capacity to precipitate soap, which is largely due to calcium and magnesium content.

3. Total Dissolved Solids (TDS):

- TDS refers to the concentration of dissolved inorganic and organic minerals, such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, and sulfates. High TDS levels can affect the taste and color of water. The desirable limit for TDS in drinking water is 500 mg/L, with a maximum permissible limit of 1000 mg/L.

4. Chloramines:

- Chloramines, formed when ammonia is added to chlorine, are common disinfectants in public water systems. Chlorine levels up to 4 mg/L (or 4 parts per million) are considered safe for drinking water.

5. Sulfate:

- Sulfates are naturally occurring compounds found in minerals, soil, rocks, air, groundwater, plants, and food. They are widely used in the chemical industry. Sulfate concentrations in freshwater typically range from 3 to 30 mg/L, though some areas may have levels as high as 1000 mg/L.

6. Conductivity:

- Pure water is a poor conductor of electricity, but the presence of dissolved ions increases its conductivity. Electrical conductivity (EC) measures the ionic capacity of water to transmit current. According to WHO standards, the EC value should not exceed 400 μS/cm.

7. Total Organic Carbon (TOC):

- TOC measures the total amount of carbon in organic compounds present in water, derived from decaying natural organic matter and synthetic sources. The US EPA recommends TOC levels below 2 mg/L in treated drinking water and below 4 mg/L in source water used for treatment.

8. Trihalomethanes (THMs):

- THMs are chemicals found in chlorinated water. Their concentration varies based on the organic material in the water, the amount of chlorine used, and water temperature. THM levels up to 80 ppm are considered safe in drinking water.

9. Turbidity:

- Turbidity measures the amount of solid particles suspended in water, affecting its light-emitting properties. It is an indicator of water quality concerning colloidal matter. The mean turbidity value observed was 0.98 NTU, below the WHO recommended limit of 5.00 NTU.

10. Potability:

- Potability indicates whether water is safe for human consumption. A value of 1 denotes potable (safe to drink) water, while 0 indicates non-potable (unsafe to drink) water.

Data Analysis Tools:

Python & Jupyter Notebook Libraries used:

- Numpy: To solve complex mathematical problems
- Pandas: Use for data frame manipulation
- Seaborn: To create data visualization
- Matplotlib: To create data visualization
- ipywidgets: Interactive analysis
- sklearn: Implement complex machine learning algorithm

Data Visualizations:

- Bar Graphs and Line Charts will be used using for better visualization.
- Pie Charts shall also be a good impact on understanding the parameters of the project.

Methodology:

The methodology used in analysing the dataset "Water Potability" is as follows:

1. **Data Collection:**
    - Utilize sensors to monitor water flow, usage, and quality in real-time.
    - Gather data from weather forecasts, population growth trends, and water demand patterns.
2. **Data Analysis:**
    - Implement machine learning algorithms to analyse collected data.
    - Predict water demand and detect anomalies in the water distribution network.
3. **Optimization:**
    - Use predictive analytics to optimize water distribution schedules.
    - Implement automated controls to adjust water flow and pressure in real-time, reducing wastage.
4. **User Engagement:**
    - Develop a mobile app for residents to monitor their water usage and receive alerts.
    - Provide educational resources on water conservation practices.
5. **Infrastructure Enhancement:**
    - Identify and prioritize areas for infrastructure upgrades based on data insights.
    - Promote the adoption of smart meters and other water-saving technologies.

Probable Outcome:

- Better understanding of the features and their relationship with the target variable (potability).
- Identification of the most important features that influence water quality and potability.
- Finding the best machine learning algorithm that can accurately predict the potability of water based on the given features.
- Providing insights and recommendations for improving water quality and potability.
- Improved efficiency in water distribution and reduced water wastage.
- Enhanced ability to predict and manage water demand.
- Increased public awareness and engagement in water conservation efforts.
- Sustainable and equitable access to clean water for urban residents.

This smart water management system aligns with SDG 6 by promoting sustainable water usage, improving water quality, and enhancing water infrastructure in urban areas.

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