# Analyzing water quality and water potability in India to establish a business application for Desalination Process Optimization

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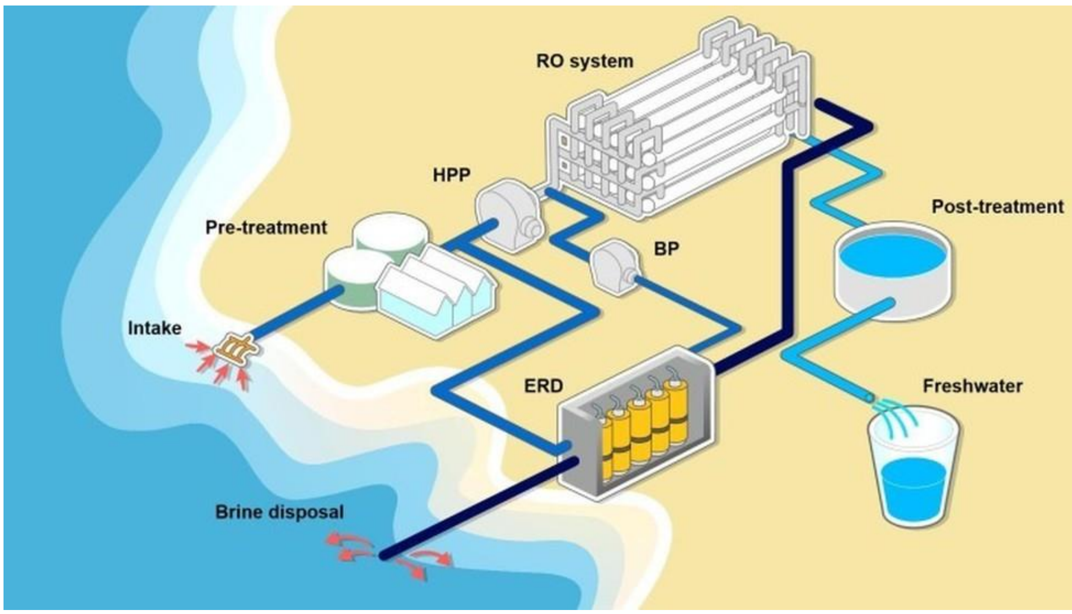
*In India's Bengaluru city (formerly Bangalore), thousands of people have been chasing tankers, taking fewer showers, and sometimes missing work to store enough water to get through the day.*

*We need to come out of this crisis anyhow. Maybe with our recent savior ... AI !!*




*"AI is probably the most important thing humanity has ever worked on. I think of it as something more profound than electricity or fire."*

## Introduction

Water scarcity and poor water quality are pressing issues in India, affecting millions of people and hampering economic growth. Despite being home to 18% of the world's population, India has only 4% of the world's freshwater resources. This imbalance, coupled with pollution and inefficient water management, has led to a significant need for advanced water treatment solutions. Among these, desalination stands out as a viable option to augment the freshwater supply. However, to maximize its benefits, there is a need to optimize desalination processes tailored to India's unique water quality challenges.

## Water Scarcity in India

India, with 18% of the global population, possesses only 4% of the world’s water resources according to the NITI Aayog Report of 2017. This scarcity ranks India among the most water-stressed nations globally. In Karnataka alone, over 7,000 villages, 1,100 wards, and 220 talukas have been impacted by the water crisis. Here are the major statistics regarding Water Scarcity in India as mentioned below.

| Statistics | Numbers |
|---|---|
| Population without access to safe drinking water | 163 million |
| Population without access to a safe toilet | 678 million |
| Percentage of India’s population facing severe water scarcity yearly | 80% |
| Population facing severe water scarcity all year round | 180 million |
| Children under five dying from diarrhea daily in India | 500 |
| Communicable diseases linked to unsafe water | 21% |

| Statistics | Numbers |
|---|---|
| Water resources available to 36% of India’s area | 71% |
| Decline in annual per capita water availability since Independence | 75% |
| Annual per capita water availability (1947) | 6,042 cubic meters |
| Annual per capita water availability (2021) | 1,486 cubic meters |
| Beneficiaries of Major Irrigation and Flood Management Project (West Bengal) | 2.7 million farmers |
| Population lacking access to safe water (out of 1.4 billion) | 35 million |
| Population lacking access to a safe toilet (out of 1.4 billion) | 678 million |

**DATA COLLECTION**: Data is collected manually from www.kaggle.com and https://www.data.gov.in

## Current State of Water Quality in India

India's water quality issues are multifaceted, involving chemical, biological, and physical contaminants. Key contaminants include:

Chemical Contaminants: These include arsenic, fluoride, nitrates, and heavy metals like lead and mercury, which often exceed permissible limits in groundwater.

Biological Contaminants: Pathogens such as bacteria, viruses, and parasites are prevalent, especially in rural areas where sanitation infrastructure is inadequate.

Physical Contaminants: Turbidity and sedimentation, often resulting from industrial discharge and agricultural runoff, degrade water quality.

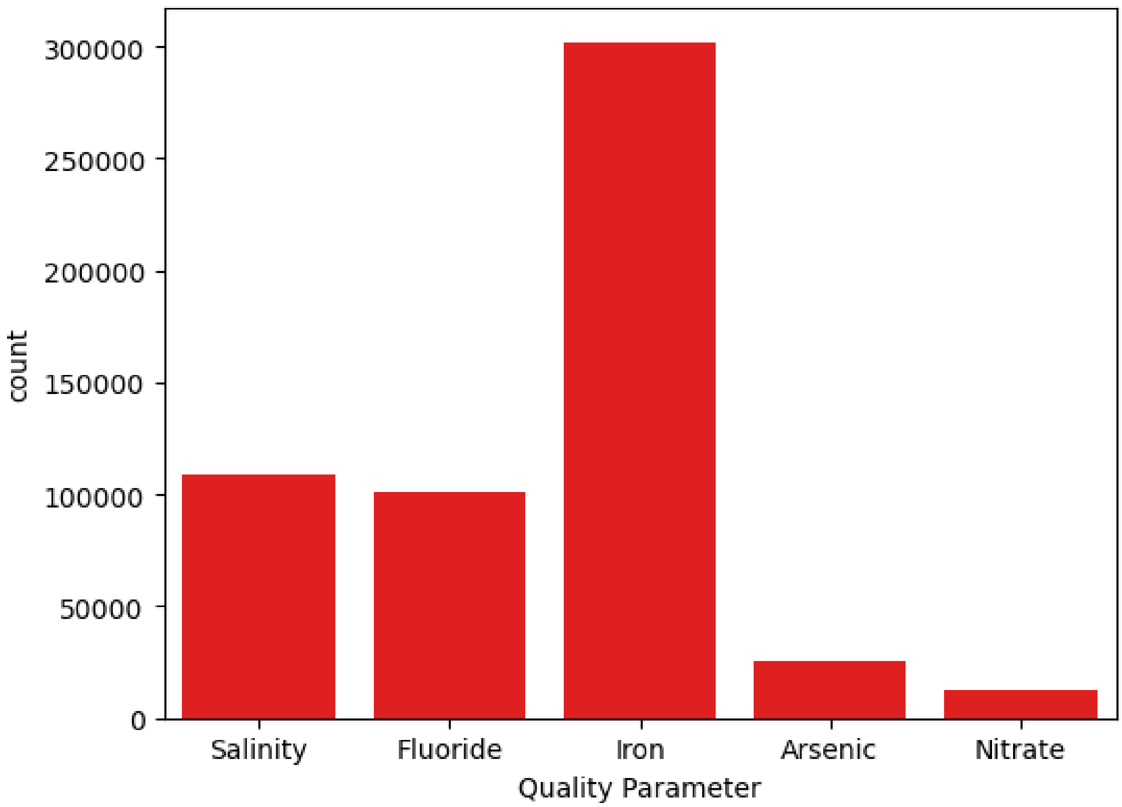
A report by the Central Pollution Control Board (CPCB) indicates that out of 445 river stretches in India, 351 are polluted due to industrial effluents, agricultural runoff, and domestic sewage. Moreover, the National Green Tribunal has frequently highlighted the severe contamination of groundwater in various states.

- Following are the insights found from the “India-water-quality-data” data . The work is done using Python coding in the “IndiaAffectedWaterQualityAreas.ipynb” file uploaded to GitHub repository.

- **Iron is the most frequent element that is causing water degradation in the country:**

quality1['Quality Parameter'].value_counts()

```
Iron         302081
Salinity     108923
Fluoride     101035
Arsenic       25705
Nitrate       12329
Name: Quality Parameter, dtype: int64
```

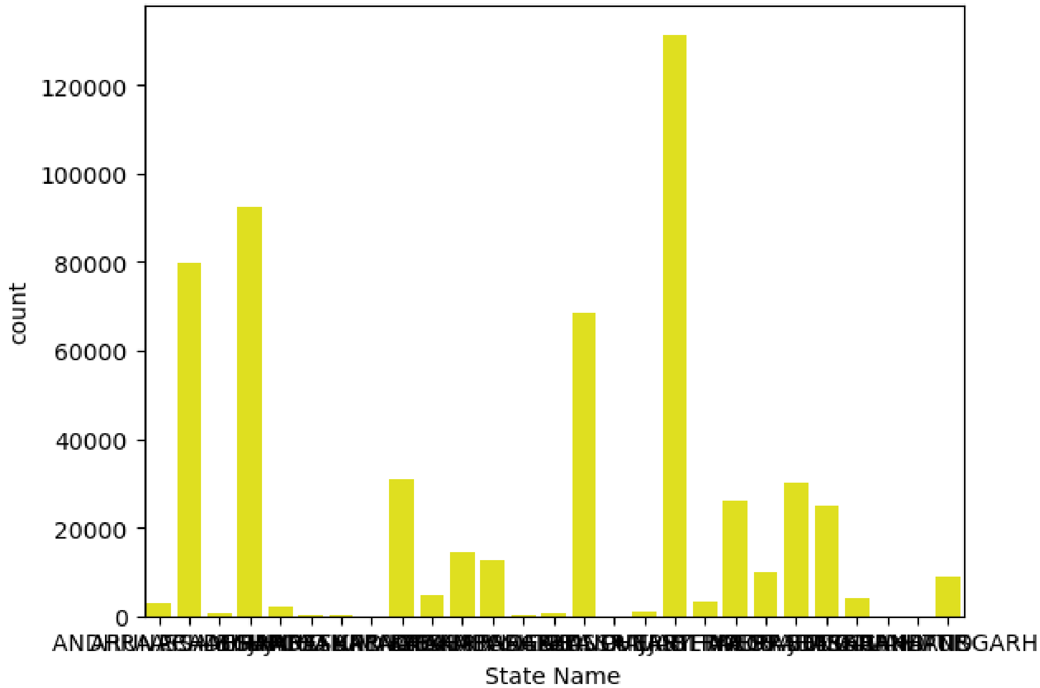


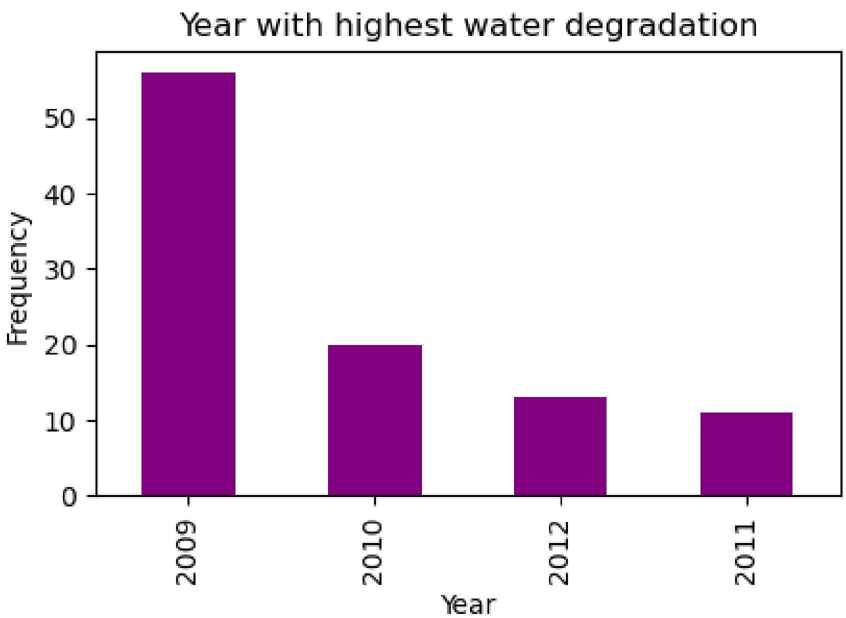

- **Rajasthan is in the first place to face water degradation:**

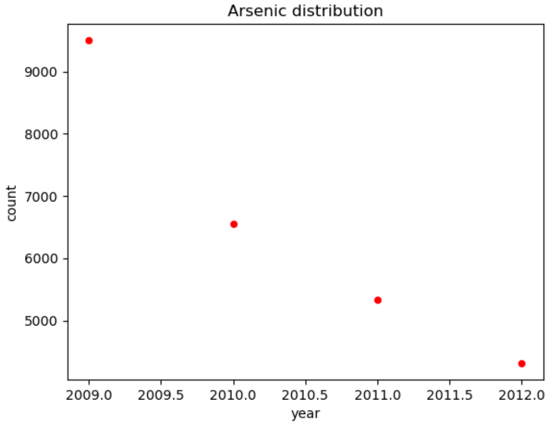
**Bihar,Assam, Orissa bag the immediate next position to Rajasthan.**

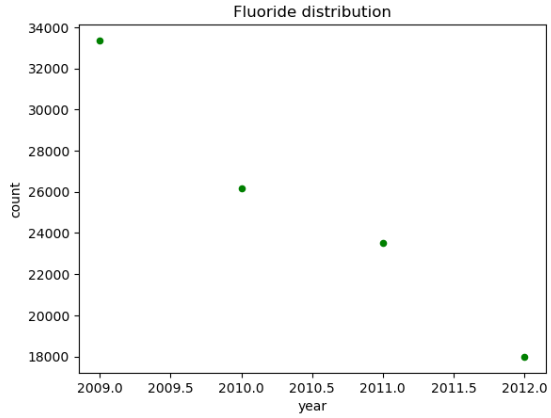
quality1['State Name'].value_counts()

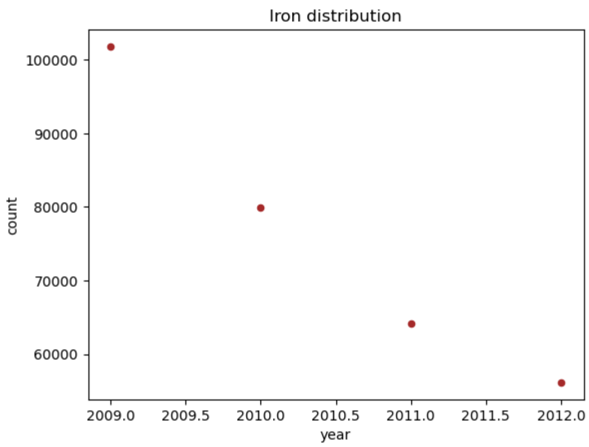
```
RAJASTHAN           131417
BIHAR                92328
ASSAM                79910
ORISSA               68618
KARNATAKA            30820
WEST BENGAL          30088
TRIPURA              26113
CHATTISGARH          25062
MADHYA PRADESH       14449
MAHARASHTRA          12480
```

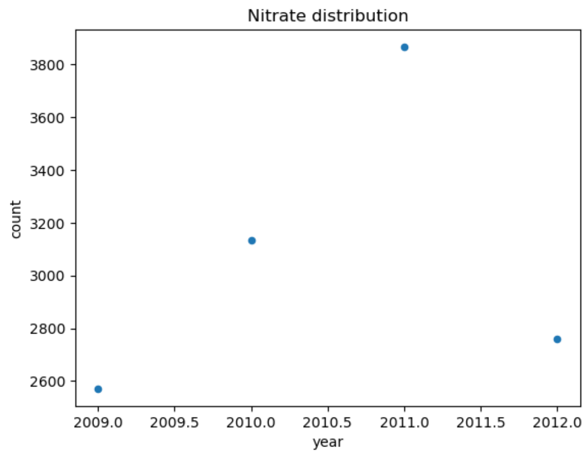

120000
100000
80000
60000
40000
20000
0
count
State Name

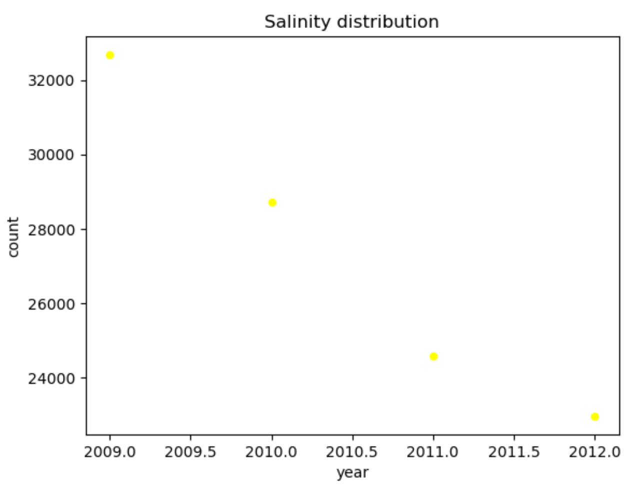

Year with highest water degradation
50
40
30
20
10
0
Frequency
2009
2010
2012
2011
Year




In most of the places in Rajasthan water quality is affected by Salinity content in water.

## Water Potability Challenges

Ensuring potability, or the safety of water for drinking, is a significant challenge in India. The Bureau of Indian Standards (BIS) specifies the permissible limits for various contaminants in drinking water. However, achieving these standards consistently is difficult due to:

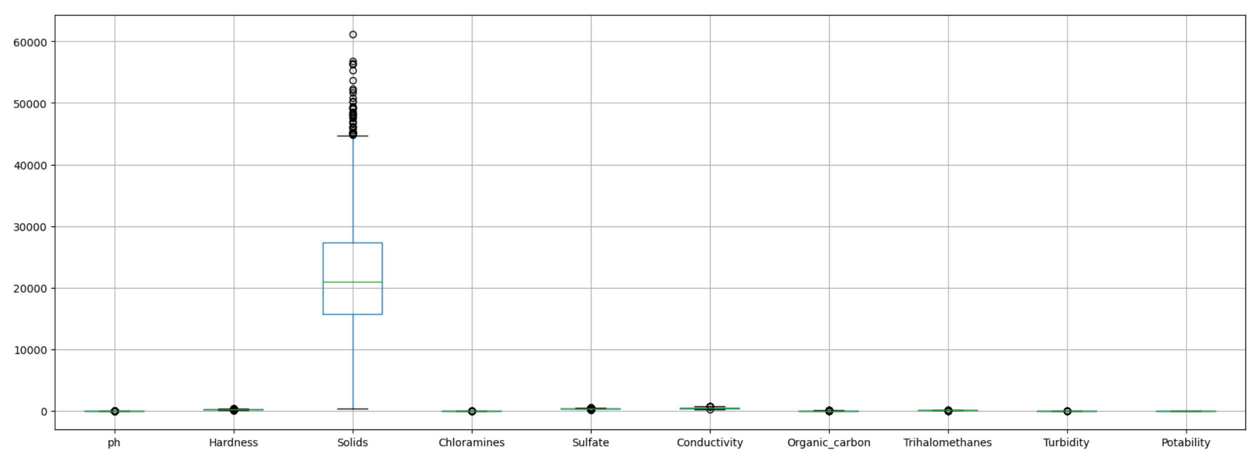
Infrastructure Deficiency: Many regions lack proper water treatment and distribution infrastructure, leading to contamination during transit.

Pollution Sources: Continuous pollution from agricultural, industrial, and domestic sources makes it hard to maintain water quality.

Groundwater Depletion: Over-extraction of groundwater, which is a major drinking water source, leads to quality degradation through processes like saltwater intrusion in coastal areas.

- Following are the insights found from the “water_potability” data. The work is done using Python coding in the “water_potability.ipynb” file uploaded to the GitHub repository.

- **The following plot shows that the boxplot in ‘Solids’ has a huge number of outliers which indicates a high amount of solid debris in water:**

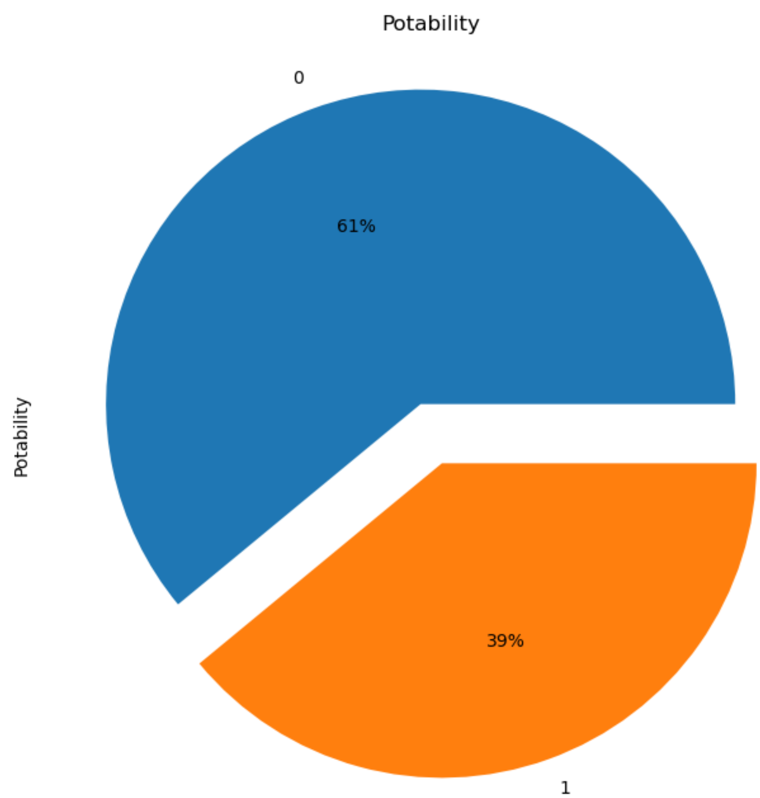


- **The count of not potable is much higher than that of potable:**

# 1 = Potable and 0 = Not potable.

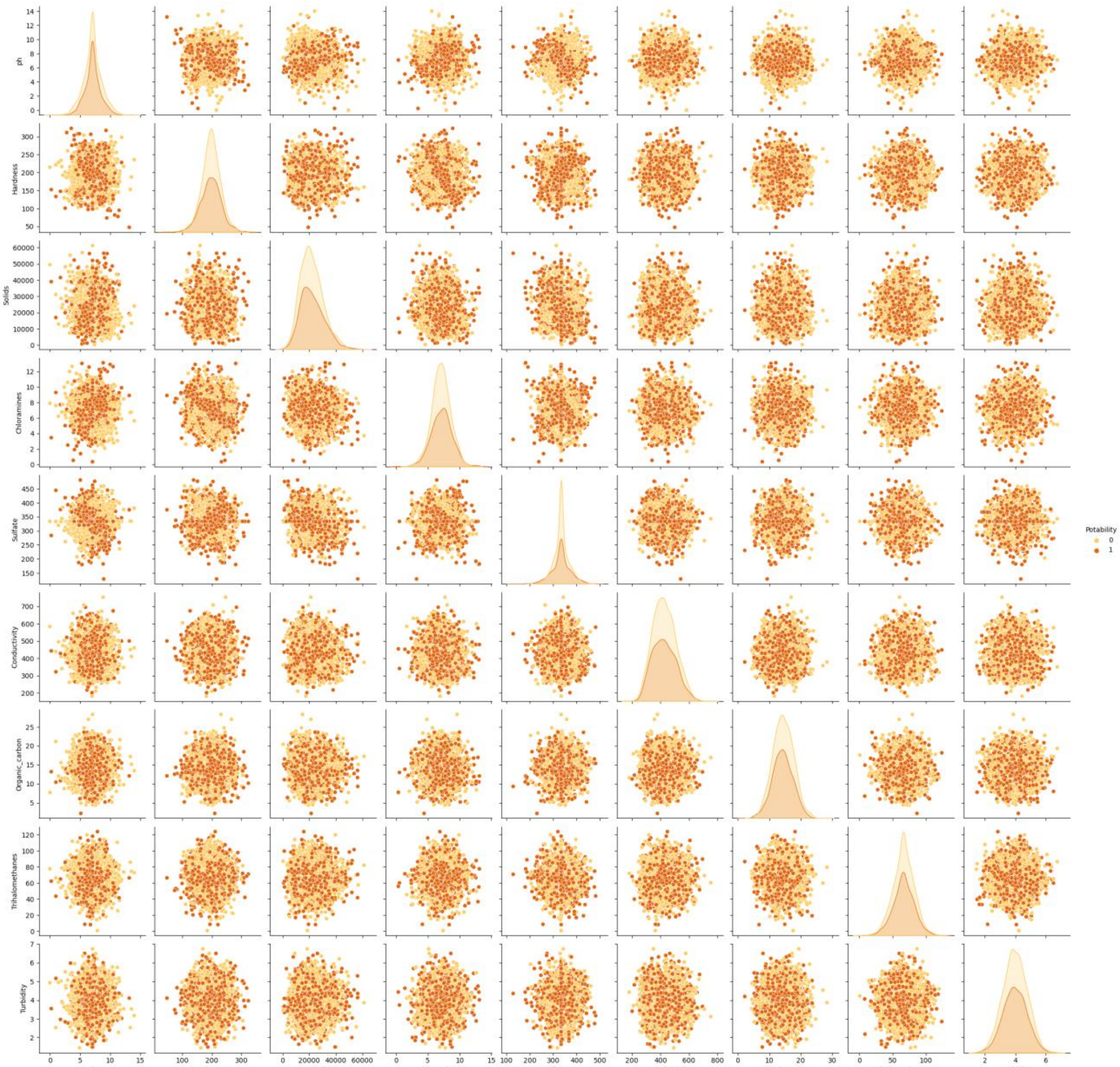
water['Potability'].value_counts()

```
0    1998
1    1278
Name: Potability, dtype: int64
```

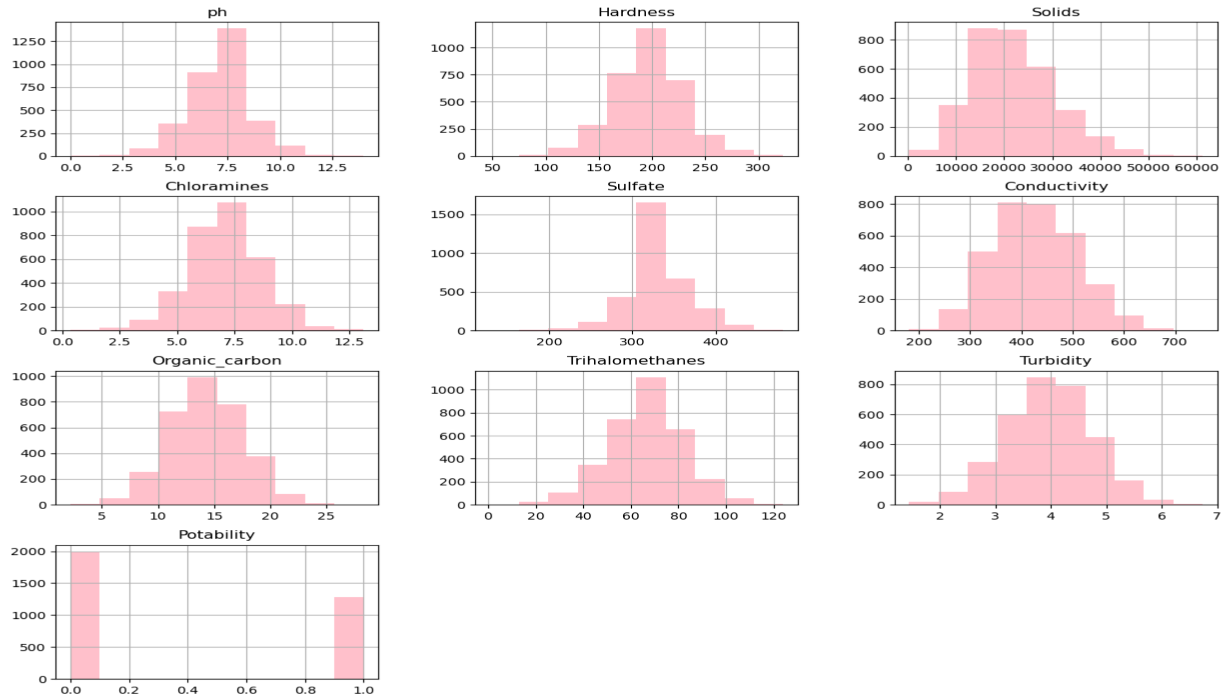



So, this is a clear picture of how bad the water quality is. Only, 39% is Potable.

- **The following pair plot shows that the data is not correlated in any way:**



The Histplot shows the distribution of all the variables:




## The Role of Desalination

Desalination, the process of removing salts and other impurities from seawater or brackish water, is emerging as a critical solution for India's water crisis. Coastal states like Tamil Nadu and Gujarat have already implemented desalination plants to supplement their freshwater needs. However, the process is energy-intensive and costly, necessitating optimization to make it more viable.

## Desalination Process Optimization

Optimization of desalination processes can address several challenges:

Energy Efficiency: Utilizing renewable energy sources, such as solar or wind power, can reduce the energy footprint of desalination plants.

Advanced Membrane Technology: Investing in research to develop more efficient and longer-lasting desalination membranes can reduce operational costs.

Hybrid Systems: Combining desalination with other water treatment processes (like reverse osmosis and multi-stage flash distillation) can enhance efficiency and reduce costs.

Brine Management: Developing eco-friendly methods for brine disposal or repurposing can mitigate environmental impacts.

## Business Application and Potential

The integration of machine learning (ML) presents an opportunity to revolutionize desalination operations by leveraging historical and real-time data to predict system performance, identify optimal operating conditions, and anticipate maintenance requirements.

Optimizing desalination processes presents a lucrative business opportunity in India. Companies specializing in water treatment technologies can capitalize on the following areas:

Technology Development: Innovating and patenting new desalination technologies tailored to Indian water conditions.

Consulting Services: Providing expertise to government and private entities on setting up and optimizing desalination plants.

Public-Private Partnerships: Collaborating with government bodies to establish large-scale desalination projects.

Renewable Integration: Offering solutions that integrate renewable energy sources with desalination processes.

## Designing the financial equation:

Designing a financial equation for our business application aimed at desalination process optimization in the current Indian market involves integrating several economic and market variables. Here is a structured approach to developing this financial equation:

### Key Variables and Parameters

1. **Capital Expenditure (CapEx)**: Initial investment costs for setting up the desalination plant.
    - **CapEx** = $C_{\text{plant}} + C_{\text{tech}}$
    - $C_{\text{plant}}$: Cost of constructing the plant
    - $C_{\text{tech}}$: Cost of technology and equipment
2. **Operational Expenditure (OpEx)**: Ongoing costs for running the desalination plant.
    - **OpEx** = $C_{\text{energy}} + C_{\text{labor}} + C_{\text{maintenance}} + C_{\text{chemicals}} + C_{\text{other}}$
    - $C_{\text{energy}}$: Cost of energy consumption
    - $C_{\text{labor}}$: Labor costs
    - $C_{\text{maintenance}}$: Maintenance costs
    - $C_{\text{chemicals}}$: Costs for chemicals used in the process
    - $C_{\text{other}}$: Other miscellaneous operational costs
3. **Revenue (Rev)**: Income generated from selling the desalinated water.
    - **Rev** = $P_{\text{water}} \times Q_{\text{water}}$
    - $P_{\text{water}}$: Price per unit of desalinated water
    - $Q_{\text{water}}$: Quantity of desalinated water sold
4. **Government Subsidies and Incentives (GSI)**: Financial support from the government.

- **GSI** = $S_{\text{init}} + S_{\text{op}}$
- $S_{\text{init}}$: Initial subsidies for setting up the plant
- $S_{\text{op}}$: Ongoing operational subsidies

5. **Loan Repayments and Interest (LRI)**: Costs associated with financing.
    - **LRI** = $L \times r$
    - $L$: Loan amount
    - $r$: Interest rate
6. **Tax Benefits and Depreciation (TBD)**: Tax deductions and depreciation benefits.
    - **TBD** = $T_{\text{deductions}} + D_{\text{depreciation}}$
    - $T_{\text{deductions}}$: Tax deductions
    - $D_{\text{depreciation}}$: Depreciation benefits
7. **Market Growth Rate (MGR)**: Expected growth in demand for desalinated water.
    - **MGR** = $G_{\text{demand}}$
    - $G_{\text{demand}}$: Annual growth rate of water demand

**Financial Equation**

The Net Present Value (NPV) approach can be used to assess the financial viability of the desalination project over a certain time period ($tt$ years):

NPV = $\sum (\text{Rev}_t + \text{GSI}_t - \text{OpEx}_t - \text{LRI}_t + \text{TBD}_t)/(1+d)^t - \text{CapEx}$

Where:

- The summation is taken over t in range (1 to n)
- *n* is the project lifespan in years
- $d$ is the discount rate to account for the time value of money

- $\text{Rev}_t$, $\text{GSI}_t$, $\text{OpEx}_t$, $\text{LRI}_t$, and $\text{TBD}_t$ are the respective values for each year $t$

**Considerations for the Indian Market**

1. **Energy Costs**: India's energy costs are a significant part of OpEx. Consider renewable energy options to reduce $C_{\text{energy}}$.
2. **Water Pricing**: $P_{\text{water}}$ should reflect local water tariffs and competition.
3. **Government Policies**: Take into account any recent government policies promoting desalination or renewable energy usage.
4. **Technology**: Invest in efficient and cost-effective desalination technologies to optimize $C_{\text{tech}}$ and $C_{\text{maintenance}}$.
5. **Market Demand**: Analyze the regional water scarcity and demand trends to accurately project $Q_{\text{water}}$.

The NPV calculation would follow the structured approach using these inputs.

This equation provides a comprehensive framework to evaluate the financial feasibility and optimize the desalination process for a business application in India. Adjust the variables as per real-time data and market conditions for accurate projections.

**External Search**

The sources I have used for this product idea are given below:

https://www.wateraid.org/in/blog/water-crisis
https://iwaponline.com/jwrd/article/13/1/51/92855/Using-machine-learning-architecture-to-optimize
https://www.geeksforgeeks.org/water-scarcity-in-india/?ref=ml_lbp
https://www.sciencedirect.com/science/article/abs/pii/S0011916422006762
https://link.springer.com/article/10.1007/s41101-023-00227-7
https://watermanaustralia.com/optimizing-the-operation-of-seawater-desalination-plants/
https://www.researchgate.net/publication/317671095_Water_Desalination_Fault_Detection_Using_Machine_Learning_Approaches_A_Comparative_Study

## Conclusion

Analyzing water quality and potability in India underscores the urgent need for reliable water treatment solutions. Desalination, if optimized, can significantly contribute to addressing India's water scarcity. By focusing on energy efficiency, advanced technologies, and sustainable practices, businesses can play a pivotal role in making desalination a cornerstone of India's water strategy, thereby ensuring a safer and more reliable water supply for its population.

GITHUB LINK of this assignment: https://github.com/ShraddhaSaha/Desalination