***PROJECT DEVELOPMENT PHASE - SPRIT II***

| | |
|---|---|
| Date | 12 October 2022 |
| Team ID | PNT2022TMID06599 |
| Project Title | Water Quality Analysis and Prediction using Machine Learning |
| Team Leader | Thamotharan.C |
| Team Member | Mohanakannan.G ,Kathirvel.P, Kokila.V |
| Maximum Marks | 8 Marks |

```
# pip install matplotlib

# pip install seaborn


# import all needed libraries

import pandas as pd
import numpy as np
import os
import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.model_selection import train_test_split

from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import OneHotEncoder
from sklearn.preprocessing import LabelEncoder
from sklearn.preprocessing import MinMaxScaler


from sklearn.ensemble import RandomForestRegressor
from sklearn.tree import DecisionTreeRegressor
from sklearn.linear_model import LogisticRegression
from sklearn.linear_model import LinearRegression

from sklearn.metrics import accuracy_score, precision_score,
recall_score, f1_score,r2_score
from sklearn.metrics import confusion_matrix, classification_report



# read csv file using pandas

df=pd.read_csv('Book0.1.csv')
df.head()

   Unnamed: 0  STATION CODE  \
```

```
0           1          1399
1           2          1475
2           3          3181
3           4          3182
4           5          1400

                                                 LOCATIONS STATE  Temp  D.O.
(mg/l)  \
0 ZUARI AT  D/S OF PT. WHERE KUMBARJRIA CANAL JOI...   GOA  29.8
5.7
1                                ZUARI AT PANCHAWADI   GOA  29.5
6.3
2                        RIVER ZUARI AT BORIM BRIDGE   GOA  29.7
5.8
3                       RIVER ZUARI AT MARCAIM JETTY   GOA  29.5
5.8
4             MANDOVI AT NEGHBOURHOOD OF PANAJI, GOA   GOA    30
5.5

    PH  CONDUCTIVITY (µmhos/cm) B.O.D. (mg/l)  \
0  7.2                      189            2
1  6.9                      179          1.7
2  6.9                       64          3.8
3  7.3                       83          1.9
4  7.4                       81          1.5

  NITRATENAN N+ NITRITENANN (mg/l) FECAL COLIFORM (MPN/100ml)  \
0                             0.2                        4953
1                             0.1                        3243
2                             0.5                        5382
3                             0.4                        3428
4                             0.1                        2853

  TOTAL COLIFORM (MPN/100ml)Mean  year
0                          8391  2014
1                          5330  2014
2                          8443  2014
3                          5500  2014
4                          4049  2014
```

```
# no need this because it give value error of continuous value error
df.drop(['Unnamed: 0'],inplace=True,axis=1)

l=['Temp','D.O. (mg/l)','PH','CONDUCTIVITY (µmhos/cm)','B.O.D.
(mg/l)','NITRATENAN N+ NITRITENANN (mg/l)','FECAL COLIFORM
(MPN/100ml)','TOTAL COLIFORM (MPN/100ml)Mean']
df[df[l]=="NAN"]
```

```
     STATION CODE LOCATIONS STATE Temp  D.O. (mg/l)  PH  \
0             NaN       NaN   NaN  NaN          NaN NaN
1             NaN       NaN   NaN  NaN          NaN NaN
2             NaN       NaN   NaN  NaN          NaN NaN
3             NaN       NaN   NaN  NaN          NaN NaN
4             NaN       NaN   NaN  NaN          NaN NaN
..            ...       ...   ...  ...          ...  ..
```

```
890           NaN        NaN   NaN  NaN          NaN NaN
891           NaN        NaN   NaN  NaN          NaN NaN
892           NaN        NaN   NaN  NaN          NaN NaN
893           NaN        NaN   NaN  NaN          NaN NaN
894           NaN        NaN   NaN  NaN          NaN NaN

     CONDUCTIVITY (µmhos/cm) B.O.D. (mg/l) NITRATENAN N+ NITRITENANN
(mg/l)  \
0                        NaN           NaN
NaN
1                        NaN           NaN
NaN
2                        NaN           NaN
NaN
3                        NaN           NaN
NaN
4                        NaN           NaN
NaN
..                       ...           ...
...
890                      NaN           NaN
NaN
891                      NaN           NaN
NaN
892                      NaN           NaN
NaN
893                      NaN           NaN
NaN
894                      NaN           NaN
NaN

    FECAL COLIFORM (MPN/100ml) TOTAL COLIFORM (MPN/100ml)Mean  year
0                          NaN                                NaN   NaN
1                          NaN                                NaN   NaN
2                          NaN                                NaN   NaN
3                          NaN                                NaN   NaN
4                          NaN                                NaN   NaN
..                         ...                                ...   ...
890                        NaN                                NaN   NaN
891                        NaN                                NaN   NaN
892                        NaN                                NaN   NaN
893                        NaN                                NaN   NaN
894                        NaN                                NaN   NaN

[895 rows x 12 columns]
```

```
# drop the all nan and empty data

for i in l:
    df.drop(df.index[df[i]=="NAN"],inplace=True,axis=0)
    df.drop(df.index[df[i]==" "],inplace=True,axis=0)

# convert all data type into float

for i in l:
```

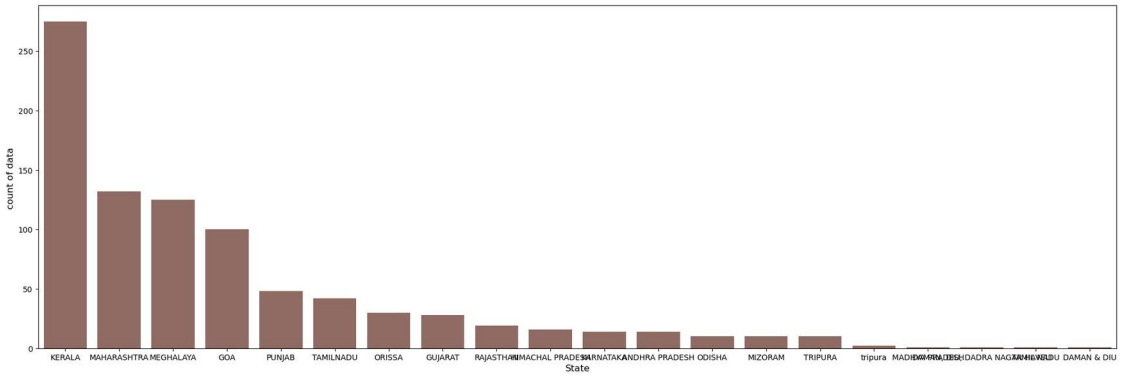
```
    df[i]=df[i].astype('float')
df.describe()
```

```
       STATION CODE        Temp  D.O. (mg/l)          PH  \
count    879.000000  879.000000   879.000000  879.000000
mean    2194.318544   26.093743     6.310728    7.232628
std      807.389674    3.261618     1.300479    0.606125
min       17.000000   16.000000     0.200000    2.600000
25%     1548.000000   24.450000     5.900000    6.950000
50%     2290.000000   27.000000     6.700000    7.200000
75%     2708.000000   28.400000     7.100000    7.600000
max     3473.000000   33.000000     9.900000    8.400000

       CONDUCTIVITY (µmhos/cm)  B.O.D. (mg/l)  \
count               879.000000     879.000000
mean               1650.803185       4.924061
std                4927.777303      12.770214
min                  27.000000       0.100000
25%                  75.000000       1.200000
50%                 159.000000       1.800000
75%                 505.500000       3.300000
max               37227.000000     185.800000

       NITRATENAN N+ NITRITENANN (mg/l)  FECAL COLIFORM (MPN/100ml)  \
count                        879.000000                8.790000e+02
mean                           1.644994                6.869346e+05
std                            2.896984                1.209315e+07
min                            0.000000                2.000000e+00
25%                            0.280000                2.550000e+01
50%                            0.590000                1.990000e+02
75%                            1.775000                9.965000e+02
max                           20.300000                2.725216e+08

       TOTAL COLIFORM (MPN/100ml)Mean         year
count                    8.790000e+02   879.000000
mean                     1.110502e+06  2012.559727
std                      2.069025e+07     1.102190
min                      4.000000e+00  2010.000000
25%                      9.000000e+01  2012.000000
50%                      5.000000e+02  2013.000000
75%                      2.425000e+03  2014.000000
max                      5.110909e+08  2014.000000
```

```
# viewing the column of state

color=sns.color_palette()

int_level = df['STATE'].value_counts()
```

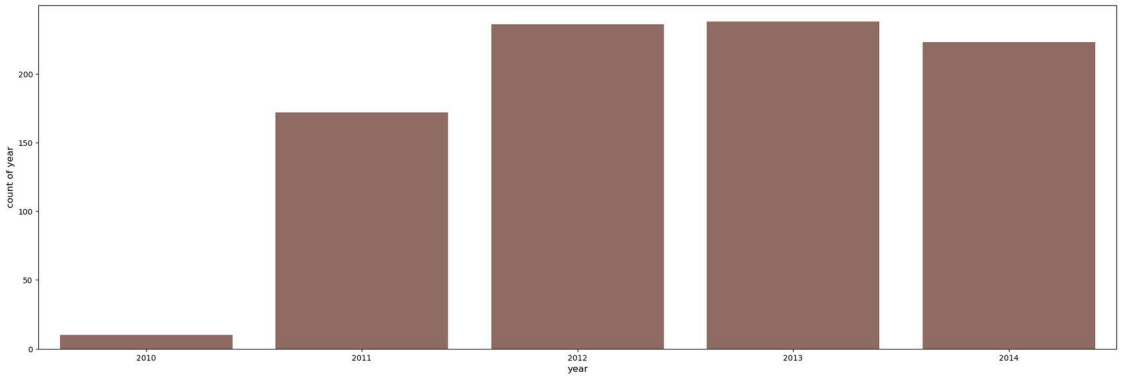
```
plt.figure(figsize=(25,8))
sns.barplot(int_level.index,int_level.values,alpha=0.9,color=color[5])
plt.ylabel('count of data ',fontsize=12)
plt.xlabel('State',fontsize=12)
plt.show()
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36:
FutureWarning: Pass the following variables as keyword args: x, y.
From version 0.12, the only valid positional argument will be `data`,
and passing other arguments without an explicit keyword will result in
an error or misinterpretation.
  warnings.warn(
```




```
# viewing the column data of year

color=sns.color_palette()

int_level = df['year'].value_counts()

plt.figure(figsize=(25,8))
sns.barplot(int_level.index,int_level.values,alpha=0.9,color=color[5])
plt.ylabel('count of year',fontsize=12)
plt.xlabel('year',fontsize=12)
plt.show()
```

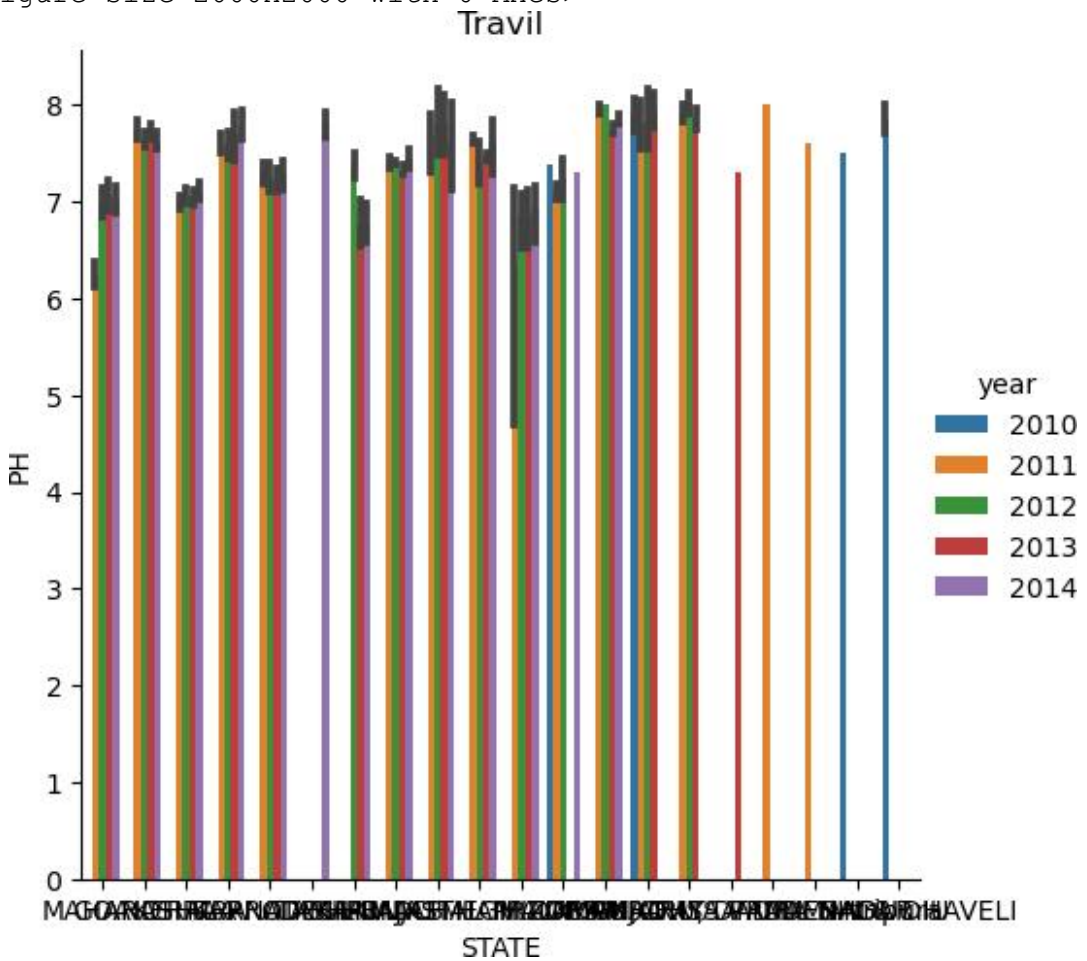
```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36:
FutureWarning: Pass the following variables as keyword args: x, y.
From version 0.12, the only valid positional argument will be `data`,
and passing other arguments without an explicit keyword will result in
an error or misinterpretation.
  warnings.warn(
```




```
# State and year comparision with ph rate

plt.figure(figsize=(20,20))
g=sns.catplot(data=df,kind="bar",x="STATE",y="PH",hue="year")
plt.title("Travil")
```

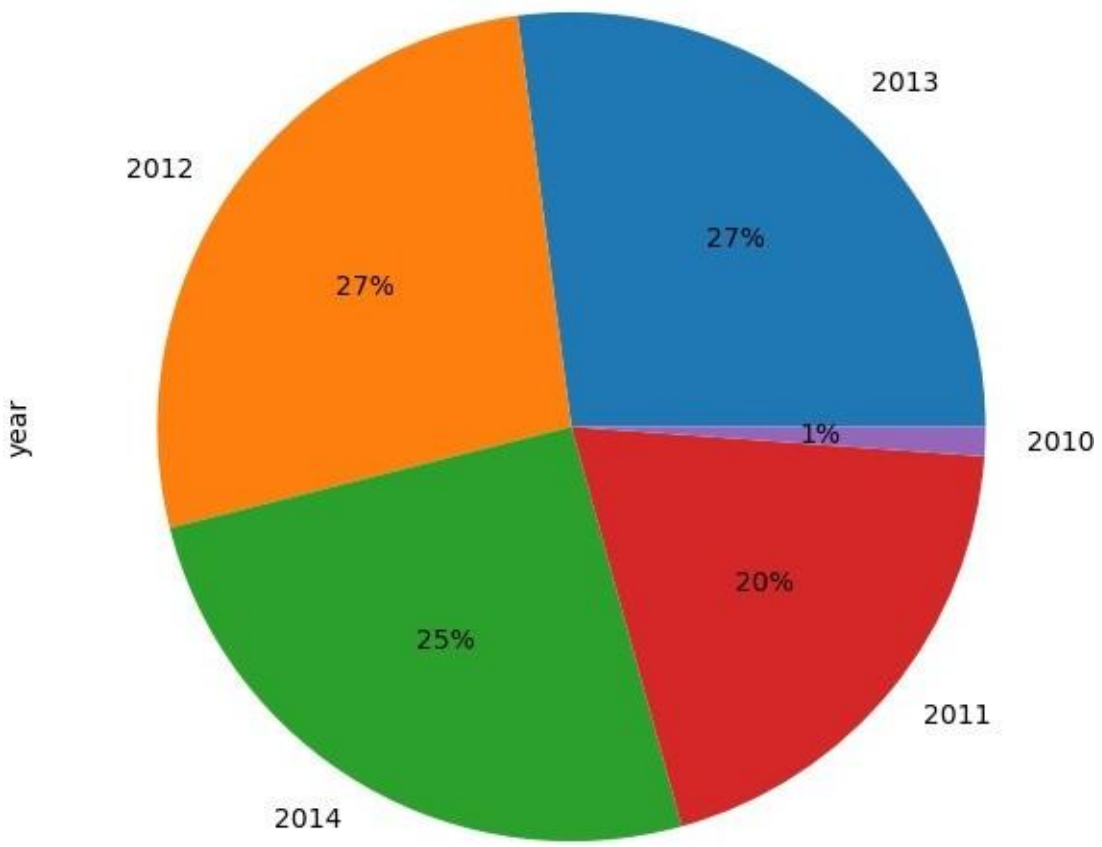
```
Text(0.5, 1.0, 'Travil')
```

```
<Figure size 2000x2000 with 0 Axes>
```

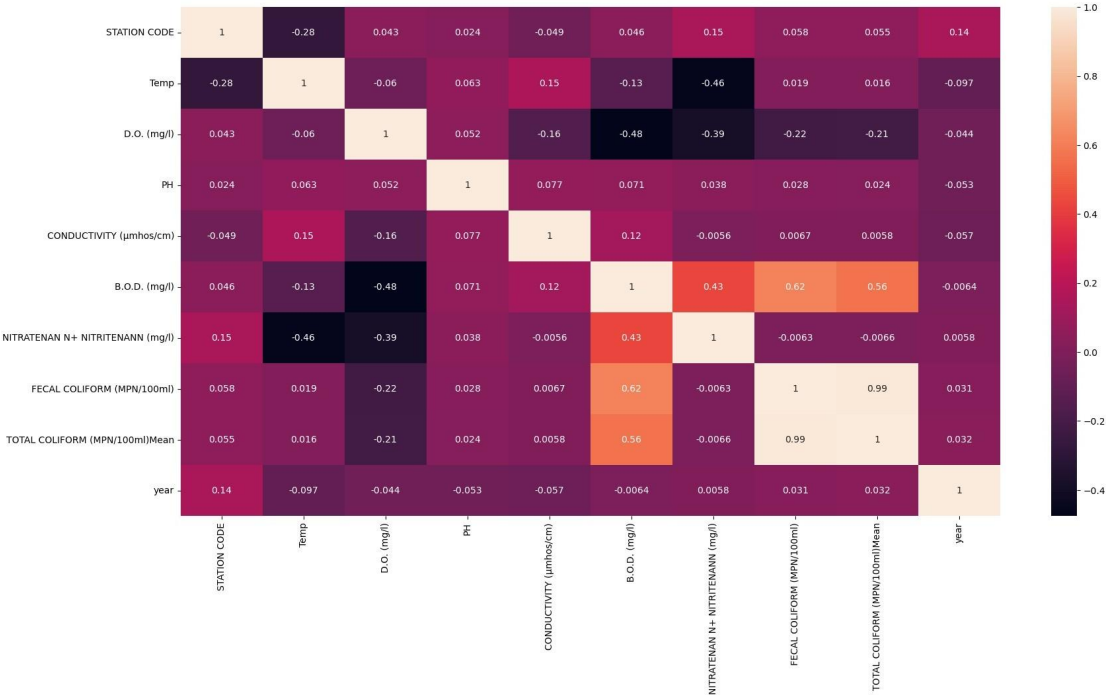



```
df['year'].value_counts().plot(kind='pie',figsize=(7,7),autopct='%1.0f
%%')
```

```
<AxesSubplot:ylabel='year'>
```




```
plt.figure(figsize=(20,10))
sns.heatmap(df.corr(),annot=True)
plt.show()
```



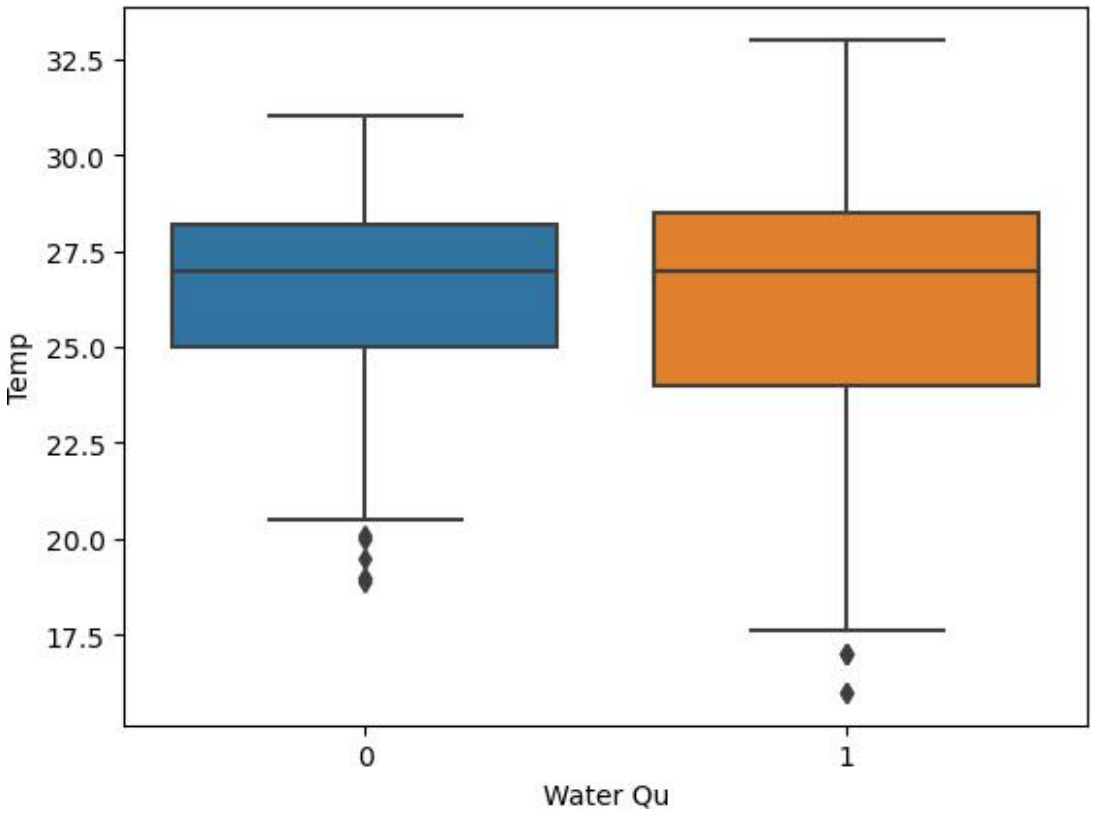
```
# Create column for the pure water range and split with undrikingable
water

df['PH Range']=pd.cut(x=df['PH'],bins=[0,6.49,7.5,14],labels=['0-
6.49','6.5-7.5','7.5-14'])
df['Water Qu']=df['PH Range'].map({'6.5-7.5':1,'7.5-14':0,'0-6.49':0})

df.drop(df.index[df['PH Range']=="NaN"],inplace=True,axis=0)

df.describe()
```

```
       STATION CODE         Temp  D.O. (mg/l)           PH  \
count    879.000000  879.000000   879.000000  879.000000
mean    2194.318544   26.093743     6.310728    7.232628
std      807.389674    3.261618     1.300479    0.606125
min       17.000000   16.000000     0.200000    2.600000
25%     1548.000000   24.450000     5.900000    6.950000
50%     2290.000000   27.000000     6.700000    7.200000
75%     2708.000000   28.400000     7.100000    7.600000
max     3473.000000   33.000000     9.900000    8.400000

       CONDUCTIVITY (µmhos/cm)  B.O.D. (mg/l)  \
count               879.000000     879.000000
mean               1650.803185       4.924061
std                4927.777303      12.770214
min                  27.000000       0.100000
25%                  75.000000       1.200000
```

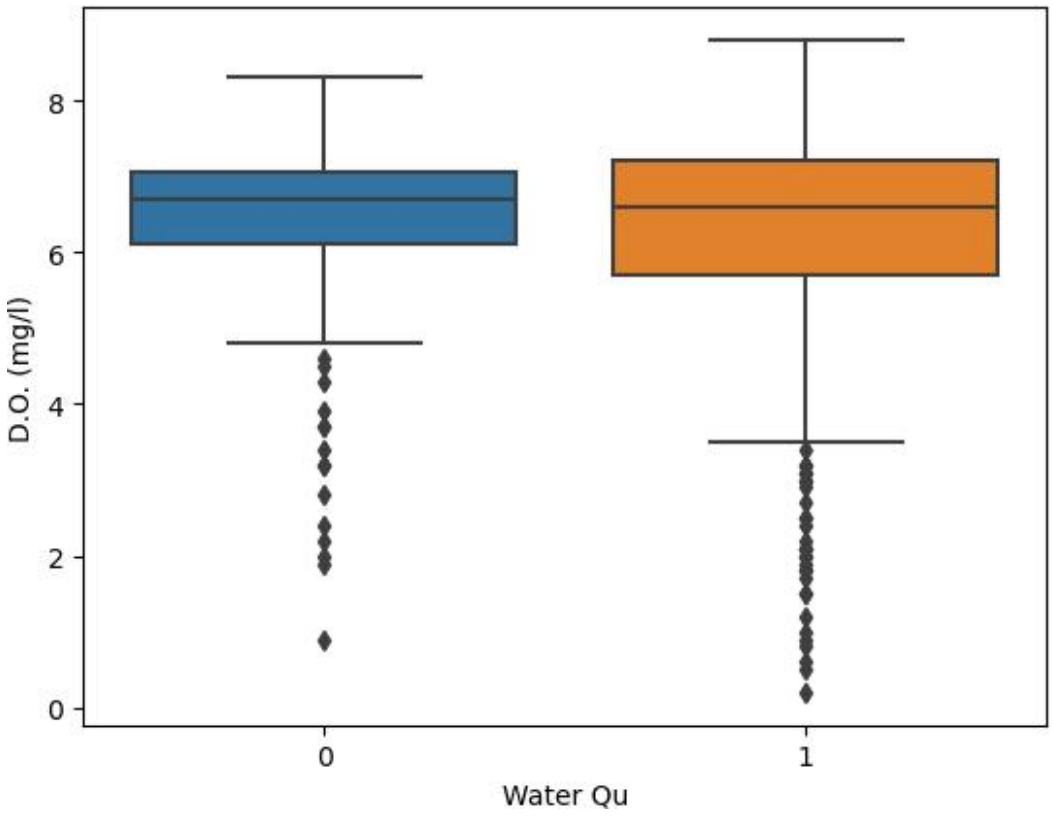
```
50%                  159.000000       1.800000
75%                  505.500000       3.300000
max                37227.000000     185.800000

       NITRATENAN N+ NITRITENANN (mg/l)  FECAL COLIFORM (MPN/100ml)  \
count                        879.000000                8.790000e+02
mean                           1.644994                6.869346e+05
std                            2.896984                1.209315e+07
min                            0.000000                2.000000e+00
25%                            0.280000                2.550000e+01
50%                            0.590000                1.990000e+02
75%                            1.775000                9.965000e+02
max                           20.300000                2.725216e+08

       TOTAL COLIFORM (MPN/100ml)Mean         year    Water Qu
count                     8.790000e+02   879.000000  879.000000
mean                      1.110502e+06  2012.559727    0.673493
std                       2.069025e+07     1.102190    0.469202
min                       4.000000e+00  2010.000000    0.000000
25%                       9.000000e+01  2012.000000    0.000000
50%                       5.000000e+02  2013.000000    1.000000
75%                       2.425000e+03  2014.000000    1.000000
max                       5.110909e+08  2014.000000    1.000000
```

```
# Box plot for comparing the ph with other column and finding the
outliers


col_pruning=['Temp','D.O. (mg/l)','CONDUCTIVITY (µmhos/cm)','B.O.D.
(mg/l)','NITRATENAN N+ NITRITENANN (mg/l)','FECAL COLIFORM
(MPN/100ml)']

for col in col_pruning:
    print("\n\n")
    coldesc=df[col].describe()
    col_IQR=coldesc[6]-coldesc[4]
    col_Lower=coldesc[4]-(1.5*col_IQR)

    col_Higher=coldesc[6]+(1.5*col_IQR)

#     print(col_Lower,col_Higher)
#     df.drop(df.index[(df[col]<col_Lower) +
(df[col]>col_Higher)],inplace=True,axis=0)
    df.drop(df.index[(df[col]>col_Higher)],inplace=True,axis=0)
    sns.boxplot(x='Water Qu',y=df[col],data=df)
    plt.show()
```

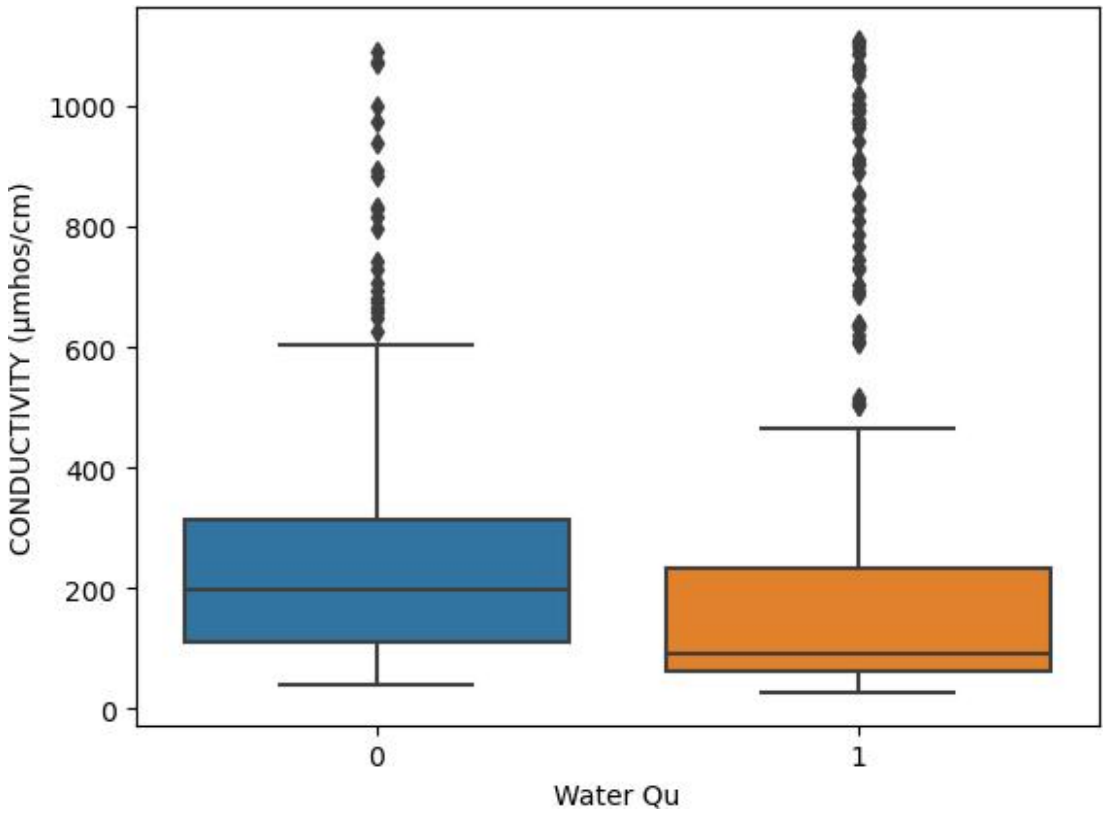
```
    print(df[col].describe())
```



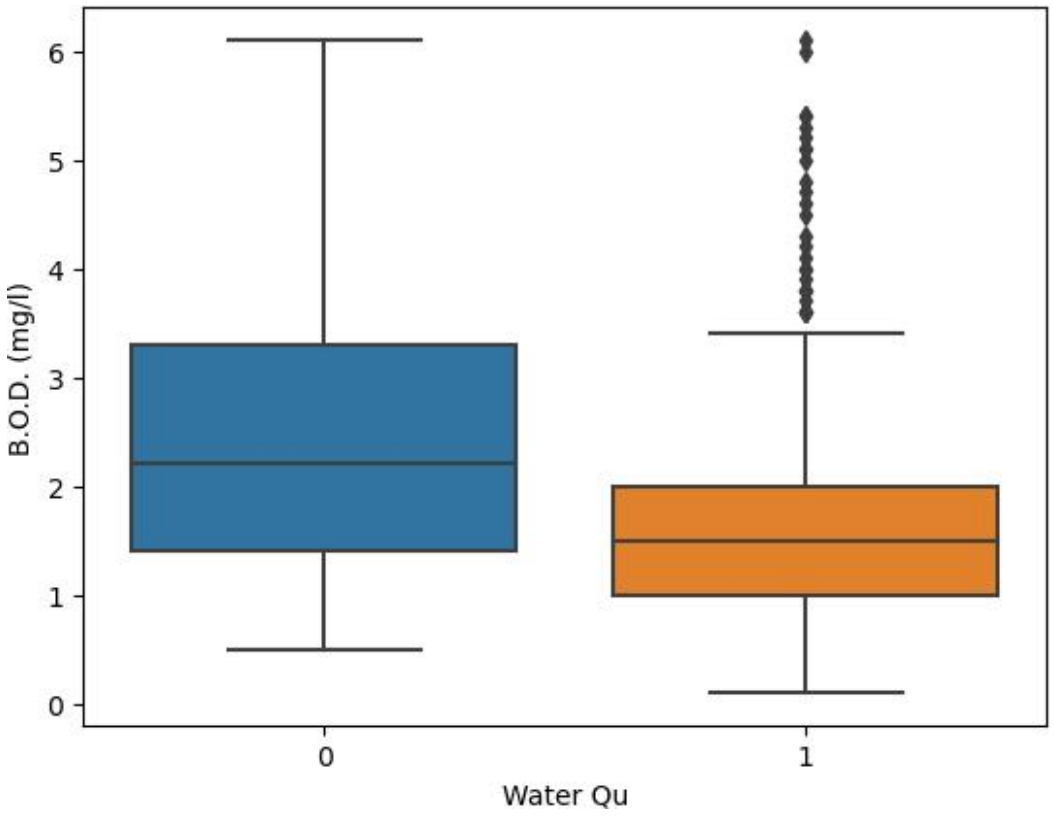

```
count    879.000000
mean      26.093743
std        3.261618
min       16.000000
25%       24.450000
50%       27.000000
75%       28.400000
max       33.000000
Name: Temp, dtype: float64
```



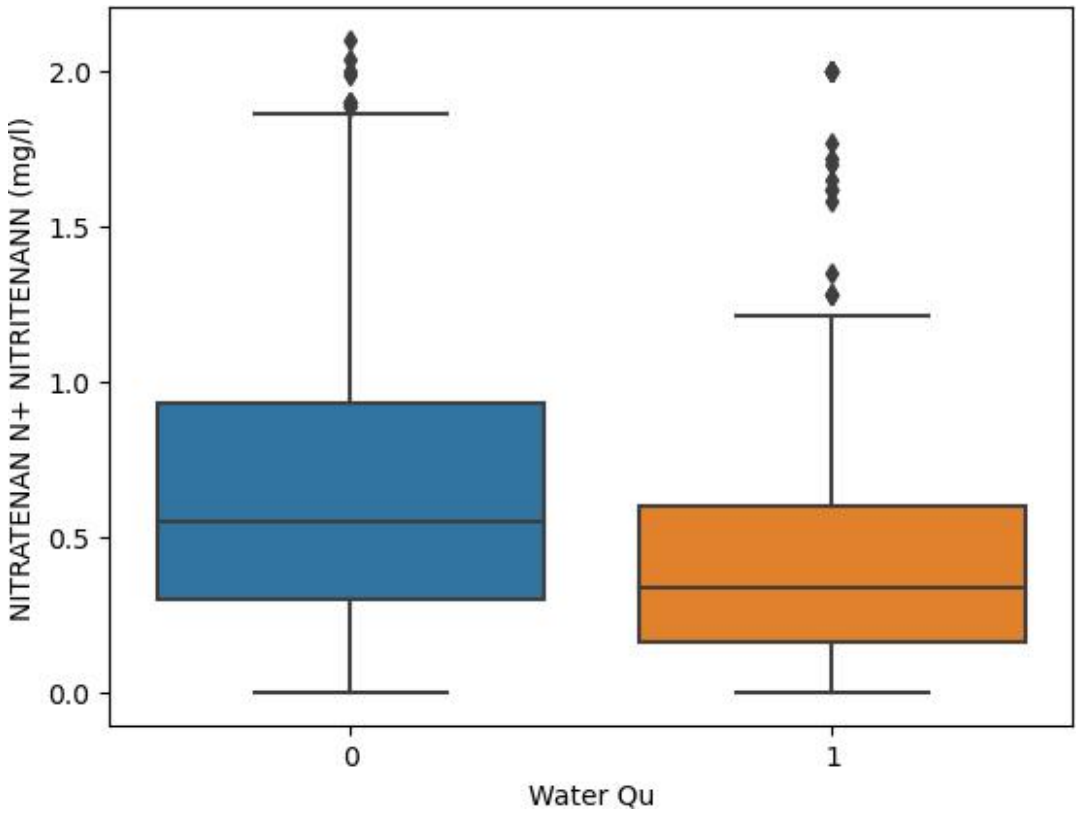

```
count    878.000000
mean       6.306640
std        1.295557
min        0.200000
25%        5.900000
50%        6.700000
75%        7.100000
max        8.800000
Name: D.O. (mg/l), dtype: float64
```



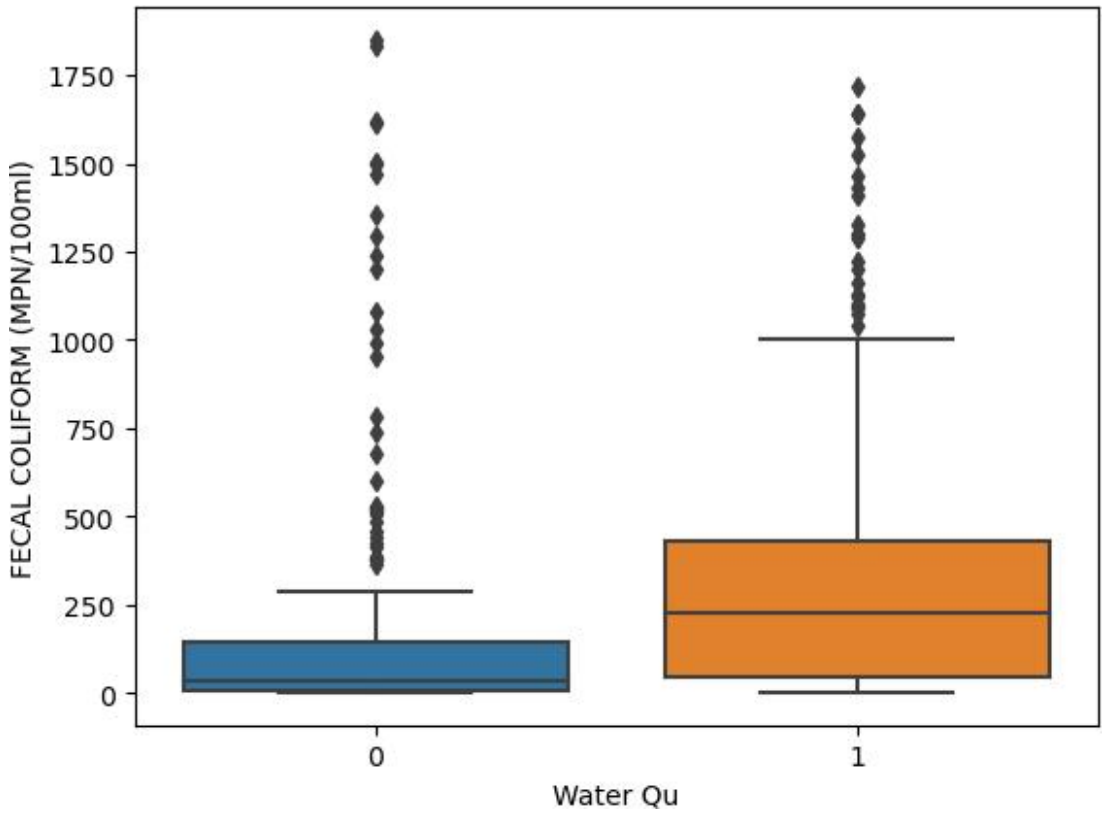

```
count      745.000000
mean       222.344966
std        243.275990
min         27.000000
25%         69.000000
50%        120.000000
75%        274.000000
max       1110.000000
Name: CONDUCTIVITY (µmhos/cm), dtype: float64
```




```
count    675.000000
mean       1.939630
std        1.140444
min        0.100000
25%        1.100000
50%        1.600000
75%        2.500000
max        6.100000
Name: B.O.D. (mg/l), dtype: float64
```




```
count    571.000000
mean       0.523135
std        0.451816
min        0.000000
25%        0.200000
50%        0.400000
75%        0.720000
max        2.100000
Name: NITRATENAN N+ NITRITENANN (mg/l), dtype: float64
```




```
count      486.000000
mean       284.436214
std        383.079776
min          2.000000
25%         22.000000
50%        131.500000
75%        380.750000
max       1850.000000
Name: FECAL COLIFORM (MPN/100ml), dtype: float64
```

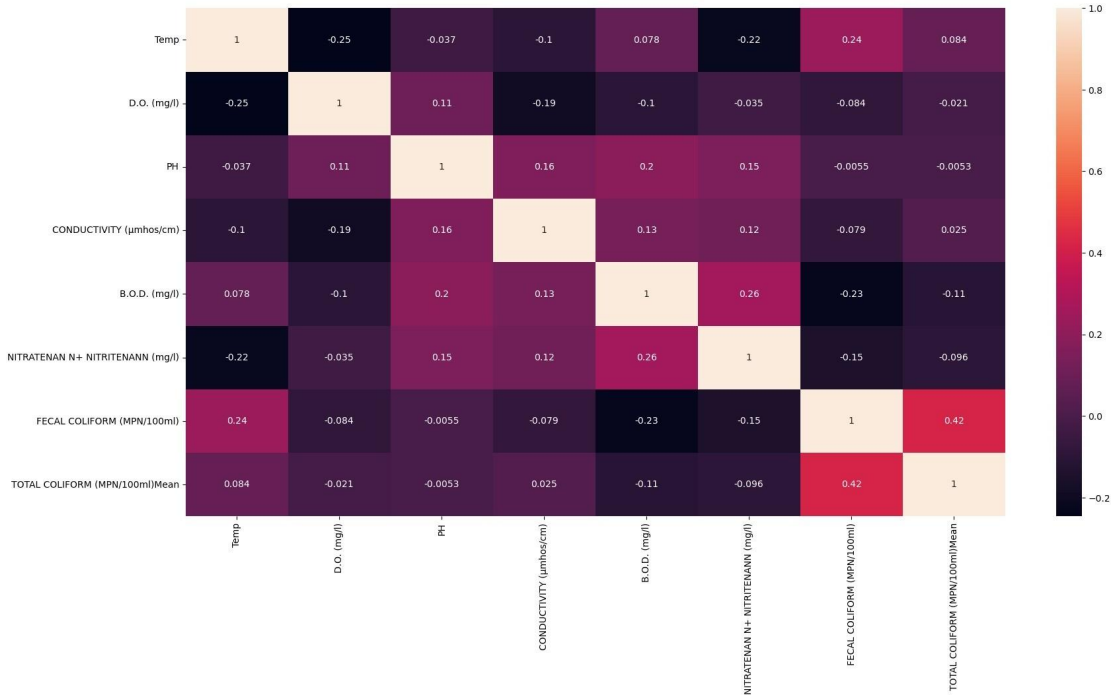
```
df.drop(['year'],inplace=True,axis=1)
```

```
df.drop(['STATION CODE','LOCATIONS','STATE','PH Range','Water
Qu'],inplace=True,axis=1)
```

```
# transforming your data so that it fits within a specific scale

mm=MinMaxScaler()
df[l]=mm.fit_transform(df[l])
df.describe()
```

```
             Temp  D.O. (mg/l)          PH  CONDUCTIVITY (µmhos/cm)  \
count  486.000000   486.000000  486.000000               486.000000
mean     0.600061     0.724280    0.813046                 0.147103
std      0.157548     0.118957    0.101386                 0.177769
min      0.000000     0.000000    0.000000                 0.000000
25%      0.534091     0.695122    0.754386                 0.038853
50%      0.629870     0.743902    0.807018                 0.077706
75%      0.701299     0.792683    0.877193                 0.184089
max      1.000000     1.000000    1.000000                 1.000000

       B.O.D. (mg/l)  NITRATENAN N+ NITRITENANN (mg/l)  \
count     486.000000                        486.000000
mean        0.307922                          0.254203
std         0.204720                          0.214196
min         0.000000                          0.000000
25%         0.150000                          0.095238
50%         0.233333                          0.190476
75%         0.450000                          0.351190
max         1.000000                          1.000000

       FECAL COLIFORM (MPN/100ml)  TOTAL COLIFORM (MPN/100ml)Mean
count                  486.000000                      486.000000
mean                     0.152833                        0.013122
std                      0.207294                        0.047275
min                      0.000000                        0.000000
25%                      0.010823                        0.001265
50%                      0.070076                        0.005544
75%                      0.204951                        0.014127
max                      1.000000                        1.000000
```

```
# Heat map for finding the corrlation between columns

plt.figure(figsize=(20,10))
sns.heatmap(df.corr(),annot=True)
plt.show()
```




df

```
          Temp  D.O. (mg/l)        PH  CONDUCTIVITY (µmhos/cm)  B.O.D.
(mg/l)  \
14    0.740260     0.817073  0.771930                 0.203515
0.233333
15    0.746753     0.817073  0.771930                 0.148936
0.150000
26    0.811688     0.719512  0.859649                 0.358927
0.316667
28    0.487013     0.731707  0.912281                 0.062905
0.800000
29    0.779221     0.768293  0.929825                 0.066605
0.816667
..         ...          ...       ...                      ...
...
882   0.370130     0.756098  0.789474                 0.239593
0.200000
883   0.714286     0.695122  0.947368                 0.126735
0.550000
884   0.707792     0.731707  0.929825                 0.156337
0.716667
893   0.675325     0.682927  0.894737                 0.137835
0.566667
894   0.740260     0.695122  0.947368                 0.158187
0.683333
```

```
     NITRATENAN N+ NITRITENANN (mg/l)  FECAL COLIFORM (MPN/100ml)  \
14                            0.095238                    0.591450
15                            0.047619                    0.694805
26                            0.047619                    0.466450
28                            0.095238                    0.007576
29                            0.190476                    0.007035
..                                 ...                         ...
882                           0.052381                    0.003247
883                           0.142857                    0.204545
884                           0.380952                    0.228896
893                           0.095238                    0.286797
894                           0.142857                    0.282468

     TOTAL COLIFORM (MPN/100ml)Mean
14                          0.036895
15                          0.045859
26                          0.023110
28                          0.000482
29                          0.000452
..                               ...
882                         0.000377
883                         0.007894
884                         0.009702
893                         0.008858
894                         0.010274

[486 rows x 8 columns]
```

```
l=['Temp','D.O. (mg/l)','PH','CONDUCTIVITY (µmhos/cm)','B.O.D.
(mg/l)','NITRATENAN N+ NITRITENANN (mg/l)','FECAL COLIFORM
(MPN/100ml)','TOTAL COLIFORM (MPN/100ml)Mean']
split=l.copy()
y=df['PH']
split.remove('PH')
x=df[split]
```

## Split the Data

```
#  train and test date spliting

x_train, x_test, y_train, y_test= train_test_split(x, y, test_size=0.25,
random_state=42)
```

```
x_train
```

```
         Temp  D.O. (mg/l)  CONDUCTIVITY (µmhos/cm)  B.O.D. (mg/l)  \
795  0.577922     0.804878                 0.023127       0.083333
105  0.623377     0.560976                 0.025902       0.083333
355  0.785714     0.573171                 0.066605       0.450000
```

```
830  0.662338     0.682927                 0.015726       0.100000
775  0.500000     0.768293                 0.164662       0.350000
..        ...          ...                      ...            ...
226  0.642857     0.573171                 0.730805       0.450000
532  0.545455     0.731707                 0.037003       0.166667
661  0.415584     0.658537                 0.407956       0.216667
808  0.584416     0.817073                 0.024977       0.200000
220  0.629870     0.682927                 0.127660       0.333333

     NITRATENAN N+ NITRITENANN (mg/l)  FECAL COLIFORM (MPN/100ml)  \
795                          0.071429                    0.160173
105                          0.333333                    0.091450
355                          0.376190                    0.056277
830                          0.100000                    0.385823
775                          0.442857                    0.000000
..                                ...                         ...
226                          0.476190                    0.003788
532                          0.252381                    0.147727
661                          0.204762                    0.001623
808                          0.195238                    0.223485
220                          0.000000                    0.151515

     TOTAL COLIFORM (MPN/100ml)Mean
795                         0.010290
105                         0.004655
355                         0.007819
830                         0.024496
775                         0.000768
..                               ...
226                         0.000286
532                         0.010033
661                         0.000181
808                         0.013694
220                         0.005062

[364 rows x 7 columns]
```

```
# print(list(x_train.iloc[1]))
```

## LinearRegression

```
# fit the Linear regression model

regressor= LinearRegression()
regressor.fit(x_train, y_train)
y_pred= regressor.predict(x_test)
# x_pred= regressor.predict(x_train)

ypred_pd=pd.DataFrame({'WQ':y_test.values,'WQ_Pred':y_pred})
ypred_pd['predicted']=ypred_pd['WQ_Pred'].map(lambda x:1 if x>0.5 else0)
```

```
ypred_pd['WQ']=ypred_pd['WQ'].map(lambda x:1 if x>0.7 else 0)
ypred_pd.head()
```

```
   WQ   WQ_Pred  predicted
0   1  0.795986          1
1   1  0.845279          1
2   1  0.789093          1
3   1  0.802417          1
4   1  0.861372          1
```

```
confusion=confusion_matrix(ypred_pd['WQ'],ypred_pd['predicted'])
print(confusion)
```

```
[[  0   8]
 [  0 114]]
```

```
print(accuracy_score(ypred_pd['WQ'],ypred_pd['predicted']))
```

```
0.9344262295081968
```

## Decision Tree

```
# Fit the desiontree regression

clf_gini = DecisionTreeRegressor(random_state = 0)

clf_gini.fit(x_train, y_train)

y_pred = clf_gini.predict(x_test)

ypred_pd=pd.DataFrame({'WQ':y_test.values,'WQ_Pred':y_pred})
ypred_pd['predicted']=ypred_pd['WQ_Pred'].map(lambda x:1 if x>0.7 else0)
ypred_pd['WQ']=ypred_pd['WQ'].map(lambda x:1 if x>0.7 else 0)
ypred_pd.head()
```

```
   WQ   WQ_Pred  predicted
0   1  0.947368          1
1   1  0.947368          1
2   1  0.736842          1
3   1  0.789474          1
4   1  0.719298          1
```

```
print('Model accuracy score with criterion gini index: {0:0.4f}'.
format(accuracy_score(ypred_pd['WQ'],ypred_pd['predicted'])))
```

```
Model accuracy score with criterion gini index: 0.9180
```

## Random Forest

```
# Fit the random forest regression

forest_model = RandomForestRegressor(random_state=1)
forest_model.fit(x_train, y_train)
melb_preds = forest_model.predict(x_test)

# print(mean_absolute_error(val_y, melb_preds))

ypred_pd=pd.DataFrame({'WQ':y_test.values,'WQ_Pred':y_pred})
ypred_pd['predicted']=ypred_pd['WQ_Pred'].map(lambda x:1 if x>0.7 else0)
ypred_pd['WQ']=ypred_pd['WQ'].map(lambda x:1 if x>0.7 else 0)
ypred_pd.head()
```

| | WQ | WQ_Pred | predicted |
|---|---|---|---|
| 0 | 1 | 0.947368 | 1 |
| 1 | 1 | 0.947368 | 1 |
| 2 | 1 | 0.736842 | 1 |
| 3 | 1 | 0.789474 | 1 |
| 4 | 1 | 0.719298 | 1 |

```
print(accuracy_score(ypred_pd['WQ'],ypred_pd['predicted']))
```

```
0.9180327868852459
```

## Linear regression has the highest accuracy score = 0.93442

## Pickle

```
# Load the model into pickle for serializing and deserializing a
Python object structure

import pickle

with open('model_pkl', 'wb') as files:
    pickle.dump(regressor, files)
with open('model_pkl' , 'rb') as f:
    lr = pickle.load(f)
lr.predict([list(x_train.iloc[1])])
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\base.py:450:
UserWarning: X does not have valid feature names, but LinearRegression
was fitted with feature names
  warnings.warn(
```

```
array([0.74676269])
```

```
with open('model_pkl', 'wb') as files:
    pickle.dump(clf_gini, files)
with open('model_pkl' , 'rb') as f:
    lr = pickle.load(f)
lr.predict([list(x_train.iloc[1])])
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\base.py:450:
UserWarning: X does not have valid feature names, but
DecisionTreeRegressor was fitted with feature names
  warnings.warn( ar

ray([0.73684211])
```

```
with open('model_pkl', 'wb') as files:
    pickle.dump(forest_model, files)
with open('model_pkl' , 'rb') as f:
    lr = pickle.load(f)
lr.predict([list(x_train.iloc[1])])
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\base.py:450:
UserWarning: X does not have valid feature names, but
RandomForestRegressor was fitted with feature names
  warnings.warn( ar

ray([0.74894737])
```