WATER ANALYSIS

Membrane Filtration in Wastewater Testing

Domestic wastewater and sewage monitoring are essential for protecting public health and ensuring clean water in the environment. Through the Clean Water Act, the Environmental Protection Agency (EPA) and individual municipalities are responsible for directly governing wastewater testing strategies and procedures. The EPA both issues and approves testing methods for a wide variety of contaminants and analytes found in wastewater including trace metals, nonmetals, salts, organic compounds, bacteria, viruses, and particles such as asbestos or silica. Individual municipalities dictate what tests are necessary, how often these tests are conducted, and how data are organized.

CLARIFICATION AND PRE-FILTRATION

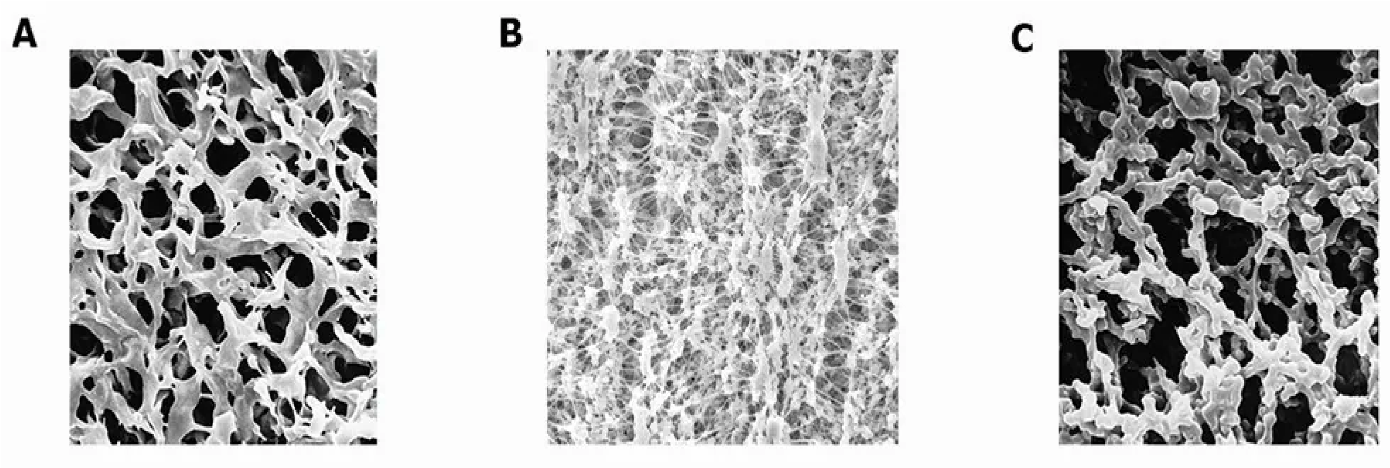
When handling and processing wastewater and sewage, pre-filtration is very often a necessary stage in sample preparation to reduce fowling and improve the efficacy of downstream microfiltration. To designate pre-filtration, methods will sometimes call for “filter paper”, “coarse filter paper”, or simply indicate “filtration” in an early clarifying or particle-removing step. Pre-filtration requires an open mesh or net filter and can best be accomplished using options such glass fiber filters or quartz fiber filters for aqueous samples, or polypropylene filters for solvent filtration. Both pre-filtration choices have broad thermal compatibility and high retentate capacities for viscous and high particulate samples common in wastewater testing.

GENERAL FILTRATION OF WASTEWATER SAMPLES

Many EPA and EPA-recommended methods do not specify filter type. They may designate parameters or specifications such as a pore size or format (disc or syringe filter) without detailing the filter material. Hydrophilic polyvinylidene fluoride (PVDF), polytetrafluoroethylene (PTFE), mixed cellulose esters (MCE), and cellulose acetate filters are all valid options for general filtration. Millipore® Durapore® PVDF and Omnipore™ PTFE filters are ideal for low-protein binding applications. Millex®-HA MCE syringe filters and MF-Millipore® MCE disc membranes are biologically inert, low binding, and thermally stable with a high loading capacity. All three membrane filters provide low extractable filtration for minimal contamination. LCR PTFE filters are specially treated to prevent the introduction of additional extractables to your sample prior to HPLC analysis or similar instrumentation.

s involve filtration for sample preparation or processing. Because a variety of filter types and formats can be successfully employed for many of these methods, the method may neglect to specify which filters are best suited beyond defining one or two parameters. For example, ASTM D3867-16 (Standard Test Methods for Nitrate-Nitrate in Water) directs the scientist to “purchase suitable filter paper… material such as fine-textured, acid-washed ashless paper or glass fiber paper are acceptable”.

This tech article will help serve as a guide to determine which filters can most successfully be applied in these methods to assist lab and processing plants in selecting the best products for their needs.



Scanning electron micrographs (SEM) of membrane filters. **A**) PVDF membrane, **B**) PTFE membrane, **C**) MCE membrane.

FILTER SIZE AND FORMAT

One of the primary considerations when selecting a filter format is sample size and volume. When filtering small volumes < 100 mL, a syringe filter is often the best choice. Because of hold up or “dead” volume considerations, the smallest possible diameter of filter should always be used. Generally, 4 mm diameter filters should be used for volumes < 1 mL, 13 mm diameter filters for volumes in the 1-10 mL range, and 25 mm or 33 mm diameter filters for volumes between 10 mL - 100 mL.

For volumes exceeding 100 mL, a vacuum filtration setup with cut disc filters is generally preferred. Consider a 47 mm filter for volumes ranging between 120 mL and 1 L. For sample volumes over a liter, a 90 mm cut disc can help facilitate a higher throughput and suitable flowrate.

Syringe filters (left) and cut disc filters (right) for sample filtration

Sample volume	Recommended filter diameter
< 1 mL	4 mm
1 – 10 mL	13 mm
10 – 100 mL	25 mm or 33 mm
100 mL – 1 L	47 mm
> 1 L	90 mm

HARDWARE AND FILTRATION ACCESSORIES

Varying filter formats require different filtration setups and workflow optimization tools. Sample composition and throughput can influence which setup will be most appropriate in terms of both convenience and practical considerations.

Cut disc formats necessitate vacuum filter holders and accessories. Glass setups can be used for aqueous solutions as well as solvents or corrosive liquids (except when specifically prohibited) and come in 13 mm, 25 mm, 47 mm, and 90 mm sizes/diameters. For non-sterile buffer filtration, conventional glass vacuum systems or the Millicup™-FLEX disposable vacuum filtration unit can also be used with any suitable cut disc membrane. The Millicup™-FLEX Disposable Filtration Unit offers a convenient, recyclable, disposable alternative to traditional glass setups that is suitable for a wide range of sample volumes. The Millicup™-FLEX filtration unit offers a safe and efficient means of filtering a variety of aqueous solutions or solvents directly into GL45 vacuum-rated filtration bottles using 47 mm disc membranes. Both glass and Millicup™-FLEX vacuum filtration options can accommodate cut disc membranes of all material types.

When using Millex® Syringe Filters to filter multiple samples, especially those that are viscous or particle laden, the vacuum-driven Samplicity® G2 Filtration System can offer an ergonomic solution to hand fatigue and bulk manual processing. The Samplicity® G2 Filtration System can quickly vacuum filter up to eight samples at a time directly into HPLC vials, improving efficiency for pre-instrument preparation. In conjunction with, or as an alternative to, the Samplicity® G2 Filtration System, Millex® HPF filters incorporate a graduated glass fiber pre-filter (0.7 - 10.0 µm) to remove larger particles prior to microfiltration. This can further assist in processing difficult samples.

CODING:

Assuming you have loaded your data into a pandas DataFrame 'df'

Step 2: Data Preprocessing

Handle missing values and other data cleaning steps

Step 4: Feature Selection/Engineering (Assuming 'ph', 'temperature', and 'dissolved_oxygen' are relevant features)

X = df[['ph', 'temperature', 'dissolved_oxygen']]

y = df['water_quality_index'] # Assuming 'water_quality_index' is the target variable

Step 6: Model Selection and Training

from sklearn.linear_model import LinearRegression

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

model = LinearRegression()

```
model.fit(X_train, y_train)


# Step 7: Model Evaluation

y_pred = model.predict(X_test)

# Use appropriate evaluation metrics to assess performance


# Step 8: Model Fine-tuning (if needed)


# Step 9: Deployment (if needed)
```

CODING:

```
import pandas as pd

import matplotlib.pyplot as plt


# Assuming you have a CSV file with water quality data

# Load the data into a pandas DataFrame

df = pd.read_csv('water_quality_data.csv')


# Step 1: Data Exploration

# Display basic statistics about the dataset

print(df.describe())


# Step 2: Data Visualization

# Visualize the distribution of water quality parameters

plt.figure(figsize=(10, 6))


# Example: Histogram of pH levels

plt.hist(df['pH'], bins=20, color='skyblue', edgecolor='black')

plt.title('pH Distribution')
```

```
plt.xlabel('pH Level')

plt.ylabel('Frequency')

plt.show()


# Example: Scatter plot of pH vs Dissolved Oxygen

plt.figure(figsize=(10, 6))

plt.scatter(df['pH'], df['Dissolved_Oxygen'], alpha=0.5, color='green')

plt.title('pH vs Dissolved Oxygen')

plt.xlabel('pH')

plt.ylabel('Dissolved Oxygen')

plt.show()


# Step 3: Correlation Analysis

correlation_matrix = df.corr()

print(correlation_matrix)


# Step 4: Data Preprocessing (if needed)
```

Handle missing values, outliers, etc.

Step 5: Further Analysis and Modeling (if needed)

Depending on your specific goals, you may perform regression, clustering, or other types of analysis.

Step 6: Reporting and Insights

Summarize the findings and insights gained from the analysis.

Step 7: Visualize Results (if applicable)

Generate plots or graphs to communicate the results effectively.

1. *Data Exploration*:

   - The df.describe() command will display basic statistics about the dataset. This will include things like the mean, standard deviation, minimum, maximum, and quartiles for each numerical column.

2. *Data Visualization*:

   - The first set of plots will display histograms showing the distribution of pH levels.

   - The second plot will be a scatter plot showing the relationship between pH and Dissolved Oxygen.

3. *Correlation Analysis*:

   - The correlation_matrix will be printed, showing the correlation coefficients between different pairs of variables. This can help identify relationships between parameters.

4. *Further Analysis and Modeling*:

   - This section is a placeholder for any additional analyses or modeling techniques you might want to apply based on your specific goals.

5. *Reporting and Insights*:

- This is a step where you would summarize the findings and insights gained from the analysis.

6. *Visualize Results*:

- If you have specific insights or results you want to communicate, this is where you would generate additional plots or graphs to effectively convey the information.