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Microbiological Assessment of Water Quality at Different Stages of an Industrial Water Treatment System

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Abstract: Water quality monitoring is essential in industrial water systems to ensure microbial safety and process efficiency. The present study evaluated the microbiological quality of three water samples collected from different stages of an industrial water treatment system, namely Hollow Fiber Ultrafiltration (HUF) Water, Demineralized (DM) Water and Process Water. Samples were analyzed for Total Aerobic Microbial Count (TAMC), Total Yeast and Mold Count (TYMC), total coliforms and specific pathogens including *Escherichia coli*, *Salmonella* spp., *Staphylococcus aureus* and *Pseudomonas aeruginosa*. The results revealed TAMC values of 2 Colony Forming Units per milliliter (CFU/ml),13 CFU/ml and 71 CFU/ml in HUF, DM and Process Water respectively. TYMC was absent in HUF and DM Water and detected at a low level (2 CFU/ml) in Process Water. Total coliforms and specific pathogens were absent in all samples. The findings indicate that the water treatment system effectively controlled microbial contamination and maintained water quality within acceptable microbiological limits.

Keywords: Water Quality, Microbiological Analysis, HUF Water, DM Water, Process Water, Total Aerobic Microbial Count.

I. INTRODUCTION

Water is one of the most essential natural resources required for human activities, industrial processes, and environmental sustainability. The quality of water directly influences public health, industrial productivity, and ecosystem stability. In recent decades, rapid industrialization, urban expansion, and population growth have increased pressure on available water resources, leading to concerns regarding water quality and microbial contamination. Drinking water of unreliable microbiological quality can result in gastrointestinal diseases and is also responsible for deaths (De Roos AJ et al.,2017 and Save-SoderberghabM et al., 2020).

Hyderabad is one of the major industrial and pharmaceutical hubs of India. Continuous urban development and industrial activities have increased the demand for high-quality water for manufacturing and processing applications. In such systems, maintaining microbiological quality is important because microbial contamination can affect operational efficiency, product quality, and overall system performance.

Water treatment technologies such as ultrafiltration, demineralization, and purification processes are widely employed to reduce microbial contamination and improve water quality. However, microorganisms may enter water systems during treatment, storage, or distribution. Therefore, routine microbiological monitoring is essential for evaluating the effectiveness of treatment systems and ensuring water safety.

Several studies have reported that microbiological assessment of water quality is an effective approach for determining the hygienic status of treated water systems. Total Aerobic Microbial Count (TAMC), Total Yeast and Meld Count (TYMC), total coliforms, and specific pathogenic microorganisms are commonly used as indicators of microbiological quality (Edberg et al., 2000; LeChevallier & Au, 2004). The absence of coliform bacteria and pathogenic microorganisms is generally considered an indicator of satisfactory water quality and effective treatment performance (WHO, 2022).

Previous investigations have demonstrated that properly operated water treatment systems can significantly reduce microbial contamination and improve water quality. Regular monitoring of microbial parameters provides valuable information regarding the efficiency of treatment processes and helps ensure compliance with accepted water quality standards (Payment & Hunter, 2001; Ashbolt, 2004).

Similar observations regarding water quality monitoring have been reported by Kaynar et al. (2022). Therefore, the present study was undertaken to evaluate the microbiological quality of HUF Water, DM Water, and Process Water collected from different stages of an industrial water treatment system located in Hyderabad, Telangana, India.

II. **Materials and Methods**

2.1 Sample Collection

Water samples were collected aseptically from three different stages of an industrial water treatment system located in Hyderabad, Telangana, India. The sampling points included Hollow Fiber Ultrafiltration (HUF) Water, Demineralized (DM) Water, and Process Water. Samples were collected in sterile containers and transported immediately to the laboratory for microbiological analysis.

2.2 Total Aerobic Microbial Count (TAMC)

The total aerobic microbial count was determined using the membrane filtration method according to standard microbiological procedures. Samples were filtered through sterile membrane filters and cultured on R2A agar. Plates were incubated at 35 ± 2°C for 72 hours and results were expressed as CFU/ml.

2.3 Total Yeast and Mold Count (TYMC)

Yeast and mold counts were determined using standard membrane filtration techniques on suitable fungal growth media. The plates were incubated under appropriate conditions and the results were expressed as CFU/ml.

2.4 Total Coliform Test

Total coliforms were analyzed using membrane filtration followed by cultivation on selective media. Characteristic colonies were examined and recorded.

2.5 Detection of Specific Pathogens

Water samples were screened for the presence of important waterborne pathogenic microorganisms, including *Escherichia coli*, *Salmonella* spp., *Staphylococcus aureus*, and *Pseudomonas aeruginosa*. The analysis was performed using standard microbiological methods involving membrane filtration, selective culture media, and confirmatory biochemical identification tests. Following incubation under appropriate conditions, characteristic colonies were examined and subjected to biochemical confirmation for accurate identification. The presence or absence of the target pathogens was recorded and compared among the collected water samples.

III. Results and Discussion

The microbiological analysis demonstrated low levels of microbial contamination in all tested water samples. HUF Water exhibited the lowest microbial load with a Total Aerobic Microbial Count (TAMC) of 2 CFU/ml, indicating effective removal of microorganisms by the ultrafiltration process. DM Water showed a TAMC value of 13 CFU/ml, which remained well within acceptable microbiological limits. Process Water recorded the highest TAMC value of 71 CFU/ml; however, this value was still within permissible limits and did not indicate significant microbial contamination. Figure 1 illustrates the variation in TAMC and TYMC among the analyzed water samples. Process Water exhibited the highest microbial count, whereas HUF Water showed the lowest microbial load. Microbiological analysis revealed the absence of Total Coliforms, *E. coli*, *Salmonella spp.*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa* in all water samples, indicating satisfactory microbiological quality throughout the treatment system.

The Total Yeast and Mold Count (TYMC) was absent in both HUF Water and DM Water samples and was detected at only 2 CFU/ml in Process Water, indicating minimal fungal contamination. Similar observations have been reported in previous studies, where treated water samples exhibited low microbial and fungal counts due to efficient purification processes (Prasai et al., 2007; Antony & Renuga, 2012).

An important indicator of microbiological water quality is the presence of coliform bacteria. In the present study, total coliforms were absent in all analyzed samples. The absence of coliform organisms suggests that the treatment system was effective in preventing microbial contamination and maintaining hygienic water quality. Similar findings have been reported in treated water systems where the absence of coliform bacteria was considered an indicator of satisfactory water quality (World Health Organization, 2022; Krishna et al., 2020).

Furthermore, none of the tested pathogens, including *Escherichia coli*, *Salmonella* spp., *Staphylococcus aureus*, and *Pseudomonas aeruginosa*, were detected in any of the analyzed samples. The absence of these pathogenic microorganisms indicates the effectiveness of the treatment process in maintaining microbiological safety and reducing potential health risks. Comparable results were reported by Chandra et al. (2016) and Sharma et al. (2017), who observed the absence of pathogenic bacteria in adequately treated water systems.

Overall, the results demonstrate that the industrial water treatment system effectively controlled microbial contamination and maintained acceptable microbiological quality. The low microbial counts, absence of coliform bacteria, and absence of pathogenic microorganisms confirm the efficiency of the treatment processes. These findings are consistent with international water quality guidelines and previous studies, which emphasize that low microbial counts and the absence of indicator and pathogenic microorganisms are important indicators of safe water quality (World Health Organization, 2022; APHA, 2017).

Table 1. Microbiological Analysis of Water Samples

Parameter	HUF Water	DM Water	Process Water
TAMC (CFU/ml)	2	13	71
TYMC (CFU/ml)	Nil	Nil	2
Total Coliforms	Absent	Absent	Absent
E. coli	Absent	Absent	Absent
Salmonella spp.	Absent	Absent	Absent
Staphylococcus aureus	Absent	Absent	Absent
Pseudomonas aeruginosa	Absent	Absent	Absent

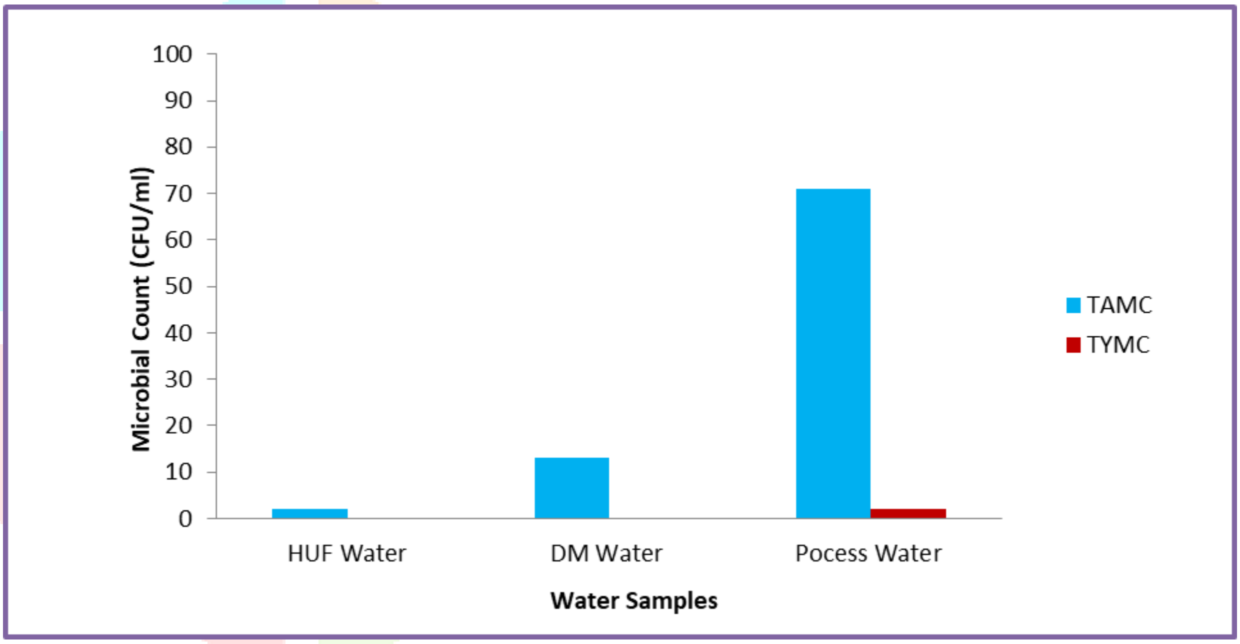

Figure 1. Comparison of Total Aerobic Microbial Count (TAMC) and Total Yeast and Mold Count (TYMC) in different water samples.

4. Conclusion

The present study evaluated the microbiological quality of HUF Water, DM Water and Process Water in an industrial water treatment system. All samples exhibited low microbial counts and were free from coliforms and pathogenic microorganisms. The results demonstrate the effectiveness of the treatment processes in maintaining microbiological quality within acceptable limits. Continuous monitoring of water quality is recommended to ensure sustained system performance and microbial safety.

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