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IMPACT OF REUSING TTDM WATER IN PAINT PRODUCTION

Dharshini S[1], Srimathi H[2], Krishnamoorthy A[3]

[1]Business Associate, Catalyst, Bangalore

[2]Professor & Associate Director, DODE, SRMIST, Chennai

[3]Professor, Associate Dean, EIE, SASTRA Deemed University, Thanjavur

Abstract:

The paint industry is one of the largest water consumers and discharges a considerable volume of wastewater in the total water footprint. As water reuse and sustainability are one of the prime goals of environmental regulation, the industries across the Tamil Nadu state are directed to use treated water for their industrial production related processes. The quality of pigment production is to be analysed while reusing treated water in the process of paint production. The study focuses the shelf life of the products and reduction of microorganism contamination, while using the biocides in tertiary treatment water and demineralised water in paint production. The project analyses the microbial growth in the usage of biocides and recommends the need for improved methods and long-term usage study of post-production to ensure shelf-life and stability.

Keywords— Paint production, Tertiary treated water, De-mineralized water, Microbial growth, Paint Shelf life

1. Introduction

The demand for water is ever increasing due to the exponential growth of population, urbanisation, industrialisation and climate change. The water potential in Tamil Nadu is about 47,680 of million cubic meter (MCM). However, the demand was more than 53,000 MCM in the year 2021 (TTRO Case study, 2019). In this context, the industries around the state, including those located in State Industries Promotion Corporation of Tamil Nadu (SIPCOT) Ltd, are recommended to reuse treated wastewater from the sewage treatment plants (STPs), and the government has released “Treated Waste Water Reuse Policy”. There are several studies focused on wastewater treatment in industries, especially effluent treatment plants of wastewater in the paint industry. Only very few articles listed mention the usage of treated water back to paint production as the state government mandates the industries to utilise the same from 2019 only. The project aims to study the impact of reusing treated water in the paint production.

The project aims at the shelf life of water-based paint products, adding biocides which promises the in-can preservation and behave as an active substance to kill microorganisms. This has necessitated the study to focus on microbial growth in tertiary treated water in the absence & presence of biocides and using demineralized water.

2. Water Based Paint production and quality

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A water-based paint is widely used in the household since it is less toxic and easier to clean. It is manufactured with water as solvent and composition of filler, pigments, additives and resin binders. The process steps are ranging from weighing the raw materials, dispersion, pre-mixing, grinding, fineness, colouring and stability inspection. The water consumption and wastage in paint industries are classified under three major processes as producing water-based pigment products, cleaning the equipment mixtures and generation of wastewater during production (Nicholas, 2018). The Environment Social Governance (ESG) policy insists the paint industries review on-site management in reduction of water usage and reuse of waste water. There are several control mechanisms to be followed on water saving efforts, utilization of rain water and treated waters.

3. Usage of Tertiary treated and Demineralized water (TTDM) in paint production

In India, the treated sewage water is used for a variety of applications, including forestry, horticulture, fish culture, and industrial usage in non-human contacts. The project analyses the microbes' growth and stability of paint products produced through tertiary treated and demineralized water, where the wastewater treatment process of both is detailed here to understand the process of removal of microorganism contaminators for better industrial reuse.

A. Tertiary Treated Water Reverse Osmosis (TTRO)

The wastewater comes from both domestic sewage and industrial activities with different compositions and the toxicity will be removed with nanoparticles (Magalhaes-Ghiotto et al, 2021). The re-usage of wastewater is entirely safe for flow as effluent in an environment when it is tertiary treated (EPA,1997 and UNEP,2012). The plant receives tertiary treated water from Koyambedu located in Tamil Nadu state capital (Koyambedu TTRO, 2019), where the simplified process steps as per the regulatory agencies are listed as follows (Naidoo et al 2014).

Step1: Pre-treatment filtering process: Wastewater flows through screens to take out suspended impurities by rapid sand filters

Step 2: Primary treatment: Wastewater flows into clarifiers to collect solid organic matters

Step 3: Secondary treatment: control silt density index – Ultrafiltration

- Wastewater flows through aerobic aerators, where the presence of oxygen digests organic matter, removes harmful chemicals and breaks down organic matter through return activated sludge.
- Flows into aerobic sludge digesters to digest the activated sludge each other.

Step 4: Tertiary treatment & reverse osmosis: to reduce TDS & provide disinfection

- It follows the process of both primary and secondary stages and, in addition, involves mechanical and photochemical processes. This is useful in sanitary sewage to disinfect microorganism contamination.
- Passed through sand filters to remove fine particulate matter.
- Photochemical process under ultraviolet lights to eliminate bacteria, viruses & infections.

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- Reverse osmosis (RO): Water flows across the semipermeable RO membrane using the high pressure will leave all the salts in the reject stream.

B. Demineralized (DM) Water

The demineralization involves the removal of dissolved minerals from de-aerated water works with the principle of ion exchange. The cation-exchange resins soften the water, while the anion-effect removes nitrate. As the de-mineralization removes all ionic mineral contaminants, it is used in industries which require high-level purity. The processes involved are distillation, deionization, membrane filtration (RO), and electro-dialysis. The main advantages are cost effective, low maintenance, and less power consumption. The study analyses the usage of tertiary treated water and demineralization water for the production of its water-based paint products, where the critical aspect is to avoid bacteria proliferation.

C. Reducing Microbial Growth

The standard water-based paint can be used for more than six years if not opened, and leftover paints can be used for two years if closed tightly and kept in a stored place. The factors involved in storage stability include both chemical stability and pigment dispersion. The study of shelf life estimation for water-based paints with regression methods (Obidi et al, 2013) suggests that the shelf life is influenced by the initial microbiological quality of raw components, packaging materials and cleanliness of the plant. The microorganisms present in the paint may not be directly harmful. However, their physical formulation affects various factors such as pH, viscosity, sedimentation and storage stability. The microbiological contamination of the recycled water in the production process triggers the microbial growth in the paint product, creating non-exacting fungi and bacteria in the water-borne paints (Maduka et al, 2019). The bio-degradation induces discolouration and the bio-deterioration has a negative impact on the microbial metabolic process with serious health hazards in the presence of oxygen (Brooks, 2017). The volatile organic compounds (VOC) act as the paint surface aid but breathing the same at a high-level cause health issues (Pandey et al, 2020). The presence of Pseudomonas bacteria, sulphate reducing bacteria (SRB) and the total bacterial count (TBC) are analysed in our study. The usage of quick kill biocide with formaldehyde-free biocides carries a low environmental impact and works synergistically in product preservation against microorganisms. At the same time, the usage of biocides is controlled as the product should not contain hazardous materials above certain limits as per the classification, labelling and packaging regulation (DEPA, 2018). Therefore, the impact of adding biocides in various ratios is analysed in this study.

4. Materials and Methods

The paint product contains different components, and it is required to mix them properly. The components of water-based paint are listed in Table 1, along with its functional usage. Each component is used for specific purposes where the pigments provide colour protection, extenders to modify the viscosity, additives to prevent defects and increase stability, solvents for consistency and avoid clumps, cellulose to prevent dripping and emulsion for durability. The block diagram of lab-based batch production is given in Figure1 with the duration and revolutions per minute (RPM).

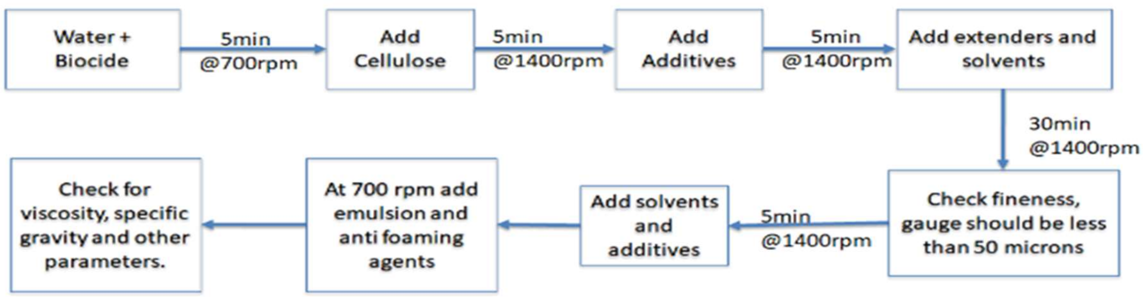

Fig. 1 Block diagram of lab-based batch production

Table 1 Components of Water based Paint Production

Process stages	Material Type	Formulation (g)	Functions
1	Water Additive 1	259 1	Base raw material Biocide to kills microbes
2	Cellulose 1	7	Provides resistant to physical impact
3	Additive 2 Additive 3 Additive 4 Additive 5 Additive 6 Water	8 2 2 3 2 7	Dispersing agent for water-based system In-can preservation Anti-foaming agent Non-ionic emulsifier pH neutralising agent for low odour proper rinse and mix
4	Pigment 1 Extender 1 Extender 2 Extender 3 Solvent 1 Water	37 40 159 265 14 96	To impart colour Corrosion resistant Corrosion resistant Corrosion resistant Resin reactant Maintain viscosity consistency
5	Solvent 1 Additive 7 Additive 3 Additive 8 Additive 9 Water	7 14 2 3 10 14	Resin reactant Prevent micro biological corrosion & fouling In-can preservation Wet state preservation Rheological Thickener Proper rinse and mix
6	Emulsion Additive 4 Water	173 2 202	Dispersing agent Anti-foaming agent Completion of mix

Paint industries follow several quality tests to ensure the control of microbial growth in their products in both coated surfaces and unused paints as they lead to serious environmental and health hazards. The re-use of tertiary treated water and demineralization of water mandate sample testing at frequent intervals as the industry started using the treated water for its production since 2019. The project collects both raw samples of treated water and lab batch production of paint with different compositions of biocides. The collected samples are tested by an accredited third-party testing lab for the following listed items, as shown in Table 2.

Table 2 Test Methods

Purpose	Name of the method	Description
Total Bacterial Count (TBC)	Pour Plate Method (Sanders, 2012)	• Counting colony forming bacteria in the liquid specimen • Sample is mixed with molten agar medium in a larger volume, the plate is inverted and incubated • More precise than streak plate method • Preparation of pour-plate is time consuming, loss of viability in heat sensitive organisms
Pseudomonas Test	Most Probable Number (MPN) test (Highsmith et al, 1975, Ali et al 2014)	• Detecting and enumerating pseudomonas aeruginosa in water and wastewater as pseudomonas cause fatal infections to weak immune person. • Sample bacteria were suspended in nutrient broth cultivate medium and incubated, diluted, and dropped on dish covered with polyethylene and placed in incubator and plate counting technique is used for counting the bacteria
Sulphate Reducing Bacteria (SRB)	BART test & Optical density (Wood et al, 2019)	• SRB causes corrosion, clogging, fouling in the water and increase hygiene risk, since Sulphate is reduced to hydrogen sulphide during incubation, reacts with ferrous iron in the tube to form black iron sulphides • BART bio-detectors act as an excellent diagnostic tool to identify the presence and activity of various bacteria, where the amount of colour change can be compared with the included chart to determine the level of contamination • Spectrophotometric growth analysis using acid amendments estimates total cell biomass based on turbidity / optical density of a broth culture

As per the directions of Tamil Nadu state government, the paint industry has started using TTRO since 2019. In addition, the industry started using DM for its production along with TTRO for enhancing the quality of the product. The usage level of DM water in pre- & post-regulation is listed in Table 3.

Table 3 Usage of DM water in the industry

Usage	Pre-regulation	Post Regulation
Total Bacterial Count (TBC)	518168.478 L	646476.65 L
Total DM Water used for cleaning	--	29619.35 L
Effluent inlet to ETP (q)	--	89473 L

The specimen collection is made in two phases and the sample is collected with kind of treated water with different combination of biocides for testing and submitted to the standard third-party testing lab.

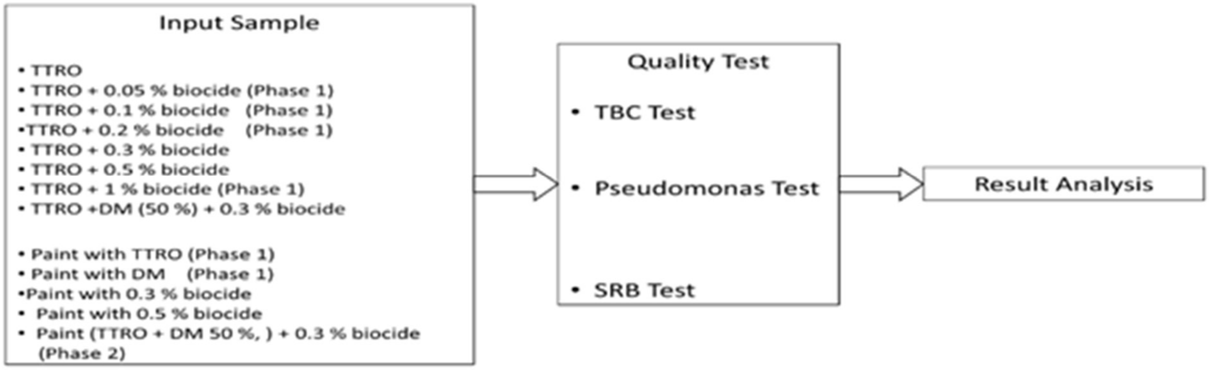

Fig. 2 Specimen collection ratio with phases

5. Results and Discussions

The results in Table 4 and Table 5 portray the immediate stability of the lab batch paint manufactured. A quick stability test is done within a day or two from when the product is made. All the water used for production here did not undergo the reverse osmosis process, which contributes to killing the microbes present. The presence of small percentage of formaldehyde-free biocide could not kill the microbes present in the water sample due to the absence of reverse osmosis process. All the paint batches manufactured has passed in the microbe check as the presence of biocides and additives used in the paint manufacturing process. However, the raw TTRO water treatment is found with SRB growth and failed in the test in both Phase 1 and Phase 2. Further it is necessary to check the shelf-life stability of the paint after one month and six months to confirm the long shelf-life period, where the procedure will vary for the same parameters.

Table 4 Phase 1 Stability test – lab batch 1 paint production

S. No	Source Tag	TBC Spec (Max)	TBC (CFU/ml)	TBC Status	Pseudomonas (Max)	Pseudomonas				Pseud / lit	Pseudomonas Status	SRB Spec	SRB After 48 Hours Incubation	SRB Status
1	TTRO as such	100000 /lit	TNTC	Fail	1000/lit	5	5	5	1600	16000	Fail	Absent	Growth observed	Fail
2	TTR0 + 0.05 % Biocide	100000 /lit	TNTC	Fail	1000/lit	5	5	3	900	9000	Fail	Absent	Growth observed	Fail
3	TTR0 + 0.1% Biocide	100000 /lit	TNTC	Fail	1000/lit	5	5	2	500	5000	Fail	Absent	Growth observed	Fail

4	TTR0 + 0.2% Biocide	100000/lit	TNTC	Fail	1000/lit	5	4	1	170	1700	Fail	Absent	Growth observed	Fail
5	TTRO as such	100000/lit	TNTC	Fail	1000/lit	5	3	1	110	1100	Fail	Absent	Growth observed	Fail
6	TTR0 + 0.3% Biocide	100000/lit	TNTC	Fail	1000/lit	5	5	2	500	5000	Fail	Absent	Growth observed	Fail
7	TTR0 + 0.5% Biocide	100000/lit	TNTC	Fail	1000/lit	5	5	2	500	5000	Fail	Absent	Growth observed	Fail
8	TTR0 + 1% Biocide	100000/lit	TNTC	Fail	1000/lit	5	5	2	500	5000	Fail	Absent	Growth observed	Fail
9	Paint sample with DM water	100/gms	TNTC	Fail	10/gms	No Growth					Pass	Absent	No Growth	Pass
10	Paint sample with TTRO as such	100/gms	TNTC	Fail	10/gms	No Growth					Pass	Absent	No Growth	Pass
11	Paint sample with 0.3% Biocide	100/gms	0	Pass	10/gms	No Growth					Pass	Absent	No Growth	Pass
12	Paint sample with 0.5 % Biocide	100/gms	5	Pass	10/gms	No Growth					Pass	Absent	No Growth	Pass

Table 5 Phase 2 stability test – lab batch 2 paint production

S. No	Source Tag	TBC Spec (Max)	TBC (CFU/ml)	TBC Status	Pseudomonas (Max)	Pseudomonas				Pseud/ lit	Pseudomonas Status	SRB Spec	SRB After 48 Hours Incubation
1	TTRO as such	100000/lit	TNTC	Fail	1000/lit	5	5	5	1600	16000	Fail	Absent	Growth observed
2	TTR0 + 0.3% Biocide	100000/lit	TNTC	Fail	1000/lit	5	5	3	900	9000	Fail	Absent	Growth observed
3	TTR0 + 0.5% Biocide	100000/lit	TNTC	Fail	1000/lit	5	5	0	240	2400	Fail	Absent	Growth observed
4	TTRO-DM water 50-50% + 0.3% Biocide	100000/lit	TNTC	Fail	1000/lit	5	5	0	240	2400	Fail	Absent	Growth observed
5	Paint sample with 0.3% Biocide	100/gms	TNTC	Fail	10/gms	No Growth					Pass	Absent	No Growth
6	Paint sample with 0.5 % Biocide	100/gms	TNTC	Fail	10/gms	No Growth					Pass	Absent	No Growth

6. Conclusion

The treated water and demineralized water in the industrial production stage are slowly emerging around the world to ensure sustainability due to the water shortage and also the need for safe re-usability of wastewater. However, there are only limited studies on the usage of paint production as the concept emerged in 2019 in India. The shelf-life, quality and durability of the paint pigment will be confirmed only after some years of usage in testing the paint-coated surfaces and also with both unused and left-over paints. The analysis made in the project helps to understand the need for microorganisms' growth in paint production. The usage of more potent biocides along with reduced moisture levels and other antimicrobial preservatives help in reducing the growth of microorganisms, improving stability and increasing the shelf life of water-based paint. However, the usage of biocides is also to be controlled as per the regulatory controls, as excessive usage causes health hazards. The study recommends the usage of treated water with
additional UV at the pre-production stage to ensure further reduction of microorganisms and enriched product quality.

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