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A Counter Current Mechanism (CCM): Cleaner Technology for Reducing Fresh Water Consumption in the Electroplating Sector of Moradabad

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Abstract

The metal ware cluster mainly produces decorative and utility-based items like metal lamps, candles, pillar holders, decorative curtains, napkin rings, and many more. These products include pattern making, metal casting, polishing, degreasing, welding, Electroplating, and finishing. These processes generate waste in the form of solid, liquid, and gaseous pollutants and use a huge amount of freshwater during the rinsing process in electroplating units in metal ware industries. The research paper comprises of study regarding to impact of cleaner technology on reducing or saving freshwater in electroplating units of metal ware industries in Moradabad through the demonstration of cleaner technology as Counter Current Mechanism. This cleaner technology, as the counter current mechanism, is initiated by WWF-India, and how metal ware industries of Moradabad can play a vital role in the conservation of Ram Ganga River by managing the wastage of freshwater.

Keywords: - Cleaner technologies, metal ware sector, Counter Current Mechanism (CCM), automatic, fresh water reduction.

Introduction

Moradabad city is a popular city of India, and it's also known as Brass City (Peetal Nagri). Moradabad city is a city in Uttar Pradesh, in the State of India. Moradabad has a municipal corporation and is situated on the bank of the river Ramganga. As per Historical data that Moradabad was established in 1600 A.D. by Murad, son of Shahjahan, during the empire of Mughal Empire. Moradabad is a very popular city for Brass art crafts and Handicrafts items as Decorative ware, Homeware, Kitchen ware, Hotel ware, Glassware & Stoneware items, etc. The metal craft cluster of Moradabad is one of the oldest clusters of India.

Brassware is an old industry in Moradabad town, but remained dormant till the 17th century. Urbanization and commercialization of the city started during the Mughals after the 17th century, and during this period, only the brassware industry got its identity and flourished. The credit for the development of handicraft skills goes to the family of artisans and blacksmiths (mostly belonging to the Mughal army), who settled down in Moradabad during the Mughal period. By the eighteenth century, the city had established trade relationships with countries like Egypt, Turkey, and Persia. The city is known as "Peetal Nagri" (Brass city) for its extensive use of brass as raw material. Further, during British rule, the cluster gained much of the patronage from the rulers. The industry achieved bloom in the 19th century when the British propagated this art to foreign countries in Europe.

In the last two decades, the extensive use of brass alloy has been reduced and diversified by the use of aluminum, steel, Iron, Wood, and Glass. With the increase in the prices of brass in the international market, the demand for brass metalware has reduced considerably, which has forced the cluster to shift to other metals.

Study of Area: The metalware cluster of Moradabad city is known across the world for brass art metalware and is popularly known as the 'brass city'. There are around 1200 registered metalware industries in the city and thousands of unregistered household units. The metalware cluster is entirely dependent on 'groundwater extraction'. The status of the groundwater table of Moradabad has a critical ecological context because the 'River Ramganga' is an aquifer-fed river in this region, therefore, the flows in the river directly depend on the status of groundwater in the district.

Fig. 1 Ground water status of Moradabad district and E flow of Ramganga River

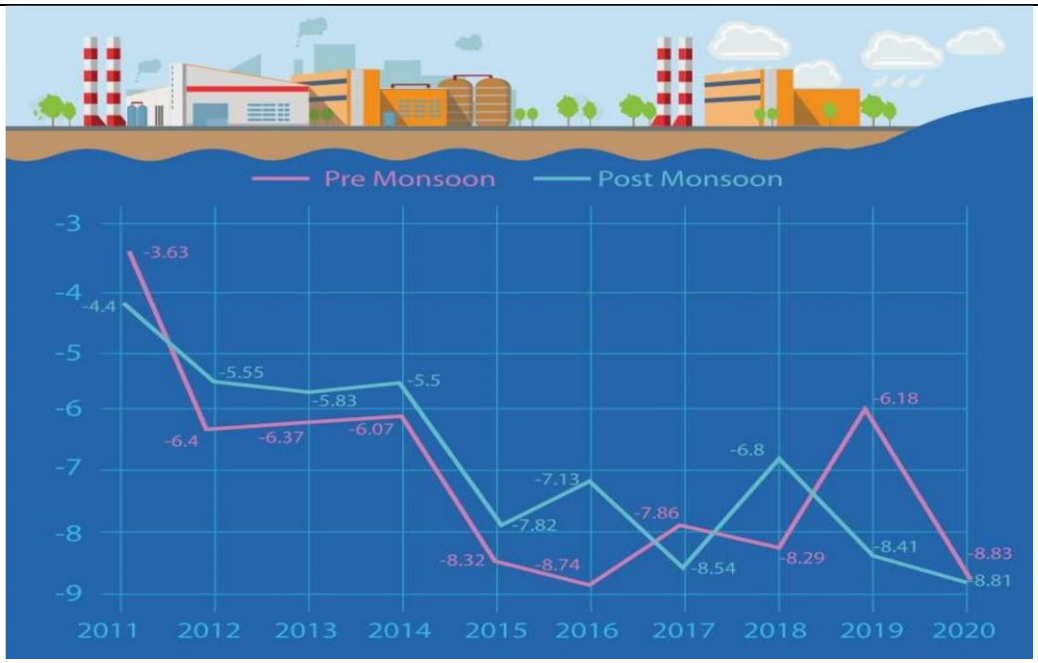


Fig. 2 The ground water table in Moradabad has been sharply declining during pre and post monsoon seasons during 2011-2020 (Source - UP Jal Jeevan Mission).

Technological improvements have been a key to the success story of Moradabad's metalware sector. However, the consequence of this technological progress or the gaps in the current the current technologies on the environment in general and water use in particular has received relatively less attention. The metalware industry uses a large volume of groundwater with very limited measures to reduce water use across industrial processes. The consumption of freshwater varies remarkably across big export units and household-level units. The electroplating process is the largest water-consuming unit in the metalware industry. Freshwater is mainly consumed in the electroplating unit either during rinsing of electroplated articles or after Ultrasonic Cleaning of articles before rinsing. Rinsing in the majority of units is still an inefficient system, which includes continuously and simultaneously operating multiple fresh water taps, thus leading to extraordinarily high use of freshwater. It is estimated that about seventy percent of the total fresh water used by a metalware industry is consumed by the rinsing process.

1. What is an Electroplating process? - Electroplating is a process that uses electricity to coat a thin layer of metal onto the surface of another material. It's commonly used to prevent rusting and improve appearance as a finishing of the products to attract the customer with its finishing, etc. There are many types of electroplating as Nickel, Copper, Zinc, Brass, Strike Nickel, Silver,

Gold, etc, and so many other processes as required for the product finishing. Metalware industries used toxic chemicals during the electroplating process on metals, which are hazardous to the environment. If effluents of industry go outside the industry without wastewater treatment, then industry wastewater directly affects the water bodies, biodiversity, and environment. Therefore, Industries use an ETP plant (effluent treatment plant) to treat wastewater, which is used for the proper treatment of industrial wastewater.

Electroplating is a process using electrolysis to deposit a layer of metal on the surface of materials [1]. The electroplated layer enhances the wear resistance, electrical conductivity, reflectivity, corrosion resistance, and aesthetic appearance of the product [2]. The development of electroplating technology has led it to become a crucial modern processing technique, extending beyond merely surface protection and decorative treatment for metals [3]. The applications have become increasingly diverse, especially in industries such as electronics, telecommunications, military, and aerospace [4]. Electroplating products range from household utensils and furniture to vehicles, including aircraft and ships [5]. With the rapid economic development and the advancement of the chemical industries, electroplating technology is poised to serve a wide array of products (Gao, J., 2025).

What is the conventional rinsing process in the electroplating of the metalware industry?

In the electroplating unit, company require to finishing of Nickel layer on Brass Items/Articles, Electroplating operator keep articles in Nickel chemical tank for 05 to 10 minutes (as per need

Fig. 3 Various types of Electroplating process are in electroplating unit of metalware industry

layer thickness) and after article rinse in 03 separate tanks where freshwater continuously running

in tanks which feed by 03 taps to remove the extra chemicals from the surface of article for better shining and better finishing. Metalware industries follow 03 steps of the main rinsing process to remove the extra chemicals on articles & improve the finishing quality, such as Step 1- After the main tank (where just electroplating on articles). Articles rinse in the first tank, where maximum

Chemicals are removed from the articles, around 70%.

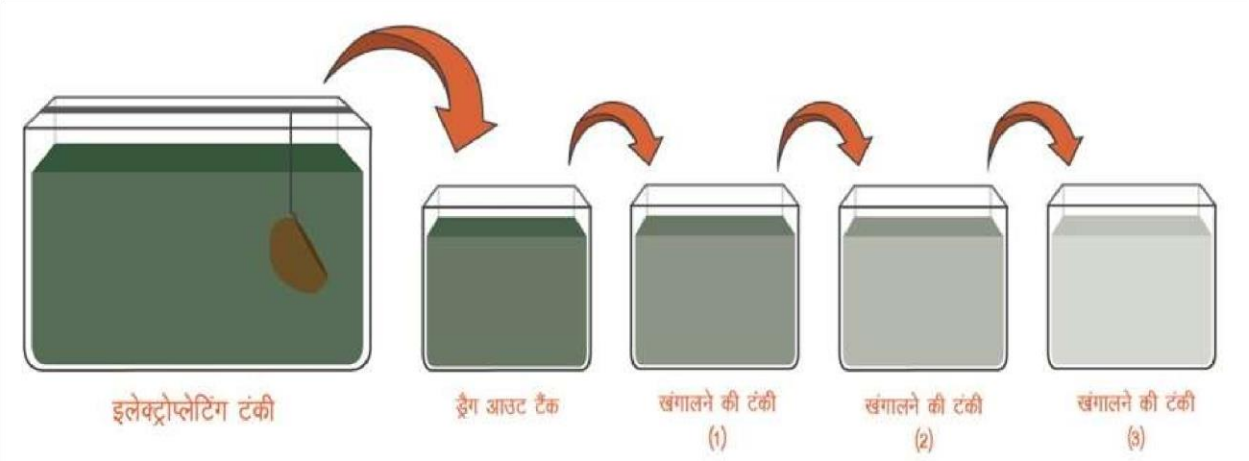


Fig. 4 Process of Conventional rinsing system in electroplating units

(Source – Unpublished reports of WWF India)

It means that the first rinsing tank is very highly full chemicals in tank. Therefore, TDS (Total Dissolved Solids) will be highly maximum in the first tank. Similarly, Step 2- After rinsing the articles in the first tank, the Articles are again rinsed in the second tank to remove around 25% chemicals from the articles. It means, second tank is low low-chemical tank compared to the first tank. Therefore, TDS will be high but not equal to the first tank. Step 3, After rinsing articles in the second tank, Articles are again rinsed in the third tank to remove around 5% chemicals from articles. It means that the third tank has very low chemical

Fig. 5 Conventional rinsing - 03 separate tanks & 03 taps levels compared to the second & first tanks. Therefore, there TDS will be very minimum or we can say that it is equal to clean water but there is very unpractical system in the metal ware industries, that There continuously feed to 03 separate rinsing tanks by 03 taps during the working days of industries and after filling the tank, water is going continuously to ETP through the overflow. Which is the reason that Electroplating units of metal ware industries use a large amount of freshwater from the groundwater extraction.

3. What is an Effluent Treatment Plant (ETP) or Wastewater Treatment Plant? – Effluent Treatment Plant (ETP) is a plant that treats the wastewater of industry through chemical processes. ETP is also known as wastewater treatment. Waste water from the electroplating unit goes to the ETP plant to treat the waste water and arrest toxic chemicals or reduce chemical contaminants.

Research Objective

The research paper examines the impact of WWF-India's interventions from 2013 to 2024 around collective action industries, on the mainstreaming of cleaner technologies in Moradabad's metal ware cluster. WWF-India, in collaboration with the Indian Institute of Technology (IIT), Kanpur, initiated exploring cleaner technology interventions in 2013-14, which primarily consisted of investigating and field testing a technical solution to reduce fresh water use during the rinse process in metal ware industries of Moradabad.

However, it is critical to state that this journey of exploring a technological solution was woven around the concept of 'multi stakeholder approach'. WWF-India and IIT-Kanpur methodically studied the uptake of technology by the metal ware sector and later developed a technology

solution to reduce freshwater consumption in the rinsing process. This partnership led to the development of a new manual rinsing mechanism known as the Counter Current Mechanism (CCM).

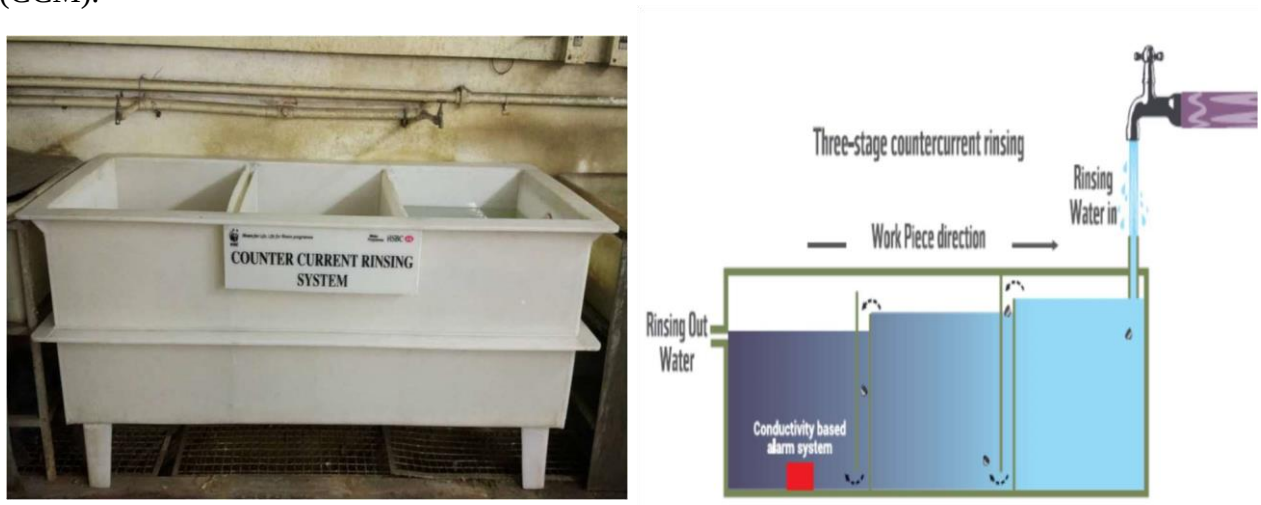


Fig. 6 Counter Current Mechanism (CCM)

(Source – Unpublished reports of WWF India)

This rinsing system essentially comprised a composite iron tank, which had multiple partitions and discontinuation of all fresh water taps except one. This manual CCM was demonstrated in nine pilot industries during 2014-2016, and the impact of the manual CCM was studied in partnership with industries and academia. The stakeholders actively worked on improving the design of the manual CCM, and by 2017-18, a new design of the CCM was developed, which made the CCM a completely automatic mechanism.

An automatic CCM comprised of a composite Poly Propylene (PP) tank with three partitions and holes drilled on the walls separating each chamber, which allowed water to flow from one partition to the other. A TDS controller mechanism is incorporated in the CCM to disconnect the flow of fresh water whenever the TDS is under the threshold (a pre-defined benchmark value). The consumption of water during rinsing at this particular CCM is measured by installing a dedicated water flow meter.

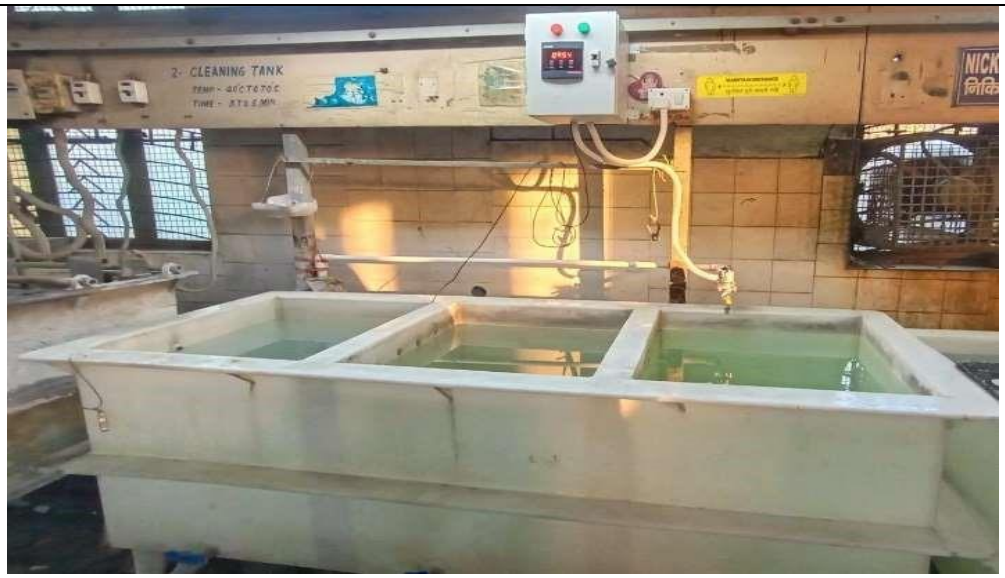


Fig. 7 Automatic Counter Current Mechanism (Source – Unpublished reports of WWF India)

The CCM is supplied with fresh water from one tap only, unlike from two to three taps in the conventional rinsing system. There will be no supply of fresh water from the tap until the TDS value in the most polluted chamber is below the threshold TDS, as this would imply that the TDS of the water is within range and fit for rinsing. However, the moment the TDS value of the most polluted chamber goes above the threshold TDS value, the solenoid valve would be activated, and that will lead to the supply of fresh water from the tap. The supply of fresh water from the tap will stop the moment the TDS value in the polluted chamber falls below the threshold TDS value due to dilution. This mechanism reduces freshwater consumption respectively 25% to 40% in the rinsing process in the electroplating unit of Metalware industries, Moradabad.

1. Difference between Conventional Rinsing and Automatic Counter Current Mechanism

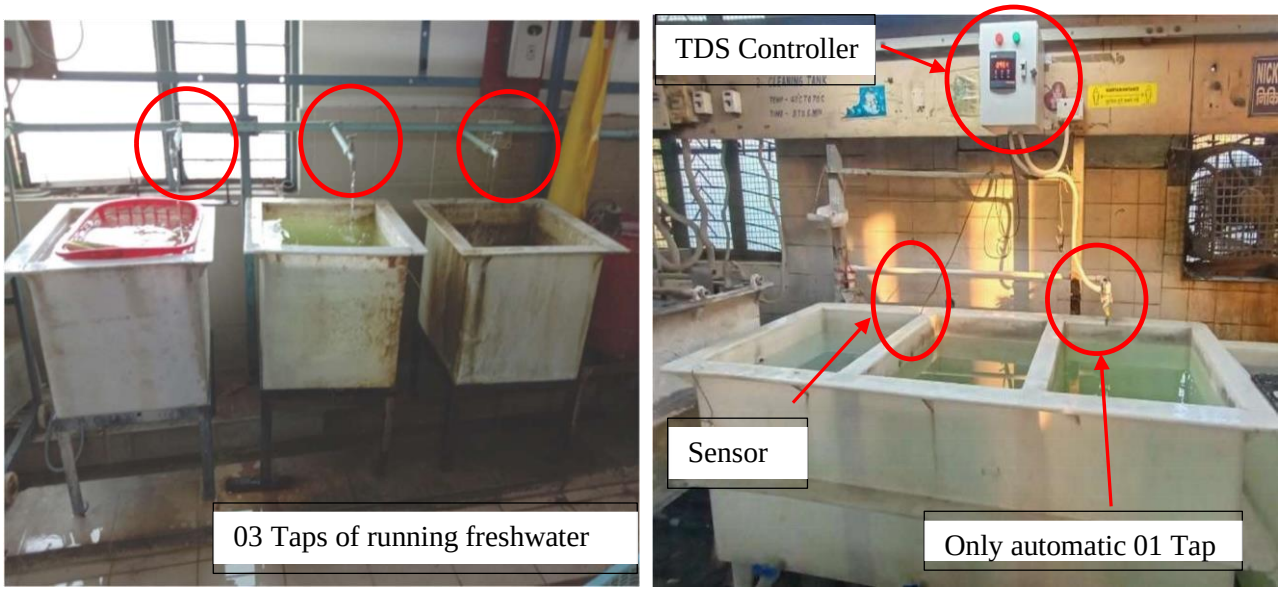


Fig. 8 Difference between the conventional rinsing system and CCM

(Source – Unpublished reports of WWF India)

Disadvantages of the conventional rinsing process

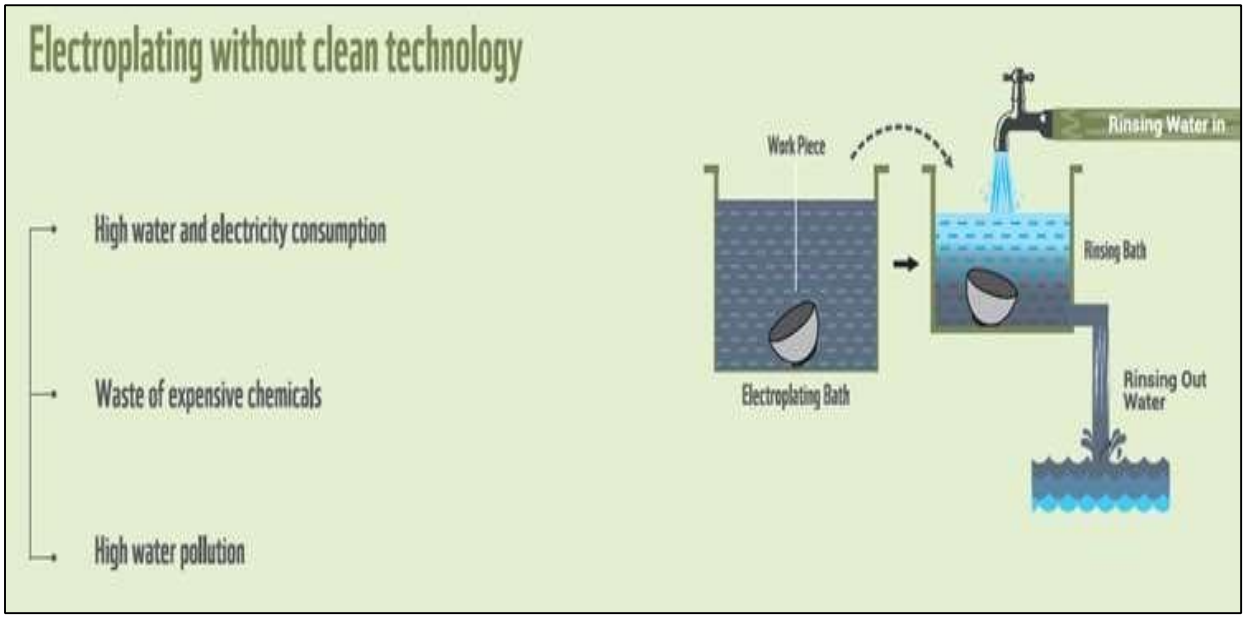


Fig. 9 Disadvantages of conventional rinsing process (Source – Unpublished reports of WWF India)

Advantages of advanced cleaner technology: Counter-Current Mechanism

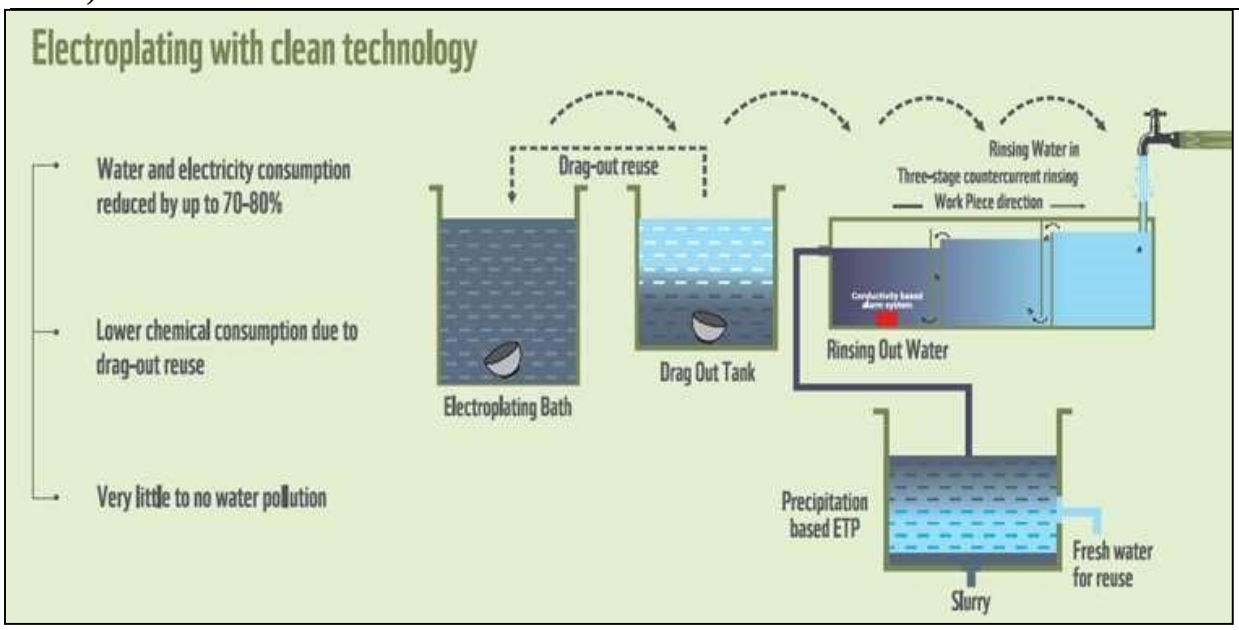


Fig. 10 Advantages of Counter Current Mechanism (Source – Unpublished reports of WWF India)

Method of Data Collection

This study is based on primary data of the industry on the consumption of freshwater during the rinsing process at the Pre & Post Counter Current Mechanism (CCM) level in the electroplating unit. WWF -India engaged to metal ware industry through the meetings and conducting the training or workshop on cleaner technology for metal ware industries collaboration with Moradabad District Administration, then conducting feasibility study of CCM replication in metal ware industry and select conventional rinsing system out of many conventional rinsing systems where will be convert

01 or more than 01 conventional rinsing system into CCM to reduce the freshwater consumption. After a feasibility study of replication of CCMs, there is installed mechanical type 01 water flow meter is installed around 20 to 30 days before the installation of Counter Current Mechanism (CCM) to collect 02 types of baseline data from selected conventional rinsing systems as follows:

Collecting baseline data of freshwater consumption at selected conventional rinsing processes as the pre-CCM level.

Collecting baseline data of the number of articles rinsed at the selected conventional rinsing process as the Pre CCM level.

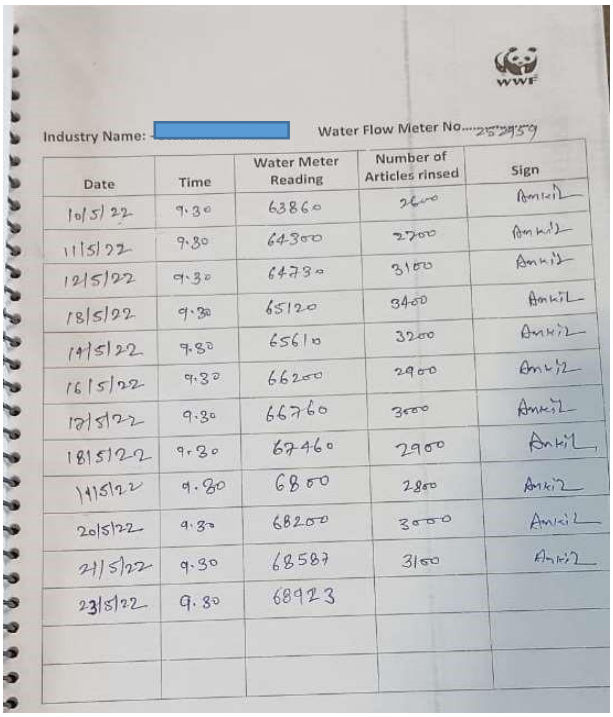
After collecting baseline data at pre-CCM level with a couple of periods, install the automatic Counter Current Mechanism and similarly collect baseline data at post-CCM level as follows-

- Collecting baseline data of freshwater consumption after installation of the automatic Counter Current Mechanism as Post CCM level.
- Collecting baseline data on the number of articles rinsed after installation of the automatic Counter Current Mechanism as Post CCM level.

Example: - We are collecting baseline data of freshwater consumption at selected conventional rinsing systems for 30 days through the electroplating supervisor of the metal ware industry, such as Total freshwater consumptions are 300000 lts and Total number of articles rinse are 50000 Nos against of freshwater consumption. Its mean that metal ware industry is rinsing 50000 Nos article in 30 days with consume 300000 lts freshwater.

Please see the collection of baseline raw data through the primary data basis.

Logbook for collecting baseline data of freshwater consumption and the number of Article rinses



Industry Name: _____ Water Flow Meter No.....

Date	Time	Water Meter Reading	Number of Articles rinsed	Sign
10/5/22	9.30	63860	2600	Ankit
11/5/22	9.30	64300	2700	Ankit
12/5/22	9.30	64730	3150	Ankit
13/5/22	9.30	65120	3450	Ankit
14/5/22	9.30	65610	3200	Ankit
16/5/22	9.30	66200	2900	Ankit
17/5/22	9.30	66760	3500	Ankit
18/5/22	9.30	67460	2900	Ankit
19/5/22	9.30	68100	2850	Ankit
20/5/22	9.30	68200	3000	Ankit
21/5/22	9.30	68587	3150	Ankit
23/5/22	9.30	68923		

Month (Pre CCM)	Water meter reading (lts)	Water Consumption (Ltr)	No. of article rinse	No. of days	Duration of Baseline data
September, 2021	0 -103400	101720	74700	24	02 Sep, 21 - 30 Sep, 21
October, 2021	103400 - 241100	137700	77700	24	01 Oct, 21 - 30 Oct, 21
November, 2021	241100 - 249000	7900	7600	4	01 Nov, 21 - 10 Nov, 21
	Total	247320	160000	52	
Month (Post CCM)	**Water meter reading (lts)**	**Water Consumption (Ltr)**	**No. of article rinse**	**No. of days**	**Duration of Baseline data**
November, 2021	2156450 - 300270	34620	33000	12	17 Nov, 21 - 30 Nov, 21
December, 2021	300270 - 371570	71300	103200	27	01 Dec, 21 - 31 Dec, 21
January,2022	371570 - 431480	59910	77600	23	01 Jan, 22 - 31 Jan, 22
Febuary,2022	431480 - 489850	58370	69400	23	01 Feb, 22 - 28 Feb, 22
March,2022	489850 - 548500	58650	59000	22	01 March, 22 - 31 March, 22
April, 2022	548500 - 624600	76100	75700	23	01 April, 22 - 30 April, 22
May, 2022	624600 - 689230	64630	44800	15	01 May, 22 - 21 May, 22
	Total	423580	462700	145	

Fig. 11 Logbook to recording baseline raw data of freshwater consumption and number of articles rinse (Source – Unpublished reports of WWF IndiaMethodology)

We used the following methodology to find the impact of reduction or saving in freshwater consumption after demonstration of CCM in the electroplating unit against conventional rinsing system and we have found that reduction of freshwater consumption without any kind of compromise in quality & finishing of articles respectively 25% to 40% freshwater after demonstration of CCM. It means that we have saved freshwater, respectively, 25% to 40%, as per the production size of the industry.

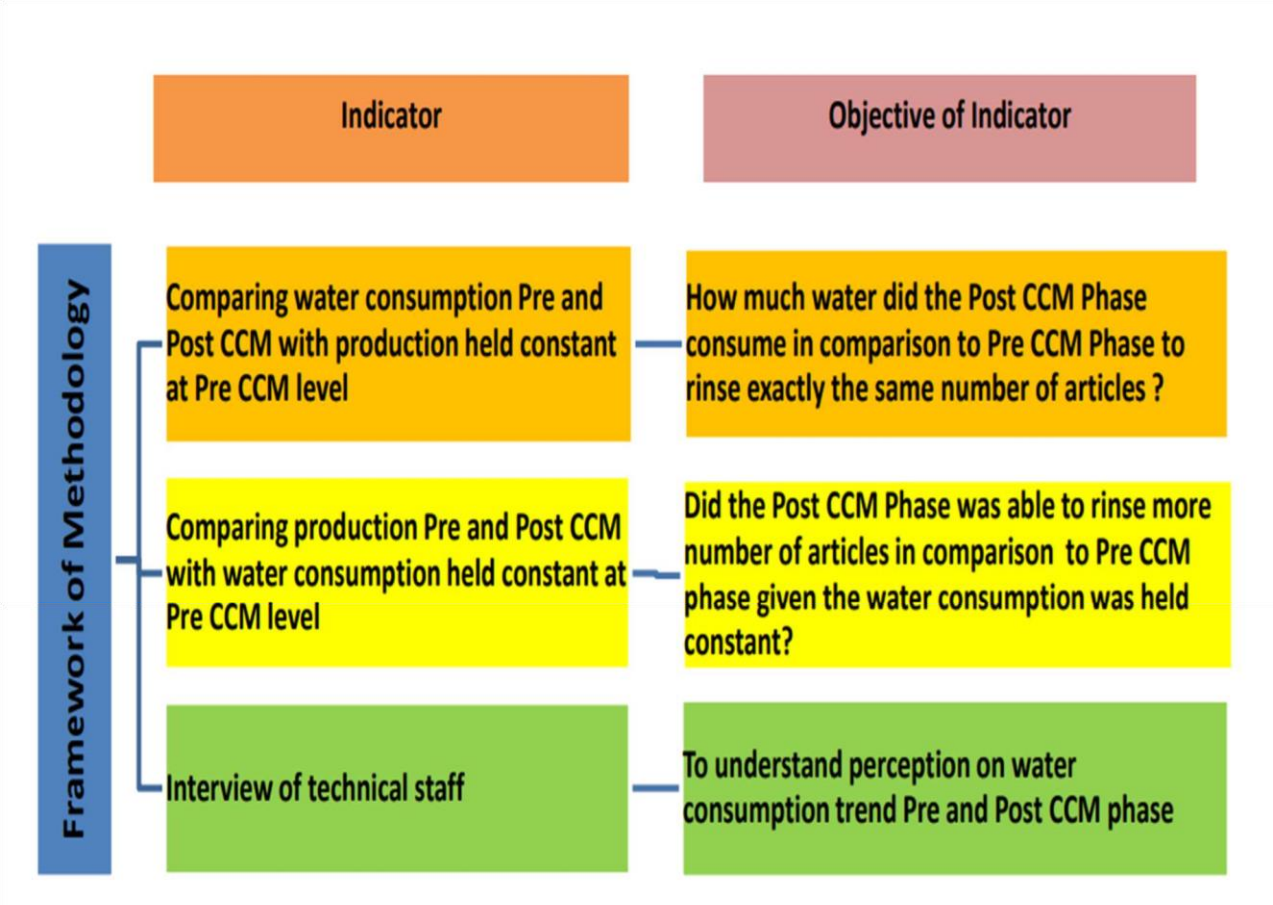


Fig. 12 Methodology used to determine the impact of CCM

(Source – Unpublished reports of WWF India)

Data Analysis

Baseline data of freshwater consumption and the Number of articles rinsed at Pre & Post CCM level collected by the electroplating supervisor of the metalware industry. The electroplating supervisor regularly collects daily basis raw data of water consumption and the total number of articles rinsed at CCM in the logbook, and he sends data every month. After that, all entries of raw

data on water consumption and the number of articles were done in MS Excel. After that, we start raw data analysis of post-CCM in slots against water consumption & article rinse at the pre-CCM level. It means that we hold the number of articles as constant at Pre & Post CCM and calculate freshwater consumption at Pre & Post CCM level, then comparison between freshwater consumption at Pre & Post CCM level during the rinsing process.

Data analysis is following the 02 methodology: -

- Comparing freshwater consumption Pre & Post CCM with Production (Number of Articles) held constant at Pre CCM level
- Comparing production (Number of Articles) Pre & Post CCM with fresh water consumption held constant at the Pre CCM level.
- Comparing freshwater consumption Pre & Post CCM with Production (Number of Articles) held constant at Pre CCM level

Graph 1: Trend of Water Consumption Pre CCM Vs. Post CCM with Production held Constant at Pre-CCM Level.

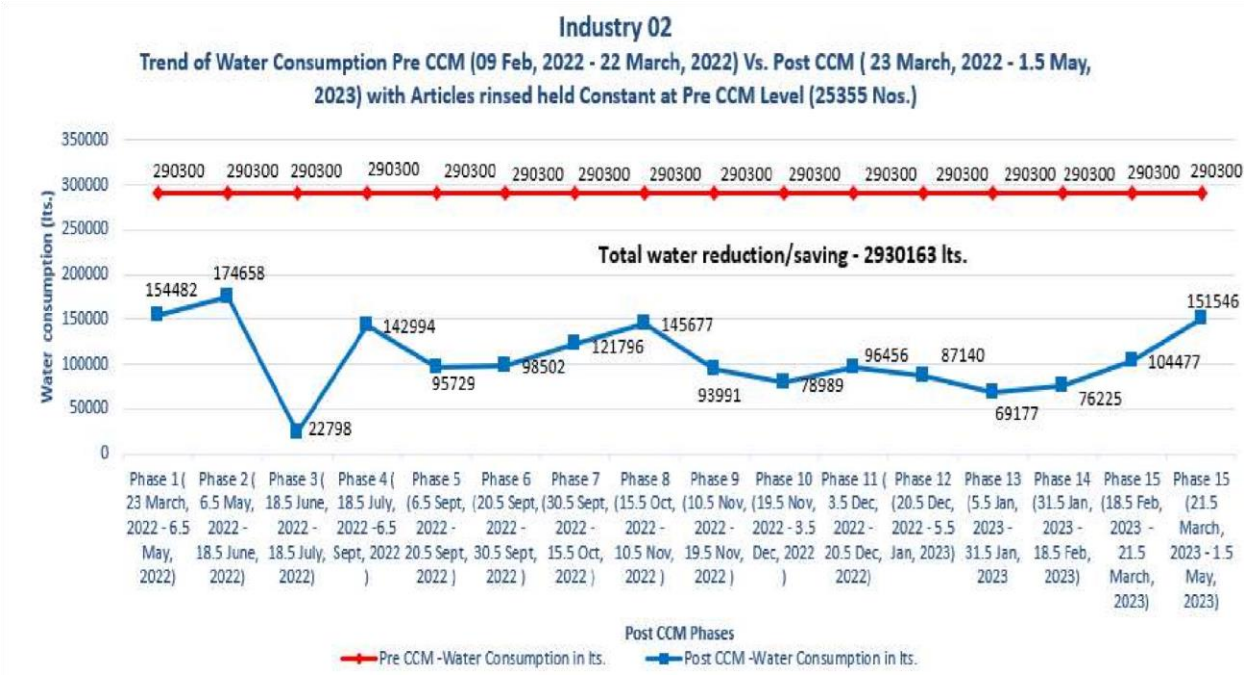


Fig. 13 Impact of CCM: To reduce fresh water with production held constant at the pre & post-CCM level

(Source: Unpublished reports of WWF India)

Key Interpretations:

The consumption of fresh water Post CCM installation has been less than the consumption of fresh water during Pre CCM i.e., 290300 lts. after holding production or the number of articles rinsed as constant at Pre CCM level i.e., 25355 nos.

The net savings or reduction in fresh water consumption, i.e., Water Consumption during Pre CCM -

Post CCM, is 2930163 lts. from 23 March 2022 to 1.5 May 2023 The total percentage of water saving/reduction is 63%.

1. Comparing production (Number of Articles) Pre & Post CCM with fresh water consumption held constant at the Pre CCM level.

Graph 2: Trend of Production Pre CCM Vs. Post CCM with Water Consumption held Constant at Pre-CCM Level.

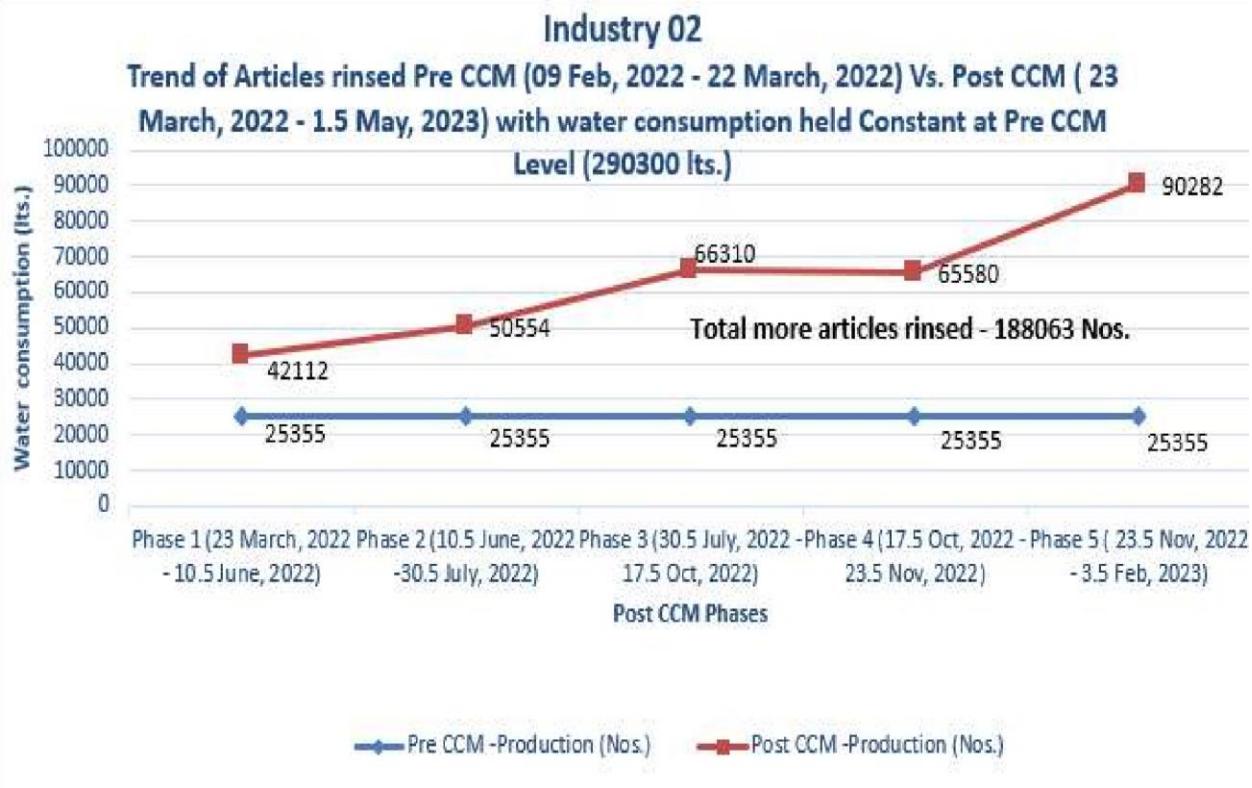


Fig. 14 Impact of CCM: To increase production with water consumption held constant at Pre & Post CCM

(Source: Unpublished reports of WWF India)

Key Interpretations:

The production or number of articles rinsed in the CCM is higher during the Post CCM phase in comparison to the Pre CCM phase, with water consumption held constant at the Pre CCM level, i.e., 290300 lts

This indicates that the Post CCM phase was able to rinse a greater number of articles in the same volume of water in comparison to the Pre CCM phase.

The Post CCM Phase was able to rinse 188063 more articles in comparison to Pre CCM-Phase with consumption of fresh water held constant at Pre CCM level (290300 lts.).

It can be seen in the graph above that the number of articles rinsed increases exponentially in the end part of the duration which coincides with the duration when TDS controller came into operation.

Key Findings

The collective action by WWF-India and other stakeholders has led to the adoption of 162 automatic CCMs by forty industries during 2010 and till now. The cumulative share of these forty industries in the total export of metalware products is estimated to be in the range of 40 to 57 percent. Therefore, these forty industries are a good sample to capture the economic breadth of Moradabad's metalware cluster. The impact of automatic CCM on the reduction of fresh water consumption in rinsing was studied by recording water consumption and the number of articles rinsed in the CCM being studied daily. Similarly, the data set was collected during the baseline study, i.e., before converting or replacing the traditional rinsing facility into an automatic CCM. It was estimated based on the data set that the average reduction in fresh water consumption was in the range of twenty-five percent to forty-seven percent after installation of automatic CCM. This sharp reduction in fresh water uses further reduced the running cost of the Effluent Treatment Plants (ETP), thus enabling the industry to acquire a double gain. The study, based on a stratified random sampling, also estimated a total reduction of about 22 million liters from June 2020 to June 2024. The assessment methodology and the data set used were also subjected to a credible third-party auditor, and the audit report validated WWF-India's methodology and its accuracy. This study has also assisted the district administration to encourage the cluster for wider adoption of automatic CCM, which subsequently led to the formation of a working group and a letter issued by the district administration to representatives of the metalware sector. The stakeholders involved

in the initiative equivocally recognize the necessary policy push that is needed to scale up the adoption of automatic CCM due to the positive consequences of this technological solution.

Conclusion

Cleaner technology as Counter Current Mechanism, is playing a very important role in metalware industries to reduce a large amount of freshwater in the rinsing process. This is a fully sustainable development system that directly reduces groundwater extraction and helps to control the groundwater table. Metalware industry can help to conservation & restoration of wetlands and the Ramganga River & its tributaries by reducing groundwater extraction and controlling wastewater of production. Because the ecological integrity of rivers and the sustainable use of water resources are critical for the social and economic progress of human society. The continuous compounding of stress on the groundwater table is contributed to by the agriculture, domestic, and industrial sectors.

Acknowledgement

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