USING WATER AUDIT AND WATER CONSERVATION PRACTICES TO REDUCE WATER CONSUMPTION AND WASTEWATER GENERATION SIGNIFICANTLY IN A FOOD PROCESSING PLANT: A CASE STUDY

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ABSTRACT

Water is a non-substitutable resource and increased stress on it in recent times has led to a need to ensure its availability for future generations. Food processing industries have huge potential for water conservation and reuse if audited properly. Water auditing of an industry could help in identifying the probable points where water can be conserved, at the same time qualitative analysis is required to find possibilities of reuse. This water conservation study was carried out in a packaged food industry. Complete qualitative and quantitative assessment was done for all the processes and operations occurring in the factory which involved water consumption, analysis of wastewater samples from all the outlets and that of treated water was carried out for studying the quality parameters. From this study it was concluded that water could be conserved by its rational use and with help of various technological advancements. There was a need to segregate water supply according to its quality. In factory water consumption could be reduced by 17.85% and hydraulic load on wastewater treatment plant by 10.33 %. Instead of conventional clean-in-place (CIP), operating ozonated CIP clubbed with hot air flushing could further reduce the amount of water consumed. Quality analysis showed that sealing water used in cooling pumps, could be re-circulated or may be used to dilute main supply for sealing water. Further grey-water might be used for flushing. Quality analysis of treated water from wastewater treatment plant showed that the quality of treated water was under discharge norms, but an additional reduction in organic load of wastewater could be done by promoting mop cleaning. Reduction in water consumption and wastewater generation will also lead to savings in energy consumption. It was concluded that complete knowledge of an industry is an important step to device water consumption reduction and possible reuse of wastewater after suitable.

INTRODUCTION

Consumption of water as well as discharge of wastewater has become a great ecological and environmental concern (4). Indiscriminate usage of water for domestic consumption, agricultural processes or industrial usage coupled with an ever-increasing demand has imposed a serious threat on its current supply and future availability (13). Industries not only impose great demand on the water resources but also play a major role in altering the water quality, which is then discharged as wastewater. Environment protection agencies with help of local legislation have imposed stringent regulatory discharge standards for protecting the environment. This has led to the requirement of more efficient wastewater treatment technologies and proper mapping of wastewater generation/water consumption points (15).

The food industry consumes relatively high volumes of water for production, cleaning, sanitization, heating and cooling, and hence producing wastewater with high organic load. The wastewater needs to be properly treated in order to meet the stringent discharge norms and despite that, the water can't often be re-used owing to the strict hygiene norms (5).

In the many scenarios, careless approach & lack of awareness about water management at basic level is evident in industrial units that allow water wastage due to unattended pipe leaks, running taps & hoses, and avoidable water sprays (2). Even, reclaimed water after treatment also is either discharged or is used only for gardening

only. Hence, there is a huge potential for water conservation using proper water auditing, water reuse, implementation of basic conservation practices. Thus, minimization of wastewater generation becomes equally important to reduction in water consumption.

The aim of this study was to analyse the potential for water conservation and reduction in wastewater generation reduction in a food processing factory in India. The factory where the study was conducted had four different production units producing fast food (plant-1), milk products (plant-2), baby food (plant-3) and milk powder (plant-4).

Water used in the various production processes comes from three bore wells. Two bore wells (1&2) were treated with sodium hypochlorite for disinfection and used regularly while the third one was kept as stand-by. One common electronic meter was installed which provided a cumulative reading for consumption from both the wells which were in use. The extracted water was stored in a water storage tank of capacity 535 m^3 (225 m^3 for fire-fighting and 310 m^3 for production processes, drinking and other services). The average water consumption in the factory during the sampling was found to be approximately 925 KL/day (by water-meter).

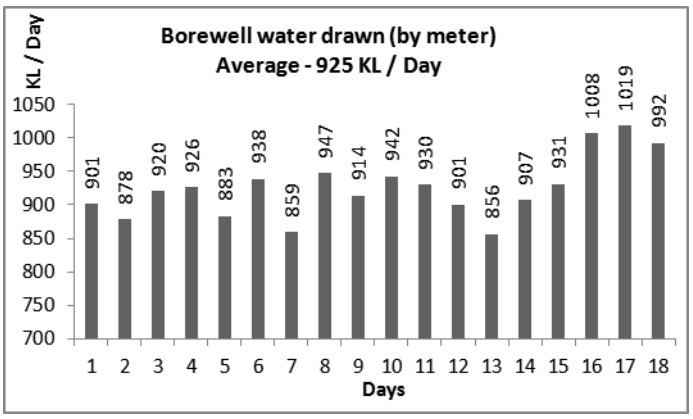

Figure.1 Average borewell water drawn

Wastewater treatment plant (WWTP) had been setup in the factory to treat the wastewater generated to make it reusable. This water was then used for irrigation purpose inside the factory lawns. WWTP worked on the activated sludge process with extended aeration (aeration time of about 48 hours).

OBJECTIVE

The aim of this study was to analyse the potential for water conservation and reduction in wastewater generation reduction in a food processing factory in India by using this plant as a case study.

METHODS

Factory characterization was done by collecting primary data and information about various production processes and services. After assessing best techniques for measurements, quantification of water consumed in each unit was done using different methods. Water lines were traced using the flow line diagrams available to identify all sources, sinks and interconnections. Water points & usage areas were mapped & marked. Different circuits were segregated based on water quality & source. Discharge rates of all the water hoses, washbasins and water batteries were calculated manually using stopwatch and bucket. Water used in production was estimated from the daily water usage records present. Amount of water used in cleaning and washing was calculated by conducting surveys, questioning the staff and personal observations. All readings were cross-checked with meters wherever available. Quality estimation of water & wastewater at all major points and outlets was done to assess re-use possibilities. Water-point diagrams were prepared for each unit to simplify the analysis. Wastewater quality parameters were analysed to check efficiency of wastewater treatment plant.

RESULTS

The factory water auditing was divided into four production units, laundry, cooling towers, boilers, social blocks and canteen. The outline of water consumed, wastewater generated, suggestion to reduce water consumption, and reclaim possibility by each unit is described below:-

Plant-1

Total water consumed (KL/day):	36
Total wastewater generated (KL/day):	21
Total water that may be reclaimed and wastewater that may be minimised (KL/day):	6

Table. 1. Production plant-1 water summary.

Suggestions for minimization of wastewater generation and water consumption:

- Water can be re-used at steamer area by installing recirculation pump and fine mesh which will trap broken noodles in water and make it suitable for floor washing.
- Water usage for cleaning floor can be reduced by usage of oil absorbing mats in fryer area
- Water can be reclaimed by application of automated water gun for cleaning oily floor (14)
- Water can be reclaimed by re-using or re-circulating sealing water as water quality was almost unaltered
- Water can be reclaimed by repairing air handling units (leakages reported)
- Manual taps could be replaced with sensor installed taps or push-button taps (10)
- Unnecessary water wastage for truck cleaning can be avoided by spreading proper awareness

Plant-2

Total water consumed (KL/day):	36
Total wastewater generated (KL/day):	35
Total water that may be reclaimed and wastewater that may be minimised (KL/day):	2

Table. 2. Production plant-2 water summary.

Suggestions for minimization of wastewater generation and water consumption:

- Water can be reused by re-circulating pump sealing water, quality almost unaltered (9)

Plant-3

Total water consumed by cereal plant (KL/day)	91
Total wastewater generated (KL/day):	28

Total water that may be reclaimed (KL/day):	23
Total wastewater that may be minimised (KL/day):	5

Table. 3. Production plant-3 water summary.

Suggestions for minimization of wastewater generation and water consumption:

- Water can be reused by re-circulating pump sealing water, quality almost unaltered (9)
- Water consumption can be reduced by promoting mop cleaning instead wet cleaning always (14)
- Water can be reclaimed by using satellite cooling water (quality unaltered, just temperature raised)
- Daily rooftop cleaning can be avoided

Plant-4

Total water consumed (KL/day):	327
Total wastewater generated (KL/day):	167
Total water that may be reclaimed (KL/day):	89
Total amount of wastewater that may be minimised (KL/day)	11

Table. 4. Production plant-4 water summary.

Suggestions for minimization of wastewater generation and water consumption:

- Water can be reclaimed by application of automated water gun at fresh milk reception area (14)
- Water can be reused by re-circulating pump sealing water, quality almost unaltered (9)
- Water can be reclaimed by using ozonated CIP instead of conventional CIP (3). It was suggested to club flushing hot air along with ozonated water to achieve removal of loose fats, milk solids, scaling and disinfection
- Sealing water can be reused for necessary truck washing (9)

Laundry

Laundry	
Total water consumed (KL/day):	10
Total wastewater generated (KL/day):	10
Total water that may be reclaimed and wastewater that may be minimised (KL/day):	1.5

Table. 5. Laundry water summary.

Suggestions for minimization of wastewater generation and water consumption:

- Machines if allowed to run on full load will reduce 4-6 batches daily (8)

Canteen

Canteen	
Total water consumed (KL/day):	18
Total wastewater generated (KL/day):	16
Total water that may be reclaimed and wastewater that may be minimised (KL/day):	8

Table. 6. Canteen water summary.

Suggestions for minimization of water consumption and wastewater generation:

- Dishwasher usage would reduce water consumption (7)
- Overflows from drinking water coolers can be prevented by installing float valves

Social Blocks

Social blocks	
Total water consumed (KL/day):	47
Total wastewater generated (KL/day):	45
Total water that may be reclaimed (KL/day):	32

Table. 7. Social block water summary.

Suggestions for minimization of wastewater generation and water consumption:

- Condensate recovered from milk evaporators or ETP treated water can be used for flushing in urinals (1 & 12)

Cooling Towers

Cooling towers	
Total water consumed as blow-down in a day (KL):	160
Total wastewater generated in a day (L):	0
Total water that may be reclaimed (KL/day):	16

Table. 8. Cooling towers water summary.

Suggestions for minimization of wastewater generation and water consumption:

- Usage of ETP treated water as make-up after further treatment by technologies like membrane filtration (6 & 16)
- Running tower on higher cycles by using better cooling tower treatment chemicals
- Blow-down can be recycled and recycled water can be used as make-up, leading to minimal water losses

Boilers

Boilers	
Total water consumed by laundry in a day (KL):	181
Total wastewater generated in a day (L):	2

Table. 9. Boiler water summary.

Suggestions for minimization of wastewater generation and water consumption:

- Usage of ETP treated water as make-up after further treatment by technologies like membrane filtration (16 & 11)

Wastewater Treatment Plant (WWTP)

WWTP had been setup in the factory to treat the wastewater generated to make it reusable. Most of this water was then used for irrigation purpose inside the factory lawns. Depending on its origin, wastewater was collected in separate sewage system:

- Polluted water (Processing, Sanitary, Canteen)
- Unpolluted water (Cooling, Condensate water)

The polluted water needs biological treatment, thus it was collected in a common sewage raw water-collecting pit. The unpolluted water went to a balance tank, from where it was directly used for lawn irrigation. WWTP works on the activated sludge process with extended aeration (aeration time of about 48 hours). Wastewater treatment plant comprises of one screening station followed by a balancing tank with floating aeration turbine then two aeration tanks with fixed aerators followed by clarifier with mechanical scrapers, then sludge silo, then four sludge drying beds and a treated water pit in the end. Water quality parameters at different stages of WWTP are shown in table below.

Quality parameters	Aeration tank	Clarifier	Treated water
Temperature (^{o}c)	28	25	26
pH	8.4	8.6	8.1
Colour	Dark brown	Light brown	Almost clear
Dissolved Oxygen (mg/L)	3.79	3.3	2.9
TDS (mg/L)	1782	542	589
TSS (mg/L)	2256	98	72
Conductivity (µS)	1293	918	1069

BOD (mg/L)	1050	26.2	25
COD (mg/L)	1600	230	230

Table.10 Wastewater quality parameters at different stages in WWTP

Total water consumption, wastewater generation and possible reductions are shown in Table below.

Total water consumed in plant (KL/day):	906
Total wastewater generated in plant (KL/day):	324
Total water that can be saved (KL/day):	177.5
Total wastewater generation that can prevented in plant (KL/day):	33.5

Table.11 Factory water consumption and wastewater generation summary

It was found that maximum water is utilized in the plant-4 for cleaning, washing, cooling and maintaining proper hygiene by clean-in-place process. Although clean-in-place is a technique to prevent water losses and maintain hygiene but with support of recent discoveries we found that by usage of ozonized water (3) clubbed with hot air flushing will prevent water losses by huge amount along with better hygiene results and less danger of contamination with acids and alkalis used. Huge potential of water reuse was found out where water was used as sealing water for cooling down pumps. This water was being discarded just after one time use but the quality was found to be almost unaltered as only a slight increase in TDS and BOD was observed. Similarly, water was used in plant-1, plant-2 and plant-3 as process water, sealing water and water used in cleaning. Here water conservation to huge amounts was not possible, although promotion of mop cleaning (14) will bring down organic load in wastewater. The boiler supplies soft water, hot water and steam in different plants whereas cooling tower brings down the temperature of non-polluted water coming from production plants so that it could be used again. Water is also used in other services which include laundry, administration block, social blocks, and canteen. Though wastewater analysis showed relatively higher BOD and COD levels due to the contamination by milk solids but the overall organic load on WWTP and the quality parameters of treated water were observed to be under permissible limits.

It was found that maximum water is utilized in the plants for cleaning, washing, cooling and maintaining proper hygiene by clean-in-place process. With support of recent discoveries that time it was found huge water savings along with better hygiene results can be achieved by modifying conventional clean-in-place process . Huge potential of water reuse was found out where water was used in sealing pumps for cooling down pumps as water quality was found to be almost unaltered. Water conservation to vast amounts was not possible in process consumption and cleaning; although promotion of mop cleaning will bring down organic load in wastewater, leading to better efficiency of WWTP. Water conservation through basic practices in boilers, cooling towers, laundry, administration-block, social-blocks, and canteen was too assessed.
Possibility of reduction of 161.67 KL/day of water consumption and 33.5 KL/day hydraulic load on WWTP was shown by this study. Quality assessment of wastewater showed that the organic load on WWTP is under controllable limits and the quality parameters of treated water were under permissible limits.
Wastage of water due to negligence was reported and economical alternative technologies to reduce water consumption were discussed and proposed.

CONCLUSION

From this study it was concluded that water could be conserved by its rational use and with help of various technological advancements. There was a need to segregate water supply according to its quality. In factory water consumption could be reduced by 17.85% and hydraulic load on wastewater treatment plant by 10.33 %.
It can be established with this study that water conservation and water reuse are very crucial tools to minimize water scarcity problems as increasing urbanization and industrialization has increased the rate of water pollution.

The complete knowledge of all the existing processes and services in an industry is an important step to devise water consumption reduction and possible reuse of wastewater after suitable treatments.

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