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Water Management in Chemical Industries

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Foreword



The chemical industry is one of the most diversified industrial sectors. It covers over 70,000 commercial products that provide critical inputs for many downstream industries. This sector is one of the major water intensive industrial sectors, requiring water for multiple processes.

A large portion of water used by the chemical industry is for return-flow applications. This generates large quantities of effluents. Effluents produced by this sector often contain organic and inorganic matter in varying concentration. Treating the effluent to safe limits and disposal remains a major challenge for the sector.

The approach to managing effluents has to focus on the 3R principles. It should be imperative for companies to - replace the inefficient processes and hazardous materials; reduce the water consumption, energy consumption and chemical usage to the extent possible; and recycle/ reuse the treated effluent by adopting zero liquid discharge.

However, an important pre-requisite will be to identify major water-using processes and equipments at each production unit. This should lead to the development of a complete water balance for the industry. A water balance will help in identifying areas where water can be saved. Monitoring the water balance at frequent intervals would help in implementation of water conservation practices.

Companies across the FICCI membership are realizing the need to reduce their water footprint. There is a growing understanding on looking at water use in the entire production cycle. This becomes significant considering the demand for industrial water is set to rise. The water demand for the industrial sector will account for 8.5 and 10.1 per cent of the total freshwater abstraction in 2025 and 2050 respectively. This is a 4 per cent rise from the current level of 6 per cent of the total freshwater abstraction by industry in 2010.

The report Water Management in Chemical Industries is therefore important in highlighting some of the best practices adopted by the industry in minimizing freshwater intake, enhancing effluent treatment and reuse. An important aspect of the case studies presented is the importance given to zero liquid discharge.

Naina Lal Kidwai
President, FICCI
Country Head HSBC India and Director HSBC Asia Pacific

Message



The chemical industry is critical for the economic development of any country providing products and enabling technical solutions in virtually all sectors of the economy.

Water is a key component in the chemical sector and is required for multiple processes. The Indian chemical sector is growing rapidly and with the increase in production, the water requirement would also increase. Availability of water can become a limiting factor for the sector. There is a need to encourage technologies which are water efficient to facilitate sustainable growth of the industry. Efforts to conserve water, wastewater treatment and reuse need to be encouraged. FICCI Chemical Committee has identified freshwater minimization and wastewater treatment/ recycling as an important area of work for sustainable future.

The publication 'Water Management in Chemical Industries' is an attempt to highlight the efforts of Indian chemical industries in the area of water management. The case studies documented in the publication depict a variety of measures various industries have undertaken. These range from desalination, rainwater harvesting, wastewater treatment, and introduction of less water intensive technology.

I hope that the publication will serve as a valuable resource and would enable sharing of best practices within the chemical sector.

Deepak C Mehta
Chairman – FICCI Chemicals Committee
Vice Chairman and Managing Director
Deepak Nitrate Limited



Background Paper

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Introduction

Chemical industry contributes significantly in improving the quality of life through breakthrough innovations like pure drinking water, reliable medical treatment, stronger homes and greener fuels. The chemical industry is critical for the economic development of any country, providing products and enabling technical solutions in virtually all sectors of the economy. With the current size of approximately US$108 billion, the Indian chemical industry accounts for around 3 per cent of the global chemical industry[1]. In the base case scenario, with current initiatives of industry and government, the Indian chemical industry is expected to grow at 11 per cent per annum to reach size of US$224 billion by 2017[2].

The chemical industry is among the most diversified industrial sector, including basic chemicals and its products, petrochemicals, fertilisers, paints, gases, pharmaceuticals, dyes, etc. The sector covers over 70,000 commercial products, and provides the building block for many downstream industries, such as finished drugs, dyestuffs, paper, textiles, synthetic rubber, plastics, polyester, paints, pesticides, fertilisers and detergents.

Based on a more functional classification, chemicals sector may be divided into following sub segments:

1. **Basic organic chemicals:** Organic chemical segment is one of the most significant sectors of the chemical industry. It plays a vital developmental role by providing chemicals and intermediates as inputs to other sectors of the industry. Methanol, acetic acid, formaldehyde, pyridines, phenol, alkyl amines, ethyl acetate and acetic anhydride are the major organic chemicals produced in India.

2. **Speciality chemicals:** Speciality chemicals are defined as a group of relatively high value, low volume chemicals known for their end use applications and/ or performance enhancing properties. Speciality chemicals include paints and coatings, speciality polymers, plastic additives, textiles chemicals, flavours and fragrances, cosmetic chemicals, rubber chemicals etc.

3. **Chlor Alkali:** The chlor alkali industry is the oldest and largest segment of the inorganic chemical industry. It comprises of caustic soda, liquid chlorine and soda ash.

4. **Pesticides:** Pesticides industry has developed substantially and has contributed significantly towards developing India's agriculture and public health. In value terms, the size of the Indian pesticide industry is US$3.8 billion in the year 2011[2]. India is a predominant exporter of pesticides to United State of America (USA), Europe and African countries.

5. **Dyestuffs:** Indian colorants industry is estimated to be at US$3.4 billion in financial year 2010 with exports accounting for 68 per cent[2]. In the XI Five Year Plan, the dyes industry witnessed a growth of 9.5 per cent. The current overall production capacity of dyestuffs is 200,000 tonne per annum and that of pigments is 150,000 tonne per annum[2]. India has emerged as the exporter of dyestuffs and intermediates, particularly in reactive, acid, direct and VAT dyes and some key intermediates. The basic raw materials used for the manufacture of dyestuffs are benzene, toluene, xylene and naphthalene (BTXN). Driven by robust exports growth, the Indian colorants industry has set a target to grow from the present US$3.4 billion to US$7.5 billion by 2017. The targets imply that the industry must grow at a rate of 12 per cent per annum over the XII plan period[2].

6. **Alcohol based chemicals:** Alcohol is a key feedstock for the manufacture of basic chemicals. Alcohol based chemical industry occupies an important place in the Indian chemical industry and is a key contributor to the growth of the sector. The current size of alcohol based chemical industry is US$1.1 billion[2]. Industrial alcohol in India is produced from sugarcane molasses. A large number of alcohol based products are manufactured in India. Some of the important alcohol based chemicals are acetic acid, acetic anhydride, acetaldehyde, ethylene glycol, glyoxal, pyridine/ picoline, pentaerythritol, ethylene oxide derivatives etc.

Water Use in Chemical Industries

Water is a key raw material for the chemical sector. Unlike other industrial sectors, the chemical industry is characterized by a wide variety of products and processes. Hundreds of different chemicals are produced, and there can be several routes for manufacture of a given product, so the water use for a particular product might vary significantly across companies. The largest use of water in the chemical industry is for cooling, with steam (e.g., heating and autoclaving) and process water (for mixing, dilution, reactants, wash, or rinse water) being the other significant uses. Chemical facilities are made up of varying combinations of these unit processes and water flows between the processes.

Historical data on distribution of water use at the facility level is not available. However, it is estimated that process cooling, process dilution, and steam production represent the most significant water uses at chemical facilities.

Broadly classified, water can be used as process water, process support water and plant services water in any industry. Some of the common uses of water in a chemical plant are indicated below:

Dilution: Dilution is the process of reducing the concentration of a solute in solution, simply by mixing with more solvent. For example, if there are 10 grams of salt (the solute) dissolved in 1 litre of water (the solvent), this solution has a certain salt concentration. If one wants to reduce its concentration by 50 per cent, one would have to add 1 litre of more water to this solution. The diluted solution would contain the same 10 grams of salt but with reduced concentration. In many chemical processes water is used as a solvent to reduce the concentration of solute in the solution.

Dissolution: The process of dissolution occurs when a solute is placed in contact with a solvent and it dissolves to form a solution. Water is used as a solvent for making solution of chemicals. The chemicals change their state from solid or gas to liquid when comes in contact with water.

Cooling: Water is used in process cooling (i.e. direct heating and cooling of chemical reactions) as well as cooling of the plant (i.e. in cooling tower). Chemical industries usually have very large comfort-cooling (reducing air temperature of building for comfort or process control) and process loads. Industries often use 100 per cent outside air for ventilation. This makes their comfort cooling loads higher than those of most other industries. Additional cooling is often needed for special equipment such as lasers and electron microscopes. Around 30 to 60 of all the water used in chemical industries is for cooling[3].

Glassware washing and rinsing: Water is used in washing and rinsing of laboratory glassware and equipments. The water required for glassware and equipments washing and rinsing is purified water or distill water. In some cases, a

solvent is also used for cleaning purpose. Some specific types of equipments like water-disinfectants require special quality of water that depends on the equipment.

Steam generation: Water is used in generating steam for various chemical processes (e.g. in autoclaving). Only distilled water is recommended for generating steam. Water is integral to the function of an autoclave. For this reason, it is very important to use only distilled water or water that has been treated for use in a sterilizer (typically, de-ionized water).

Service Water: Water is used for maintenance and plant wash-up activities, flushing, hand washing etc. in the plant and for safety related activities like fire fighting, deluge system etc. The service water is generally groundwater or municipal supply water. Some industries also recycle treated wastewater for use as service water.

Potable Water: Water is used for drinking water for the employees in plant. Groundwater or municipal water or mineral water is generally used as potable water.

The various processes in the worldwide chemical industry have the capacity to use over 100 trillion gallons of water annually[3]. Although there are some consumptive uses, such as water in the product and evaporative losses, most water used by the chemical industry is for return-flow applications. In fact, most of the water is used as non-contact cooling water, without contacting the chemical being produced. The exact quantity of water that is consumptive is unknown. However, it is estimated that less than 5 per cent of water used is incorporated into final products in the chemical industry[1].

Out of all the segments of chemical industries, dyestuffs use the maximum amount of water as water is an important component in the manufacturing of colorants. On an average about 50,000 litres of water is required to process one tonne of colorant. The estimated water requirement to meet target of XII Five Year Plan (to reach US$7.5 billion by 2017) would be around 150 million litres per day[1]. The exact quantity of water requirement for other segments is still unknown. Industries need to come forward for water disclosure so that a database could be prepared which would help in benchmarking water consumption in various processes.

Effluent Generation and Minimization

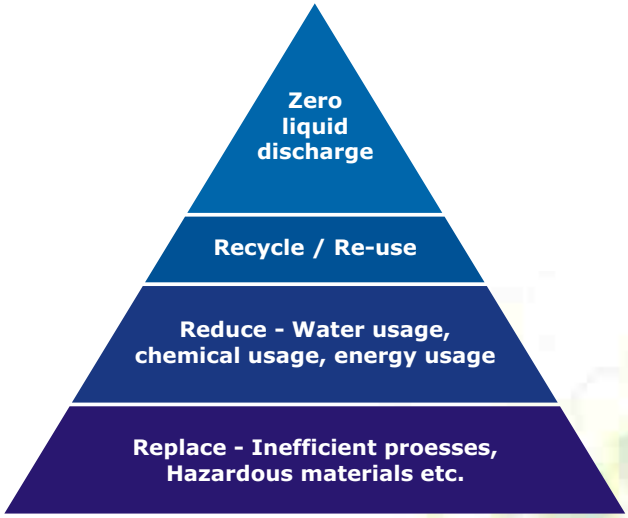
Water is mainly used as a media in chemical manufacturing processes. Most of water used by the chemical industry is for return-flow applications which results in large quantity of effluent generation. Effluent becomes a major concern for chemical industries. The effluents produced by this sector often contain organic and inorganic matters in varying concentration.

Many materials in the chemical industry are toxic, mutagenic and carcinogenic or non-biodegradable. Surfactant, emulsifiers and petroleum hydrocarbons that are being used in chemical industry reduce performance efficiency of many treatment operations. The best strategy for treatment of toxic industrial wastewater is to segregate the waste chemicals/ solvents at the source and by applying onsite treatment within the production lines with recycling of treated effluent.

Effluent minimization

Effluent minimization coupled with recycling is a very effective strategy to conserve water and solve the wastewater problem. Effluent minimization implies the reduction of quantity and quality of effluent at source by resources (raw material, water, energy etc.) conservation and the promotion of re-use/recycle. For example solvent recovery is an important means by which both the quantity and quality of the effluent can be improved. Solvents which cannot be recovered at source should be segregated and sent to authorized vendors for recycling/ reuse.

The effluent can be minimized by adopting the three 'R' principles i.e. replace the inefficient processes and hazardous materials, reduce the water consumption, energy consumption and chemical usage to the extent possible and recycle/ reuse of the treated effluent and finally by adopting zero liquid discharge.



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Water Conservation Measures in Chemical Industry

- **Creating a water balance:** The first step is to document all major water-using equipments and processes at the site with usage amounts and prepare a complete water balance for the industry. It would help in identifying the possible areas where water can be saved. Monitoring the water balance on frequent intervals would help in implementating water conservation practices.

- **Increasing Cycles of Concentrations (COC):** Cooling towers use water in three ways: evaporation, drift, and bleed-off or blow-down. A huge amount of loss occurs in the cooling tower in the form of evaporation, drift and blow-down loss. Make up water is provided to compensate for these losses. Since the water is circulated many times in the close loop, the concentration of dissolved solids in the circulating water increases over a period of time which decreases the cooling efficiency of the tower. Thus, water is intentionally wasted and make up water is use to compensate the loss in order to reduce the concentration of dissolved solids. The cycle of concentration (COC) is the ratio of dissolved solids in the circulating water to the make-up water. Cooling towers are normally designed for a COC of around 5. By increasing COC, the blow down water can be reduced[4].

  The best way to increase the cycles of concentration is through better monitoring and management of the water chemistry. The first step is to understand the quality of the incoming water and what the controlling parameter should be, such as hardness, silica, or total dissolved solids. There will be a relationship between these parameters and conductivity, based on the water chemistry specific to a site. This relationship can help to establish a conductivity set point. The conductivity controller opens a blow-down valve as needed to maintain your control parameter within acceptable limits. Special features of towers and water systems that promote water efficiency include side-stream filtration, sunlight covers, alternative water treatment systems, and automated chemical feed systems.

- **Use of blow-down water or reverse osmosis (RO) rejects:** The blow-down water from cooling tower and/ or the RO rejects can be used as service water in flushing and/ or as firefighting water. It can significantly reduce the amount of fresh water intake.

- **Equipment cooling:** Single-pass cooling typically consumes more water than any other cooling method in a chemical industry. In single-pass or once-through cooling systems, water is circulated once through a piece of equipment and then discharged in to the sewer. Single-pass systems use approximately 40 times more water than a cooling tower operating at 5 cycles of concentration to remove the same heat load[3]. The best way to combat the

water waste associated with single-pass cooling is to use a process or cooling loop. This loop provides water at a preset temperature to cool equipment. A small packaged chiller or central plant towers can reject the heat from these systems.

- **Reducing leaks and over flows:** Leakages from valves, taps, fire fighting hoses, underground fire fighting lines, cooling towers, gardening hoses account for huge amount of water loss. There lies a possibility of reducing the water consumption by plugging the leakages.
- **Scale-down approach:** The chemical process optimization can be achieved by scale-down approach wherever possible. It would not only save resources but also lead to significant amount of water savings.
- **Equipment rinsing:** There is a significant opportunity to save water in rinsing process. A counter-current rinsing operation can result in significant saving of water. In counter-current rinsing, the flow of rinse water is opposite to that of the workflow.
- **Flow control:** Many equipments in a chemical industry remains 'on' continuously, even when the process runs only a few hours per day or a few days per year and water is continuously flowing to some of these equipments. Using a control or solenoid valve in these applications allows water to flow only when the unit is being used. Another option is to use shut-off valves or timers to turn equipment off after normal working hours and when a process is shut down for maintenance or other reasons. This can result in significant amount of water as well as energy saving.
- **Wastewater recycling:** Studies have shown that water is mainly used as a media in chemical processes resulting in high amount of wastewater/ effluent generation. There is huge opportunity of recycling/ reuse of wastewater/ effluent after necessary cost effective treatment. It will not only reduce the intake of freshwater but also help in reduction of contamination of nearby freshwater resources.
- **Use of treated municipal wastewater:** Reclaimed wastewater is an option in limited circumstances, when an industry has access to municipal wastewater that has been treated to a secondary disinfection level. Reclaimed wastewater can be use for some non-potable applications, such as service water, fire fighting water, and cooling tower make-up etc.

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3. Labs for the 21st Century, 'Water Efficiency Guides for Laboratories by EPA and US department of Energy' - http://www.i2sl.org/documents/toolkit/bp_water_508.pdf last accessed on August 21, 2013
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Case Studies

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Organisation:
Chemplast Sanmar Limited

Location: Raman Nagar, Mettur Dam, District-Salem, Tamil Nadu

Types of chemicals and production capacity of the plant:

Chemicals	Production capacity (MT) (2011-12)
Refrigerant Gas HCFC 22	1,663.2 MT
PVC including manufacturing of intermediate raw material Vinyl chloride (VCM)	6,600 MT
Caustic	48,048 MT
Chlorine	42,570 MT
Chloromethane	33,580 MT

Water consumption:

Chemicals	Water consumption (m^3)			Specific water consumption (m^3/unit of production)			Source of Water
	2009-2010	2010-11	2011-12	2009-2010	2010-11	2011-12	
Refrigerant Gas HCFC 22	23,230	26,433	25,531	58.2	58.8	58.5	Surface water (Stanley reservoir)
PVC including manufacturing of intermediate raw material Vinyl chloride (VCM)	5,06,252	4,36,243	4,52,574	16.59	14.92	15.13	
Caustic	1,59,432	2,45,503	1,50,873				
Chlorine				2.03	2.45	2.40	
Chloromethane				3.68	3.6	3.60	

Water conservation measures:

- Reuse of polymer effluent to cooling tower saving 14,600 m^3 of water annually.
- Treated effluent use for dust suppression at coal storage of power plant saving 5,840 m^3 of water annually.
- Use of dilute acid stream from the incinerator to enrich the salable acid saving 13,840 m^3 of water annually.
- Use of Alkali portion of demineralization (DM) plant regeneration stream for brine preparation saving 5,185 m^3 of water annually.
- Use of part of treated sewage water to cooling tower saving 44,895 m^3 of water annually.
- Reuse of strong base anion (SBA)/ weak base anion (WBA) rinse water to cooling tower saving 2,800 m^3 of water annually.
- Installation of Air Cooled Condenser (ACC) for cooling tower for coal based power plant saving 3,000 m^3 of water daily.



Air cooled condenser



Rainwater harvesting pit

Wastewater generation and treatment:

Total wastewater/ effluent generated during the year 2011-12 was 3,70,870 m^3 from all the three plants. All of which is treated and 100 per cent of the treated effluent is recycled back to industrial processes. Effluent treatment plant (ETP) treated water is mixed in equalization tank and further treated by clarifiers, filters, softeners and High Efficiency Reverse Osmosis (HERO) unit. The process is unique in nature as the entire wastewater is converted in to the sodium salts through an exhaustive pre-treatment process.

Effluent reduction measures undertaken in the plant:

1. Removal of Ferric chloride along with few hundred ppm of acidity from crude Ethylene Dichloride (EDC) was done earlier with conventional static mixture resulting in equal volume of water washings with that of EDC. This system has been modified for effective mixing by adding wash water at pump suction instead of pump discharge, resulted only 0.35 KL of water/ KL of EDC - a reduction of 180 KL /day of effluent generation in the EDC washing area.

2. Oxy acidic effluent having organics is processed through distillation column to remove organics and reused for acid absorption to 30 per cent salable commercial HCL acid - a reduction of 40 KL/day of high TDS effluent.

3. Neutralization of acidic effluent generated during power failure at the acid area of PVC plant is eliminated by the installation of UPS to run the absorber feed water pump. Acidic effluent generated during the start-up and shutdown operation is used for acid make-up after removal of organics through distillation column. These two initiatives cumulatively resulted in reduction of 140 KL of effluent/day.

4. A new polymer effluent treatment system was implemented to remove PVC particles from process water and the recovered water is reused in the cooling tower. This resulted approximately 400 KL /day of water savings.

5. Alkaline portion of the ion-exchange column of the regeneration effluent of caustic soda membrane plant and demineralised (DM) water regeneration effluent are being used for brine preparation plant resulting in reduction of 40 KL /day of effluent.

6. Recycle of the lean effluent stream generated from the cooling tower blow down is recycled to the scrubber as an acid absorption media in refrigerant plant to become a "zero discharge" plant.

Volume of water and cost saved

Measures undertaken	Year of implementation	Annual water saved (m^3)	Annual cost saved (INR in Lakhs)
Reuse of polymer effluent to cooling tower	2010	14,600	2.08
Treated effluent used for dust suppression at coal storage of power plant	2010	5,840	0.82
Usage of part of ZLD reject for lime preparation for chlorine absorption	2010	9,380	1.28
Usage of dilute acid stream from the incinerator to enrich to salable acid	2010	13,840	1.95
Usage of alkali portion of DM plant regeneration stream for Brine preparation	2010	5,185	0.75
Usage of part of treated sewage water to cooling tower	2010	44,895	6.35
Reuse of SBA/WBA rinse water to cooling tower	2011	2,800	0.41
Usage of activated carbon filter (ACF) outlet water for chemicals (lime & soda ash) makeup at ZLD	2012	7,300	1.06

Company profile:

Chemplast Sanmar is the flagship company of The Sanmar Group. The Company is a major manufacturer of PVC resins, Caustic Soda, Chlorochemicals, Refrigerant gas and Industrial Salt. The manufacturing facilities are located at Mettur, Cuddalore, Panruti and Vedaranyam in Tamil Nadu and Karaikal in the Union Territory of Puducherry. At Chemplast, integration – forward and backward – is the key. The basic feedstock for its PVC plant at Mettur, alcohol and chlorine, comes from its industrial alcohol plant at Panruti and chlor-alkali facilities at Mettur and Karaikal.

Chemplast has played a pioneering role in the field through its ingenious choice of feedstock and manufacturing processes, and efficient, eco-friendly practices. Its constant development of environment-friendly production processes has reduced the consumption of valuable natural resources including water.

Contact Person
Mr. S. Venkatesan
Chief Executive - Operations
Email: sv6@sanmargroup.com

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Organisation:
Jubilant Life Sciences Ltd.

Location: Bhartiyagram, Gajraula, District – Jyotiba Phule Nagar, Uttar Pradesh

Types of chemicals and production capacity of the plant:

Product	Quantity	Unit	Product	Quantity	Unit
Ethyl alcohol	1,14,800	KBL	3-Cyanopyridine	4,200	MT
Acetaldehyde	1,08,330	MT	Fine chemicals	5,128	MT
Acetic anhydride	33,000	MT	Formaldehyde	1,56,750	MT
Ethyl acetate	46,200	MT	Biogas	561	LNM^3
Carbon dioxide	37,620	MT	Steam	24,00,240	MT
Pyridine & Picoline	52,000	MT	Power	3,67,920	MT

Water consumption:

Chemicals	Water consumption (m^3)			Specific water consumption (m^3/unit of production)			Source of Water
	2009-2010	2010-11	2011-12	2009-2010	2010-11	2011-12	
Ethyl alcohol	19,404	15,723	1,77,671	5.2	5.18	5.02	Ground water
Acetaldehyde	1,71,959	1,73,028	1,75,113	3.15	3.11	3.08	
Acetic anhydride	1,91,822	1,84,320	1,57,660	6.7	6.60	6.02	
Ethyl acetate	1,57,174	1,51,992	1,89,011	5.2	5.19	5.05	
Carbon dioxide	15,336	6,380	1,26,255	12.78	12.76	12.59	
Pyridine & Picoline	7,51,976	6,72,538	7,34,889	20.38	19.86	17.72	
3-Cyanopyridine	88,264	77,785	1,20,713	37.4	37.34	36.25	
Fine chemicals	2,23,270	2,10,740	1,52,937	128.1	127.9	106.09	
Formaldehyde	79,295	95,491	71,589	1.0	0.99	0.75	
Biogas*	468	0	3,280	26.15	0	20.0	
Steam	12,41,513	11,93,476	12,87,998	0.865	0.864	0.855	
Power	1,50,704	1,52,320	1,37,101	1.1	1.1	0.90	

** Biogas was not in use in 2010-11*

Water conservation measures:

- Optimising Cycle of Concentration (COC) of cooling towers saving 1,05,000 m^3 of water annually.
- Recycling of steam condensate after heat recovery as a substitute of soft water saving 4,93,092 m^3 of water annually.
- Reverse Osmosis (RO) permeate is recycled in distillery for molasses dilution.
- Slop Fired Boiler condensate is recycled back to the distillery for molasses dilution.
- Installation of Cooling Tower-Reverse Osmosis (CT-RO) plant to treat cooling tower blow down water saving 1,54,576 m^3 of water annually. CT-RO permeate is used for cooling tower make up.
- The treated water from Common Effluent Treatment Plant (CETP) and Sewage Treatment Plant (STP) is used for horticulture purpose.
- Recycling of RO permeates & CO_2 scrubbing water for molasses dilution.
- Multi Effect Evaporator condensate is recycled in cooling tower make up.
- Rainwater harvesting of 2,91,550 m^3 annually through rainwater harvesting ponds since 2008.

Wastewater generation and treatment:

Total wastewater/ effluent generated during the year 2011-12 was 10,69,318 m^3 all of which is treated. Approximately 40 per cent of the treated water is recycled back into the industrial process and rest is used for horticulture purpose thus maintaining zero water discharge. The various wastewater treatment measures employed in the plant are:

- Common effluent treatment plant for treatment of industrial effluent.
- Sewage treatment plant for treatment of domestic water.
- Biogas plant for generation of biogas from distillery effluent (Spent wash).
- Reverse osmosis for treatment of Bio-methanated effluent of Biogas plant.
- Cooling Tower-Reverse Osmosis (CT-RO) for treatment of cooling tower blow down
- Slope Fired Boiler for treatment of distillery waste (Spent wash)
- Multi-Effect Evaporation (MEE) for treatment of pyridine plant effluent.



Slop Fired Boiler



Incinerator and Multi-Effect Evaporator

Distillery water management (technology advancement)

Conventional Technology Bio-gas, RO & Bio-compost.	Advanced Technology MEE & Slop Fired Boiler
Low recovery (50 per cent)	High recovery (83 per cent)
Cost of operation (-) 42 Rs/ m^3	Cost of operation 158 Rs/ m^3
Cost of investment (Rs 180 crore)	Cost of investment (Rs 60 crore)
Investment Rs 1.0 crore/ KBLD of Alcohol.	Investment Rs 0.5 crore/ KBLD of Alcohol.

Jubilant Life Sciences has been maintaining zero discharge liquid since November 2005 visibly demonstrating its commitment. To maintain this status, new technologies have been adopted to increase water recovery, despite high operating cost. Jubilant Life Sciences has invested Rs. 165 crores in its effluent treatment facility and also been spending around Rs. 49.2 crores per annum towards operating cost.

Volume of water and cost saved

Measures undertaken	Year of implementation	Annual water saved (m^3)	Annual cost saved (INR in Lakhs)
Optimization of COC of cooling towers	2005	1,05,000	0.51
Recycling of steam condensate after heat recovery as a substitute of soft water	2010	4,93,092	0.72
Rain water harvesting	2008	2,91,550	0.43
Installation of Multi-Effect evaporators (2nos) MEE-1 MEE-2	 2008 2009	4,21,862	0.62
Slop Fired Boiler	2009	70,204	0.10
RO (2nos) 1st 2nd	 2005 2008	1,41,712	0.21
Installation of Cooling Tower-Reverse Osmosis (CT-RO) plant to treat cooling tower blow down water	2008	1,54,576	0.23

Company profile:

Jubilant Life Sciences Limited is an integrated Pharmaceutical & Life Sciences company. Jubilant is the largest Custom Research and Manufacturing Services (CRAMS) company and one of the leading Drug Discovery and Development Services (DDDS) companies of India. The Company's strategic focus is to innovate, collaborate and accelerate the process of delivering products to the market for its customers which has resulted in Jubilant being successfully positioned as an outsourcing partner of choice. The Company through its presence in India, USA, Canada, Europe and China constantly serves its customers spread across 98 countries.

Jubilant believes that long-term sustainability can be achieved by good performance in the social, environmental and financial areas. The concept of 'sustainability' has been built on the foundation of company's promise i.e. caring for environment, sharing the economic value and growing with all stakeholders.

Contact Person
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HSBC

Organisation:
LANXESS India Pvt. Ltd.

Location: Jhagadia, District - Bharuch, Gujarat

Types of chemicals and production capacity of the plant:

LANXESS is a multiproduct manufacturing facility. The plant at Jhagadia manufactures liquid purification technologies, rubber chemicals, high performance materials, material protection products and additives and release agents.

Water consumption:

Year	Annual water consumption (m^3)	Production capacity of the plant (MT)	Specific water consumption (m^3/MT)	Source of Water
2010-11	83,836	2,899	47.97	GIDC (Surface water)
2011-12	2,64,864	9,352	33.71	
2012-13	3,43,384	16,660	21.41	

GIDC - Gujarat Industrial Development Corporation

Note: Boiler water has not been included. This data is only for process water consumption at the site.

Water conservation measures undertaken:

1. **Sewage treatment plant:** Installation of 100 m^3 capacity sewage treatment plant (STP) in 2013 for the treatment of sewage water generated in the plant. The treated sewage is further recycled and utilized for the purpose of gardening.
2. **Sprinkler system for gardening:** Installation of sprinklers in the green fields at site helped in saving of water.
3. **Self-closing taps:** Installation of self-closing taps throughout the site has reduced the wastage of water due to open taps and resulted in significant water saving.

Volume of water and costs saved

Measure undertaken	Annual water saved (m^3)	Annual costs saved (INR)
Sewage treatment plant	18,250	41,063
Sprinkler system for gardening	9,902	22,280
Self-closing taps	2,475	5,570
Total	**30,627**	**48,913**

Wastewater generated and treatment:

Total wastewater (effluent) generated from 2009 to 2013 is 12,78,874 m^3 from both process and boiler.

Future plans:

1. Reduction of specific water consumption by process improvement and recycling in the process.
2. Rain Water Harvesting – There is a potential for use of rainwater during monsoon to further decrease the water consumption.

Contact person

Mr. Namitesh Roychoudhary
Vice President- IEA & Capital Investment
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HSBC

Organisation:
LANXESS India Pvt. Ltd.

Location: Nagda, District - Ujjain, Madhya Pradesh

Types of chemicals and production capacity of the plant:

The LANXESS Advanced Industrial Intermediates Business Unit manufactures specialty chemicals that serve a wide range of application segments such as Agrochemicals, Pharmaceuticals, Dyestuff, Flavors & Fragrances and Coatings.

The major products are Benzyl Chloride, Benzotrichloride, Benzyl Alcohol, Benzaldehyde, Benzyl Acetate, Cinnamic Aldehyde, Benzyl Benzoate, Thionyl Chloride, Sulphuryl Chloride, Sodium Benzoate, Sulphur Dichloride and Black Pigment.

Water consumption:

Year	Industrial cooling water (m^3)	Domestic water (m^3)	Process water (m^3)	Water to cogen and boiler consumption (m^3)	Total water process (m^3)
2010-2011	93,291 - Fresh 2,51,622 - Treated Sewage	9,366 - Fresh	18,777 - Fresh	2,28,551 - Fresh	7,01,607
2011-2012	1,02,261 - Fresh 4,71,016 Treated Sewage	- 17,995 - Fresh	13,518 - Fresh	3,25,744 - Fresh	9,30,533
2012-2013	1,12,273 - Fresh 5,04,735 - Treated Sewage	28,107 - Fresh	14,830 - Fresh	3,72,654 - Fresh	1,032,598

Specific water consumption:

Name of Product	Specific consumption in m^3/ MT		
	2010 - 2011	2011- 2012	2012 - 2013
Benzyl chloride	1.04	1.03	1.03
Benzal chloride	1.54	1.54	1.54
Benzaldehyde	2.34	2.35	2.36
Sodium benzoate	2.38	2.37	2.38
Benzyl alcohol	3.63	3.64	3.64

Water conservation measures:

One of the noteworthy projects at this site is in the area of wastewater treatment. This is a region where water is rather scarce both for the residential areas and for the industries especially in the summer months. As a result, consistent efforts have been made to improve water utilization in the plant. Sewage water treatment plant has been installed to treat sewage water from the colonies and the treated sewage water is use in the production processes.

A wastewater post treatment - reverse osmosis (WWPT-RO) plant was installed in November 2012 with an investment of nearly INR 35 crores to treat the discharge of existing effluent treatment plant (ETP) in a manner that no liquid effluents are discharged from the site. The water from RO plant is used in the production processes, which has further bridged the gap in availability of water during the summer months.

Wastewater generation and treatment:

Total wastewater/ effluent generated during the year 2012-13 was 48,242 m^3. All of which is treated in ETP. Approx 16 per cent of the treated effluent is used in gardening inside plant while 50 per cent is discharged. The rest 34 per cent is sent to wastewater post treatment - reverse osmosis (WWPT-RO) system and after further treatment, recycled back to industrial processes. ETP treated water is mixed in equalization tank and further treated by clarifiers, filters, softeners and High Efficiency Reverse Osmosis (HERO) unit.

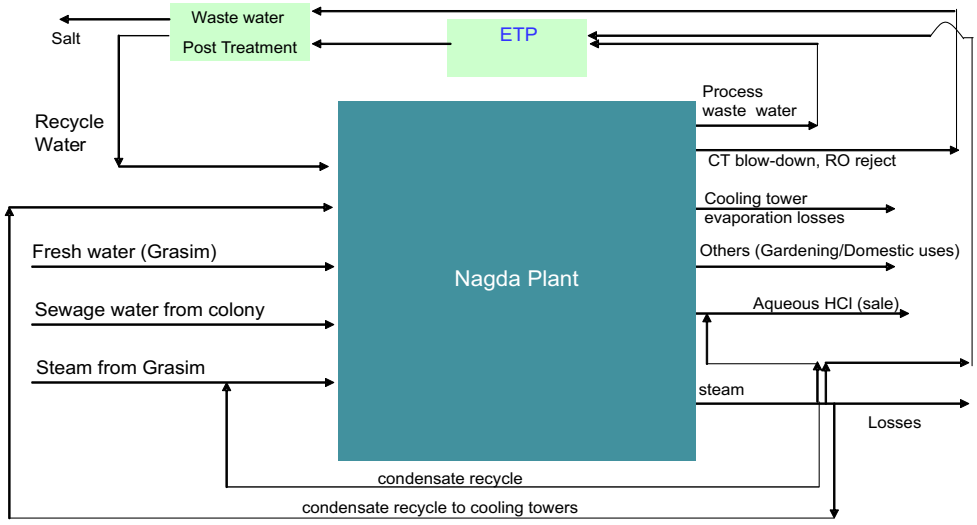
The process is unique in nature as the entire wastewater is converted in to the sodium salts through an exhaustive pre-treatment process. Wastewater post treatment (WWPT) includes evaporation plant, reverse osmosis plant, effluent treatment plant and sewage treatment plant including demineralised water storage.

- **Sewage treatment plant, existing RO and demineralised water storage:** Sewage water from the colonies is treated in the sewage treatment plant. A part of this treated water is used in the processes. The balance treated sewage is taken through the existing RO and demineralised water plant and stored in tanks. This is then used for cogen boiler feed water.
- **Effluent treatment plant (ETP):** Process wastewater from all the production plants is fed to this existing but revamped and modernized effluent treatment plant. This plant biologically treats these wastewater streams to comply with environmental norms. Prior to installation of the wastewater post treatment facility, this treated wastewater from the ETP was discharged into the river.
- **New R.O. plant:** Earlier, all wastewater streams were sent to the ETP. Consequent to a detailed analysis followed by lab trials and pilot runs using water samples from different sources, the influents to the reverse osmosis process were separated into three categories namely - treated effluent from process, effluent from cooling tower blow down and reject from existing reverse osmosis plant.

There are 2 RO units in this plant. The first RO unit is fed with the cooling tower blowdown and existing RO reject. The permeate from this 1st RO unit is re-used in the production processes. The reject from this RO unit is blended with the treated wastewater from the ETP and fed to the 2nd RO unit. The permeate from the 2nd RO unit is again used back in the production processes. The reject from the 2nd RO unit is fed to the evaporation unit of the new WWPT facility. This evaporation unit is one of its kind and using state of the art materials and technology from one of the reputed global industrial house.

- **Evaporator plant:** Reject from the new wastewater post treatment - reverse osmosis (RO) plant is fed to the evaporator. The recovered water from the evaporator is used back in the production processes.

Water Management Flow- Nagda



2

LANXESS

Company profile:

LANXESS India was incorporated in India on February 20, 2004, and was named as LANXESS India Private Limited on June 30, 2004. LANXESS India Private Limited, a wholly-owned subsidiary of LANXESS Deutschland GmbH is represented through all its fourteen business units, operating out of its registered office in Thane and sales offices in New Delhi and Chennai with 971 employees across its operations. The company also has manufacturing facilities in India for six of its business units. The manufacturing sites are located in Nagda in Madhya Pradesh and Jhagadia in Gujarat. Production facilities for business units Rubber Chemicals, Liquid Purification Technologies, High Performance Materials (high tech plastics), Material Protection Products and Rhein Chemie (polymer bound rubber chemicals,

additives and release agents) are operational in Jhagadia while that of Advanced Industrial Intermediates has a production facility in Nagda. LANXESS also operates a technical centre for Rubber Chemicals in Thane.

In all its activities around the world, LANXESS subscribes to the principle of sustainable development. The company's goal is to bring in line economic, ecological and social aspects within its corporate strategy. LANXESS is a member of the leading sustainable indices Dow Jones Sustainability Index (DJSI) World, FTSE4Good and the Carbon Disclosure Leadership Index (CDLI).

Contact person

Mr. Namitesh Roychoudhary
Vice President- IEA & Capital Investment
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Organisation:
Solvay Specialitites India Pvt. Ltd.

Location: Panoli, District - Bharuch, Gujarat

Types of chemicals:

Category	Chemicals
Speciality polymers	Poly Ether Sulphone (PESU)
	Poly Ether Ether Ketone (PEEK)
Monomers	Di Chloro Di Phenyl Sulphone (DCDPS)
	Di Hydroxy Di Phenyl Sulphone (DHDPS)

Water consumption:

Year	Annual water consumption (m^3)	Source of water
2009-10	28208	GIDC (Surface Water)
2010-11	50277	
2011-12	36438	GIDC + Ground water
2012-13	49992	

GIDC - Gujarat Industrial Development Corporation

Water conservation measures:

Various steps have been initiated for water conservation. Primary among them are the following two projects which involve innovative ways to re-use/ recycle water:

- **Ground water remediation (Project ACQUA)** - When Solvay acquired the polymer division; various site surveys were conducted in consistent with Solvay global commitment on operating its manufacturing sites with utmost environmental care. Even though fully compliant with the local regulatory requirements, Solvay had voluntarily implemented a water remediation unit with the permission of State Pollution Control Board to treat the historical contamination of the underground water. It is the first of its kind approval provided by the Gujarat Government to an industrial enterprise.

The method adopted for treatment was hydraulic containment. Under this scheme, on an average 240-250 m^3/day is being pumped from underground. This water is treated to such an extent that it meets stringent water quality requirements such as boiler feed water. The hydraulic containment system comprises of the following:

1. Installation of wells and abstraction of water from the wells,
2. Ex-situ remediation of groundwater - Air stripper followed by reverse osmosis (RO) system.

- The volatile organic matter in abstracted water is removed in air stripper.
- The organic free water is then fed to RO to reduce the dissolved solids.
- The permeate from RO is recycled back in to the process including application such as boiler feed water.
- The ratio of permeate water to reject water is around 80:20.
- The volatile organic matter from air stripper is adsorbed in activated carbon bed.
- The reject from RO is transferred to conventional effluent treatment plant.

The system runs round the clock and is operating successfully since last 23 months. Solvay is committed to run it consistently in the future.

❖ **Waste minimization (Project RIPPLE) -** In continuation to the sustainable commitment, Solvay has installed a world class innovative wastewater minimization plant, a first of its kind among all global operating industrial Solvay sites. This is used for the purpose of treating the final effluent to make it fit for re-use.

The technical scope included an upgrade of the existing Effluent Treatment Unit (ETU), Hardness Abatement Unit (HAU), Reverse Osmosis (RO) units and Multiple Effect Evaporator (MEE). With successful implementation the site re-uses up to around 80 per cent of wastewater generated from the plant.

- **Upgrade of effluent treatment unit for treating COD and BOD** - Additional equalisation tank, biodek, clarifiers etc were installed. In addition, automation of chemical oxidation system was taken up.
- **Hardness abatement unit (HAU)** - This unit reduces the hardness of feed water (Ca & Mg hardness). As otherwise, this could lead to problems in RO membranes and MEE.
- **Reverse osmosis (RO) units** - The clarified softened stream is processed after pH adjustment through a RO system. Permeate of sufficient quality is recovered and recycled as cooling tower make-up water.

- **Multiple effects evaporator (MEE) and polishing RO** - RO reject containing up to 50 per cent dissolved solids is further concentrated by evaporation. A three stage MEE is used to recover useable water from reject of RO. Recovered condensate water is then fed to polishing RO for recycle. Concentrated stream is dewatered in a centrifuge and sludge is sent for land fill.



Reverse osmosis plant



Multi effect evaporator

These systems are being operated successfully for the last 12 months. The quality of the treated water is very good even to be recycled as boiler feed water. The benefits realized through this project are:

- Reduced impact on receiving body of effluent,
- 40 per cent water savings.

This project was adjudged the "Best Design Project" in the 2012 International Water Association (IWA) Project Innovation awards held for Europe and West Asia.

Volume of water and costs saved

Measure undertaken	Year of implementation	Annual water saved (m^3)	Costs saved (INR in Lakhs)
Groundwater remediation			
(ACQUA project)	2011	1,20,000	24
Waste minimization program implementation (RIPPLE project) Reverse osmosis project (RO) Multi effect evaporator (MEE)	2012	72,000	14.5
Total		**1,92,000**	**38.5**

Replicability of the measures undertaken:

With this unit, Solvay presents a real sustainable development and provides a nice opportunity for replication in other sites because of the following reasons:

- **100 per cent legal compliance confidence:**

  The treated effluent discharge through this method consistently meets all the laid down parameters by Gujarat Pollution Control Board (GPCB). The quantity is also within the specified limit by GPCB.

- **Sustainable development:**

  As a result of re-use of treated effluent water, fresh water intake reduces drastically and effluent streams are effectively treated to considerably reduce its impact on the receiving body.

Future plans:

- As more experience is gained in operating these systems, optimization of operation will be done to derive further benefits.
- These projects provide a sustainable way of development applicability. Thus addition to this, other locations of Solvay will be considered for such initiatives.

Company profile:

As an international chemical group, SOLVAY assists industries in finding and implementing ever more responsible and value-creating solutions. The Group is firmly committed to sustainable development and focused on innovation and operational excellence. Solvay serves diversified markets, generating 90 per cent of its turnover in activities where it is one of the top three worldwide. The group is headquartered in Brussels, employs about 29,000 people in 55 countries with net sales of 12.4 billion euros in 2012.

Solvay Specialities India Private Limited (SSIPL) is a 100 per cent subsidiary of Solvay Group incorporated in 2005. It enhanced its India presence through acquisition of polymer business of Gharda Chemicals in the year 2006. The manufacturing unit is located in Panoli, Gujarat and the unit manufactures range of specialty polymers like Poly Ether Sulphone (PESU), Poly Ether Ether Ketone (PEEK), captive products Di Chloro Di Phenyl Sulphone (DCDPS) and Di Hydroxy Di Phenyl Sulphone (DHDPS).

Solvay recently inaugurated its Global Research, Development and Technology Centre at Savli, Gujarat. The centre will focus its efforts mainly on the development of high-performance polymers, organic chemistry, nano-composites and green chemistry. It is housed in a LEED certified green building which is energy and environment efficient sustainable building.

Contact Person

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Organisation:
Tata Chemicals Limited

Location: Mithapur, District – Jamnagar, Gujarat

Type of chemicals and production capacity:

Inorganic chemical complex producing Soda Ash and other marine chemicals, Vacuum Salt and Cement having total production capacity of 2.26 million MT per annum.

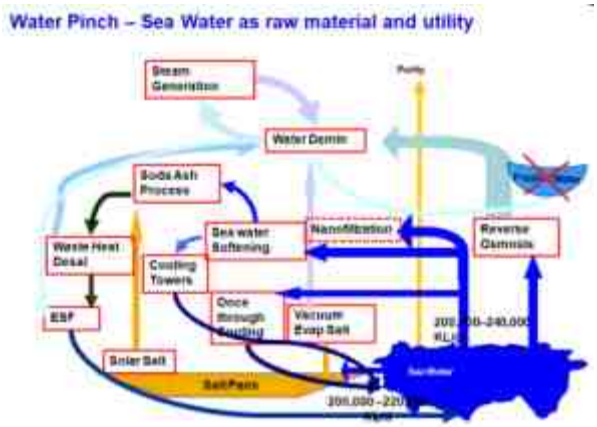
Water consumption:

Year	Annual Water Consumption	Production capacity of the plant (Million MT)	Specific Water Consumption (m^3 per MT of production)	Source of Water
2009-10	889,255	1.93	0.54	Rain Fed Lake
2010-11	1520,363	1.85	0.92	
2011-12	1454,506	2.09	0.76	
2012-13	802,461	2.36	0.39	

Out of total water requirement of Mithapur more than 97 per cent is met through sea water and water generated within complex through various processes like vacuum evaporation, thermal distillation, etc. The above table provides water consumption which is related to water withdrawn from external fresh water sources.

Water conservation measures:

Mithapur operations have steadily reduced its dependence on fresh water by effective process integration and water pinch analysis. Some of the conservation measures employed are - thermal desalination, softened sea water, substitution of raw water by sea water, water from effluent heat, sea water reverse osmosis (RO) etc. The option of nano-filtration is under consideration for future. The details of water conservation measures adopted by TCL, Mithapur are as follows -



- **Weak Liquor Distiller Still (WLDS):** WLDS is mainly used to remove the ammonia present in the condensate. Steam is used as stripping medium. Approximately 1.5 KL/tonne of soda ash of condensate is generated. Approximately 3600 KL/day condensate goes to water softening. WLDS is considered to be one of the major sources of water for this complex.



- **Make Up Water Plant (MUW):** This plant was established in early 1980's mainly to generate condensate for boiler feed water. The by-product of this plant is vacuum salt sold in the market under brand name Tata Salt. This is India's first vacuum evaporated iodized salt. Approximately 5.5 KL of condensate is generated per tonne of salt. On an average per year 20 lakh KL of water is generated from this plant.

- **Effluent Treatment Plant (ETP) and Desalination Plant:** The effluent from soda ash plant is of 100 °C. The effluent treatment plant contains 2 streams with flash chambers held under vacuum. The vapours from effluent treatment plant goes to desalination plant to desaline sea water.

  Desalination plant contains 4 cells (at a decreasing temperature from cell 1 to cell 4. Heat released by condensation allows a portion of spent cooling seawater to evaporate at a temperature of 65 °C in vacuum 22" Hg). Desalination plant combined with ETP plant gives raw water of about 100 KL/hr that goes to water softening

- **Steam condensate recycling:** The condensate from low pressure turbines and all process heating are recycled as boiler feed water.

- **Sea water reverse osmosis and nanofiltration:** 5,903 KL/ day based on sea water reverse osmosis plant is in operation. Nanofiltration to remove divalent ions (Ca^{2}+, Mg^{2}+ and SO_4^{2}-) from sea water is under pilot testing.

Volume of water and costs saved

Measure undertaken	Qty. of water saved m^3/ annum	Costs saved in INR
Internal generations (condensate, WLDS, MUW, etc.)	5,560,497	83,407,459

Wastewater generation and treatment:

Out of total water consumed (freshwater + seawater + internally generated water) around 88 per cent is generated as wastewater which is discharged in to Gulf of Kutch. Before discharging the wastewater, more than 90 per cent of it is used multiple times within the complex for various purposes.

Replicability of the measures undertaken:

Water conservation measures employed in the organisation can be replicated easly elsewhere also (e.g. desalination, distillation, seawater RO desalination unit, seawater based cooling system, softened seawater use for processes etc.).

Future plans:

The future plan is to achieve zero dependence on external fresh water sources for process water by means of effective internal generations and recycling.

Company profile:

Tata Chemicals Limited is a global company with interests in businesses that focus on LIFE: Living, Industry and Farm Essentials. Tata Chemicals is the world's second largest producer of soda ash with manufacturing facilities in Asia, Europe, Africa and North America. The company's industry essentials product range provides key ingredients to some of the world's largest manufacturers of glass, detergents and other industrial products.

Tata Chemicals' Mission, Vision and Values are deeply rooted in the principles of sustainability. For the company, sustainability encompasses stakeholder engagement, environmental stewardship, creating economic value, promoting human rights and building social capital. Tata Chemicals supports the UN Global Compact and is committed to reporting its sustainability performance in accordance with GRI guidelines. The company actively works towards improving its eco-footprint with a policy of 'avoid, reduce and reuse'. Resource optimisation, alternative sources of fuel and raw materials, and maximising reuse and recycling are key drivers in operations.

The company has been recognised for its clear commitments to sustainability and its good environmental management practices.

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FICCI Water Mission

Access to safe water is one of the essential elements for sustainable development and poverty reduction. However, the past few decades has seen an increase in demand amongst various water using sectors putting enormous stress on the natural resource.

FICCI constituted a 'Water Mission' to promote and provide thought leadership in the area of water efficiency. It aims to facilitate the sharing and dissemination of best practices across industry sectors in order to encourage corporate and industry players to imbibe a culture of water conservation within their organizations.

The Mission is working to create awareness on the existing situation pertaining to water scarcity, quality and generate a discourse on sustainable use of water amongst various users. With growing and extensive depletion and pollution of our water resources, our current work is being restructured to bring this issue back in focus to provide a sense of urgency to the debate of water management.

The objectives of the Mission's work are:

- To formulate suggestions for changes in policy framework in India for better water resource allocation, conservation and management;
- To promote fresh water conservation strategies across the irrigation, industry and domestic sectors;
- To document and disseminate best practices across various sectors and create a forum to facilitate exchange of information and experiences in the country;
- To promote new innovative technologies of water saving and management like rainwater harvesting, watershed management, desalination, water auditing and accounting across water intensive sectors through projects, workshops, conferences and training programmes.

Queries to FICCI may be directed to:

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