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# Case study of GHG reduction and sustainable solutions in a Chemical Industry with reference to the climate change action plan of the Puducherry region, India

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***Abstract:*** *Increasing vehicular traffic, expanding tourism and institutional sector contribute to the green house gases emissions in Puducherry region. Further, better health and educational facilities and cosmopolitan status of the living style have attracted many people migrating to the city and also transit to the city from the neighbouring districts. An effort has been made to estimate the greenhouse gases inventorisation of Puducherry in 2013. This has revealed that 3.46 million tonnes of $CO_2$ equivalent is emitted annually. The Government of India has taken a policy decision that all the new chlor-alkali plants will be of membrane based technology and had also set a deadline for phasing out of the highly polluting mercury technology. The total anticipated energy savings is around 30 % compared to the conventional mercury based chlor-alkali process. Hence, an attempt is made to analyse and explore the options / scope for the present emission of GHG emission and its potential reduction by appropriate interventions in a chlor-alkai industry situated in Puducherry region.*

***Keywords -*** *Biodiversity and carbon sequestration potential of plantation, Chlor- alkali industries, green house gases reduction, Hydro Chlor-alkali plant with heat recovery,membrane technology, Puducherry, Ultra filtration system for the treatment of brine.*

## 1. Introduction

The chemical industry is one of the world's largest industrial sectors. Chemical products and technologies are used in almost every area of the world economy. As the global economy grows, it increases the demand for the chemical industry's products. This growth drives product innovation, and the industry creates new products every year while striving to improve production processes and use resources more efficiently. The steam cracking for olefin production is the most energy-consuming process in the chemicals industry, accounting for emissions of about 180 $MtCO_2$/year and significant reductions are possible [1]. The chemical industry is highly diverse, with thousands of companies producing tens of thousands of products in quantities varying from a few kilograms to thousands of tonnes. Because of this complexity, reliable data on Green House Gas (GHG) emissions is not available. The majority of the $CO_2$- eq direct emissions from the chemical industry are in the form of $CO_2$, the largest sources being the production of ethylene and other petrochemicals, ammonia for nitrogen-based fertilizers, and chlorine[2]. These emissions are from both energy use and from venting and incineration of byproducts. In addition, some chemical processes create other GHGs as byproducts, for example $N_2O$ from adipic acid, nitric acid and caprolactam manufacture; HFC-23 from HCFC-22 manufacture; and very small amounts of $CH_4$ from the manufacture of silicon carbide and some petrochemicals [3]. Chemical products have a twofold effect on greenhouse gas emissions (GHGs): GHGs are emitted in the manufacturing of chemical products, whilst at the same time the use of many of these products enables significant reduction in global emissions. The emissions reduction enabled by the use of these products can be far in excess of the amount of GHGs emitted during their production. High-performance foam insulation of a house significantly reduces the heating required, thereby reducing energy consumption and GHG emissions [4]. Between 1990 and 2005, chemical production in the EU rose by 60 percent, while total energy consumption was stable. This meant that the chemical industry has cut its energy intensity by 3.6 percent annually. Absolute GHG emissions, meanwhile, fell by almost 30 percent. In UK, energy efficiency improvements, structural changes, and fuel switching lead to GHG emission reductions [5].

The Japanese chemical industry reduced unit energy consumption by 2002 to 90 percent of the 1990 fiscal year level – eight years ahead of target. By 2006, further improvements meant that the performance achieved was 82 percent of the 1990 level; Since 1974, the US chemical industry has reduced its fuel and power energy consumed per unit of output by nearly half. Since 1990 the US industry's absolute GHG emissions fell 13 percent, a reduction that exceeds the target of the Kyoto protocol; The Brazilian association members reduced specific overall energy consumption between 2001 and 2007 by 25 percent while increasing overall production by almost 30 percent. In other words, for every $GtCO_2$ emitted by the chemical industry in 2005, 2.1 to 2.6 $GtCO_2$ was saved via the products and technologies it provides to other industries or users.

Depending on the assumption and scope, the net $CO_2$emission abatement enabled by the chemical industry's products across the economy amounted to 3.6 to 5.2 $GtCO_2$+/- 30 percent in 2005. In comparism to total global emissions of 46 $GtCO_2$ in 2005, there would have been 3.6 to 5.2 $GtCO_2$, or 8 to 11 percent, more emissions in 2005 in a world without the chemical industry. The chemical industry's in global level has incremental abatement (composed of both own emissions and product savings) between the above two scenarios is 4.7 $GtCO_2$. This corresponds to 12 percent of the 38 $GtCO_2$abatement opportunity identified in the GHG abatement cost curve published by McKinsey & Company 2009. Furthermore, the chemical industry generates 5.5% of $CO_2$emissions (7% of global GHG emissions) and is responsible for 17% of industrial $CO_2$emissions (20% of the industrial GHG emissions). Energy consumption and GHG emissions associated with the manufacture of products are a major focus. In 2005, global GHG emissions across the chemical industry were 3.3 $GtCO_2$-eq (+/- 25%), with 2.1 Gt from the manufacture of products and 1.2 Gt from extraction of feedstock/fuel and disposal phases.

$N_2O$ emissions from industry (e.g. from adipic acid production in the chemical industry) have decreased sharply between 1990 and 1999 or 2000 in many countries, e.g. -95% in the UK, -88% in Japan, -60% in France and -55% in Canada [6-9]. These one-off reductions have helped some countries meet their aim of stabilising 2000 emissions at 1990 levels [10]. Perhaps the most rapid emission trends in industrial emissions over the 1990s were due to technology development, e.g. the ability to cost-effectively reduce $N_2O$ emissions from adipic acid production, reductions in GDP, e.g. in EIT countries, or from demand growth, e.g. for HFCs. To promote reduced $CO_2$ emission, which is a global problem, it is important that measures be taken from the perspective of pursuing total optimization through a full understanding of the life cycle of products, instead of considering partial optimization, such as that for the reducing $CO_2$ emission during manufacture[11].

The sustainable development of chemical industry must be based on the attempts of controlling the emissions of conventional toxic pollutants, as well as accelerating the emission reduction of GHG to protect the global climate. Up to 2010, the chemical production in US will reduce by 43 billion US dollars, which is 12.4% less than the estimation without emission reduction requirement. Chemical facilities with high energy cost, such as bases, fertilizer and chemical mining, will be affected seriously. Exportation of chemical produced will decrease 27% while the import will increase 11%. The chemical industry in US will reduce 120-150k staffs [12]. The present paper has made an attempt to examine GHG reduction and sustainable solutions in a Chemical Industry (Chlor-alkali Industry) in the Union Territory of Puducherry, India, with reference to the climate change action plan of the region.

## 2. Study area

The Union Territory of Puducherry spread in an area of 492 Sq. Km. comprises four erstwhile French establishments of Puducherry, Karaikal, Mahe and Yanam. The Union Territory of Puducherry consists of two districts, viz., Puducherry and Karaikal, situated at different geographical locations isolated from one another. Puducherry District comprises Puducherry, Mahe and Yanam regions. Karaikal regions forms the Karaikal District. Puducherry region, which is the largest of all the four, lies on the east-coast, and consists of 12 scattered areas lying in between $11^o$ 42' $12^o$ 30' N, and between $76^o$ 36' and $79^o$ 53' E. Karaikal region is about 150 Km. south of Puducherry and is sandwiched by Nagapattinam District of Tamil Nadu. It is located between $10^o$ 49' and $11^o$ 01' N, and $79^o$ 43' and $79^o$ 52' E. Yanam region is located between $16^o$ 42' and $16^o$ 46' N and $82^o$ 11' and $82^o$ 19' E. at about 840 Km. North East of Puducherry near Kakinada in Andhra Pradesh. Mahe region lies almost parallel to Puducherry between $11^o$ 42' and $11^o$ 43' N and $75^o$ 31' and $75^o$ 33' E at 653 Km. away on the west-coast near Tellicherry in Kerala.

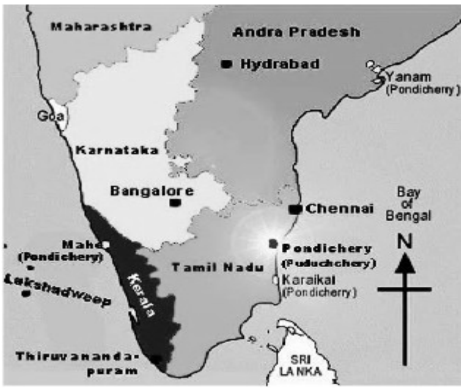


Figure 1: Map showing the four geographically disconnected regions of UT of Puducherry

## 3. Result and Discussion

### *3.1. Membrane technology*

Membrane technology plays a key role in the treatment of waste water and process streams. The immense potential of this technology has driven in chlor-alkali industry and its group companies, to explore the possibilities of its application in wastewater in general and brine treatment in particular. The best fit for Ultra filtration in chlor alkali industry is in the treatment of brine. In the process of brine treatment, the impurities present in the salt such as calcium and magnesium are transformed to insoluble moieties. Majority of the precipitated impurities are made to settle in the clarifier and remaining escapes in the overflow. The suspended solids in the brine overflow, is trapped in a series of filters to render the brine suitable for electrolysis, whereas the conventional brine treatment system in a chlor-alkali industry comprises of media filter and precoat filters for the removal of suspended solids in brine [13]


**Fig 2** Estimated GHG reduction made in the elimination of alpha cellulose

### *3.2. Production of soda ash from flue gas*

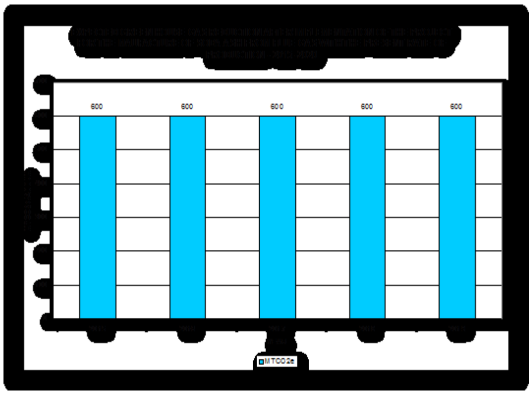


**Fig 3.** Expected GHG reduction for soda ash manufacturing

Soda ash or sodium carbonate is one of the raw materials in chlor-alkali industry, which is used for the treatment of brine. Impurities such as calcium salts are precipitated out by the addition of sodium carbonate. A technique for the production of sodium carbonate from the flue gas emanating from Thermic Fluid heater stack was developed and optimized. The sodium carbonate thus produced is being used for the treatment of brine thus eliminating the purchase of soda ash from the market [14,15].

*3.3. Biodiversity and carbon sequestration potential of plantation activities of Carbon stock*

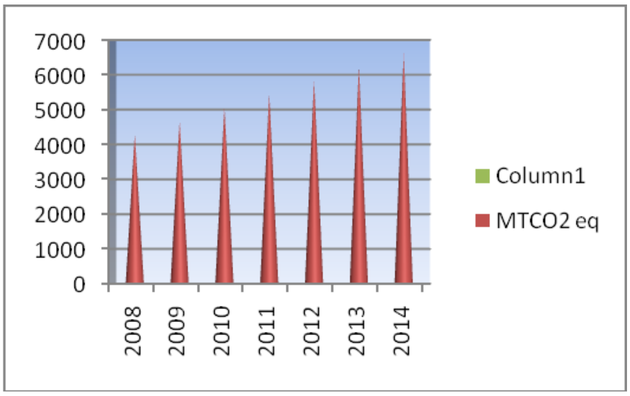


**Fig 4.** Carbon stock raised over the last 6 years.

The carbon stock from the plantation activities within the unit premises is estimated at 6625MT $CO_2$e. The CERs generated annually through plantation activities within premises 390 MT $CO_2$e.

*3.4. Membrane technology for sulphate removal and recovery of sodium sulphate – Elimination of chemicals*

The unit has been in the forefront of water conservation in the chlor-alkali sector. Its specific water consumption is lowest among the chlor-alkali sector in India. Various innovative techniques such as Membrane technology and Soda ash production has been implemented in chloro-alkali industry to recycling of wastewater and reduction of gas emission. An innovative technique of water conservation and elimination of barium salts for manufacturing has resulted in savings of 71540cum of water/ annum. This resulted in the reduction of 121.6 MT $CO_2$e / annum.

*3.5. Water conservation, recycle and Rain water harvesting*

Rivers, lakes and ground water are all secondary sources of water. At present, the chloro-alkali plant depends on any one of these sources.  Puducherry gets a rain fall of 1.392.2 mm on an average. The number of rainy days in the city range from 45-50 days in a year. The unit has carried out an ambitious programme on rain water harvesting and every year, sizable quantity of water is being charged into the aquifer.

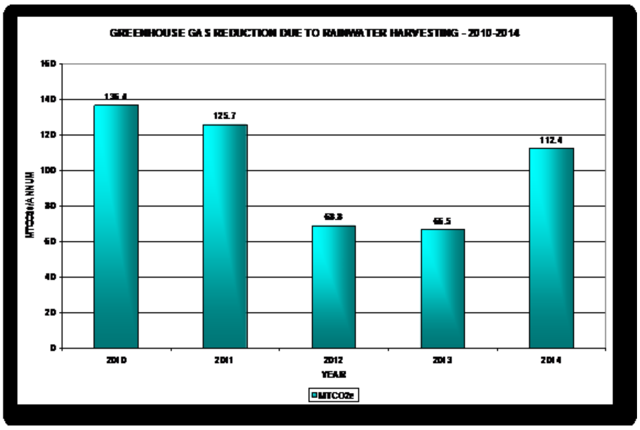


**Fig 5.** GHGs saved / avoided due to rain water harvesting during 2010-2014

*3.6. Hydrochloric Acid Plant With Heat Recovery System*

Hydrochloric acid is a strong acid that contains a hydrogen and a chlorine atom per molecule upon combustion form HCl gas which is absorbed in water to produce dilute hydrochloric acid. It is an important acid commercially and biologically, and this lesson will discuss the properties of HCl that contribute to these uses.

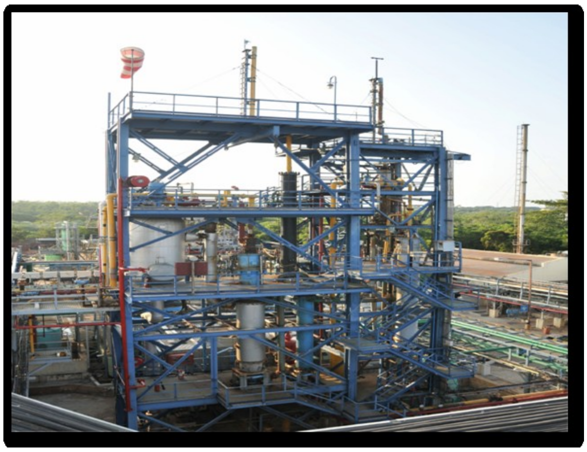

**Fig 6.** HCL Plant

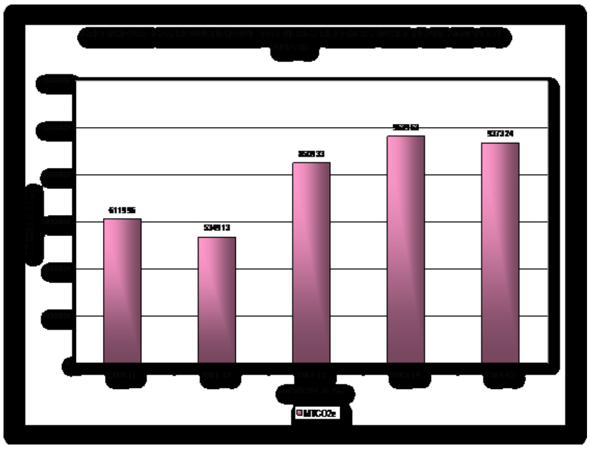

**Fig 7:** GHG reduction due to energy recovery in HCL Plant

Considerable heat is generated during the process which is normally absorbed by the cooling water. In this plant, about 50% heat is converted to steam, which is used in the caustic concentration plant. This improved process aids in energy recovery, reduced water consumption and reduction in the carbon footprint.

- GHG reduction equivalent to the reduction in energy consumption : 4600 $MTCO_2E$.
- GHG reduction equivalent to the reduction in water consumption : 21.42 $MTCO_2E$.

## 4. Conclusion

All industries are moving towards more efficient and low or zero emission processes due to economic benefits, regulation, and concern for health and the environment. New materials and process technologies are playing an increasing role in emission treatment and by product utilisation. This study examined the GHG reduction and sustainable solutions in a Chlor-alkali industry in Puducherry region. The results demonstrate the environment friendly and energy efficient Membrane technology - process to treat wastewater and process streams . The GHG reduction made in the elimination of alpha cellulose was around 73.3MT $CO_2$ and the greenhouse reduction for the last 5 years is 121.6 MT $CO_2e$ / annum. The unit has carried out rain water harvesting system for ground water recharge. based on these facts , it may be concluded that this chemical industry by implementing cleaner processes and pollution prevention measures have resulted in both economic and environmental benefits without any significant negative impacts on humans as well as the environment. Such low energy input, energy/resource efficient, economically feasible, reliable, and environmentally benign emission treatment technologies are highly sought after by the modern process scientists and engineers, indicating the future potential for replication/transfer of closed loop production.

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