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Sustainable Business Practices for Chemical Industries

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Abstract: ***Sustainable business practices are crucial in today's rapidly growing economy to ensure long-term ecological balance. Following green industrial practices contributes largely to the survival of industries as well as the environment in the long run. Chemical industries, in a country as large as India, substantially contribute to the overall GDP; however, the inadequacy in following sustainable business practices has resulted in the deterioration of the environment. The aim this paper is to understand the current practices of chemical industries and provide recommendations for making their manufacturing processes and business practices more sustainable. This study takes as basis, a previously conducted research work to assess industrial waste water of Lucknow district, and discusses the results in detail. The paper, in turn, focuses on implementing sustainable practices in the operations of chemical industries and the business strategies that are followed in other similar industries across the world. Moving forward, a roadmap of various sustainable business practices has been proposed for the Indian chemical industries, which can be up scaled considering their feasibility in India.***

Keywords: Chemical industries, sustainability, business practices, green industry

1. Introduction

We live in a technologically-enabled world where chemicals are used in almost everything we use on a regular basis. For instance, even the food we consume has chemicals such as Monosodium Glutamate, Sodium Nitrite, Guar Gum and Artificial Food Coloring [1]. These chemicals enhance the overall flavors and intensify colors. Chemical industries around the globe are primarily responsible for producing industrial chemicals and are majorly dependent on technology, science, and management. The chemicals produced here are used in the food products we consume, the fibre we wear, and even to fuel the vehicles we use for commute. Overall, it can be stated that using chemicals is inevitable.

Although chemical industries play an important role in improving the quality of our lives, certain business practices of these industries contribute to the deterioration of "Mother Earth."One major challenge faced by these industries is the disposal of chemical waste. Unsafe business practices, for example, disposing untreated chemical waste in sewers and water bodies, directly or indirectly, results in a multitude of environmental concerns: increased global temperature, overall climate change, rise in the ocean level, melting of ice caps, and so on. A study conducted by NASA used the Intergovernmental Panel on Climate Change (IPCC) report to assess changes in sea levels in India [2].The report predicted that large cities in India including metropolitan cities might submerge in the rising seawater level. This raises a serious concern for humanity.

In order to avoid such practices, the term "Sustainable business" came into existence. Sustainable business majorly deals with a set of sustainable and green business practices implemented with an aim to reduce the environmental impact caused by these modern industries. Most chemical industries in India adhereto a few environmental and health regulations, risk management and safety standards. However, no significant steps have been taken by them to prevent environmentally harmful activities. Modern industries today face major challenges while implementing sustainable business practices and green logistics in their supply chain due to excessive dependency on fossil fuel and lack of infrastructure to apply green logistics. Building a more sustainable and greener business is a powerful weapon to protect the environment against chemicals, and will soon become a necessity for businesses to sustain and grow in the near future.

In this paper, research conducted by K. Srivastava et. al. [3] is used as a reference and the existing state of chemical industries in Lucknow is discussed. The cited research work presents an analysis of a waste water sample from Indian Pesticide Limited, a chemical industry in Lucknow. This paper discusses the results of above-mentioned study in detail and highlights the implications explicitly. Feasible sustainable practices that chemical industries can consider as a step towards green manufacturing and eco-friendly processes are suggested in the paper. Following this, the paper also discusses solutions and sustainable business practices followed across the globe to deal with issues faced by similar industries.

2. Types of Chemical Industries

Some important considerations for chemical industries include energy usage, capital investment, rapid depreciation, price stability, and overall market competition. There are primarily five types of chemical industries [4].

a) **Agriculture chemicals**: The agriculture and allied sectors contributed 20.2% of Gross Value Added to India's economy in 2020-21 [5]. Mostly, pesticides and fertilizers are the two broad types of chemicals used in farmlands to grow and protect the crops. In the past few years, the pesticide industry in India, especially in Lucknow, has grown immensely. Chemicals industries

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such as Sakshi Fertilizers Pvt Ltd, Krishimitra Fertilizers Pvt.Ltd, C. Sri Sakthy Acids and Chemicals, among others, produce pesticides in large quantities.

b) **Inks, Dyes, and Paints** - From food products to textiles, leather, paints, plastic, inks, and so on, almost everything around us is dyed using synthetic colors. Dyestuffs are usually manufactured from Toluene, Xylene, Naphthalene, and Benzene. The per capita use of dyes in India, according to a feasibility report by Dyechem Industries is around 50 grams, whereas it is much higher in Europe and Japan, which are 400 grams and 300 grams, respectively [6]. The use of chemicals in these colors is harmful to humans as well as the environment. Some prominent Inks, Dyes, and Paints industries in Lucknow are Lakshmi Industry, Lucknow Color Company, and others.

c) **Petrochemical products and petroleum** - Another promising area of the chemical industry in India is the production of intermediates, petrol-based products, and petrochemicals: petroleum gas, Kerosene oil, Naphtha, Lubricating oil and Bitumen. These are the downstream products of oil and gas industries. In Uttar Pradesh, there are 15 units of petrochemical plants functioning at the moment. The most prominent ones are Allen Petrochemical and Radhika Petrochemical.

d) **Organic and inorganic chemicals** - The basic organic and inorganic chemical manufacturing companies play a pivotal role in providing chemicals as inputs to various sectors, including pharmaceuticals, paints, dyestuffs, pesticides, leather chemicals, alcohol, ethanol, formaldehyde, and others. Some of the world's major producers of organic chemicals are the USA, Germany, the UK, China, Japan, India, and Brazil.

e) **Chlor-Alkali, Light and Derived chemicals** - Another notable and oldest segment in the inorganic chemical industry in India is the Chlor-Alkali industry. These industries are mainly indulged in producing three products – Caustic soda, liquid chlorine, and Soda ash. One major Chlor-Alkali industry in Lucknow is DCM Shriram Limited, Lucknow.

Among the several renowned chemical industries known for producing high-quality chemicals like Bharat Chemical Industries, Sanjeev Chemicals, Bansal Chemical Industries among others. However, they might not be at the top when it comes to following sustainable or green practices.

3. Basis of Study

As mentioned in Section 1, this paper uses a previously conducted research [3] as a basis to understand the quality of industrial waste water produced from chemical industries and the harm it can cause to the environment. This section will discuss the research conducted by K. Srivastava et. al. titled "*Study on Physico-Chemical Parameters of Industrial Waste Water of Lucknow District*" in brief, along with an extensive discussion on their approach and findings. The above-mentioned research work takes Lucknow as the area of study – the capital city of one of India's most populous states, Uttar Pradesh. The choice of area in the study is intelligent since Lucknow is famously known for housing over 50 renowned chemical industries engaged in the production of chemicals that are further used in different industries. Some of the most prominent chemical industries set up in Lucknow are Mechelene Polymeric Industries, Bharat Chemical Industries, Shree Ji International Industries, Amrendra Chemicals, REP Fragrance & Chemicals and M/S Cooltech Enterprises, among others.

Many chemical industries in Lucknow are set up across water bodies purposefully due to easy availability of water for hassle-free disposal of wastes. The cited research uses a waste water sample (2 liters) collected from Indian Pesticide Limited (IPL), one of the most renowned chemical industries in Lucknow. The study also mentions that the rate of discharge in the water bodies such as ponds, rivers and lakes has increased drastically in the past few years to the extent that it is higher than the total purification rate. Due to excessive water contamination, the population around this area is vulnerable to several diseases. These chemical industries contribute significantly to the national economy; analyzing their business practices and the impact they have on the environment is crucial at both state and national levels. Hence, introducing green or sustainable business practices to conserve the environment for the upcoming generation is important.

The analysis of the water sample is done using different parameters such as pH, TDS, TSS, DO, BOD, COD, Hardness, Alkalinity and Chloride content (all parameters discussed in detail later in this section). Technologies like ultrafiltration systems, reverse osmosis systems, vacuum evaporators and filters, solid bowl centrifuges, tramp oil separators and paper bed filters are generally used to test and analyze these parameters. According to the cited study, these values exceed the prescribed limits. In the following discussion, the effluent standards for pesticide industries mentioned by the Ministry of Environment and Forests in its notification dated 13th June 2011 and those provided by the Bureau of Indian Standards (BIS) have been considered applicable [7].

- **pH** - pH shows how basic or acidic the water is. If the pH of water is above 8.5, the water starts to taste bitter. Although it does not cause any serious health issues it may lead to skin problems such as rashes and dryness. The BIS has set the pH limit for water between 6.0 and 8.5. The pH value of the IPL waste water sample was found to be 8.65, which is above the desired limit.
- **TDS** - TDS stands for total dissolved solids. It measures the combined amounts of organic and inorganic substances dissolved in water. Water with more than 500mg/L is unfit for consumption which can lead to several health issues. The waste water sample from IPL had a TDS value of 612.66 mg/L which is beyond the acceptable limit.
- **TSS** – TSS stands for total suspended solids, which is used for assessing the specimen quality of any type of water body. Higher TSS leads to adverse effects for both humans and the environment. The acceptable limit is within 100 mg/l, but the IPL water analysis gives TSS at 194 mg/l which is above the limit.
- **DO** - Dissolved oxygen (DO) is one of the most important parameters to check the water quality. More the DO, better the water quality. An extremely high DO level, however, speeds up corrosion in water pipes. The

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standard DO limit for drinking water is 2.3 - 5.9, but the waste water sample has a DO value of 9.5.

- **BOD** –Biochemical Oxygen Demand (BOD) is a parameter used to measure the total amount of oxygen needed to remove organic waste matter from the water. Higher the BOD value, more is the contamination. The standard BOD limit is 100 mg/l against 130 mg/l found in the waste water sample.
- **COD** - COD or chemical oxygen demand is the measure of oxygen equivalent of the organic matter in the water body. High COD indicates increased pollution of water. The permissible limit is to have COD not more than 250 mg/l, but the IPL waste water sample had COD at 324 mg/l.
- **Hardness** - When water passes through chalk areas or limestones, magnesium and calcium dissolve into it, and the water hardens. Extreme hardness in the water leads to adverse effects on aquatic organisms. Additionally, water with hardness above 300 mg/l of calcium carbonate is unfit for drinking. The IPL industrial waste water had a hardness of 501.
- **Alkalinity** - Alkalinity is the measure of the water capacity to neutralize acids. This is also called the buffering water capacity. The waste water sample had alkalinity of 430 which is above the desirable limit of 200 mg/l.
- **Chloride** - Chloride constitutes nearly 0.05% of the total earth's crust. High chloride affects the taste of water and can contaminate marine water. Additionally, fish and aquatic communities cannot survive in high level of chlorides. The permissible limit for chlorides as per BIS is 1000 mg/l. The waste water sample had chloride well within limits at 336 mg/l.
- **Nitrate** - The permissible limit of nitrates in waste water is 50ppm. The water sample had nitrate content above this limit.

4. Introducing Sustainable Business Practices

A considerable number of articles and research studies are available as conference proceedings and published in the world's leading journals related to sustainable business practices or green logistics [8, 9]. According to the available literature, sustainable business practices are activities to meet business demands without causing any harm to the environment or the people. Over the years, several ways have been proposed to promote them. Here is a list of some major green business practices for chemical industries.

a) **Reducing GHG Emission:** The chemical industry plays a significant role in building a sustainable economy. They cannot eliminate the use of carbon entirely, however, carbon can be used way more efficiently while reducing Greenhouse Gas (GHG) emissions. Some of the most effective ways to reduce GHG emissions are as follows:
   - Optimizing energy efficiency
   - Exchanging residual heat
   - Switching from coal to biomass
   - Biorefining green raw materials from biomass
   - Using bacteria to make green raw materials from CO_2

b) **Reducing and recycling plastic waste:** The world is under the mounting plastic trash crisis, which is not the easiest problem to solve as there are several technical, social and economic dimensions which have to be taken into account. The chemical industry is central in unlocking several plastic-waste issues and challenges. Large quantities of used plastics in chemical industries undergo poor waste treatment resulting in excessive environmental pollution. Recycling plastics and curbing their usage is crucial in solving this ever-evolving issue.

c) **Using bio-based feedstocks:** With the rise in awareness about sustainable business practices and green chemistry, chemical leaders are continuously discussing use of bio-based feedstocks or biomass sustainability. The chemical industry needs to look for more sustainable options such as bio-based drop-ins, organic and a better alternative to crude oil. Crude oil is believed to be the driving force of the chemical industry. Hence, finding its alternative would minimize its negative impact on the environment. Organic feedstocks will decarbonize the chemicals sector in the long run.

d) **Energy-efficient designs** - Energy plays a significant role in any industry. Every task performed in or outside the lab requires energy. During most processes, we often need to regulate the temperature and pressure of experiments which results in using a large amount of energy. In order to minimize wastage of energy, it is best recommended that chemical leaders conduct reactions at atmospheric conditions or room temperature.

e) **Using safer chemicals to prevent accidents** - Dealing with hazardous chemicals opens doors for unnecessary accidents, including releases, explosions, and fires. Effective control of the chemical risk can be done by substituting harmful chemicals with safer chemicals. Water is an excellent alternative to other toxic solvents in the chemical industry. The most common example of using water as solvent is in the paint industry, where water is used in place of other solvents like acetone and toluene. There are other practices that need to be followed while working in the chemical industry to prevent accidents. Some of these are:
   - Keeping workstations clean and dry
   - Labelling all chemical containers properly
   - Placing chemical containers at a distance from one another
   - Conducting safety checks at fixed intervals
   - Keeping safety gears handy
   - Forbidding drinking and eating around chemicals

f) **Reducing catalyst usage** - The proper use of catalysts minimizes the overall energy usage and waste generation during manufacturing processes in all chemical industries. When catalysts are used, the chemical which are harmful for the environment should be susbstituted with an environmentally-friendly chemical.

g) **Optimization of Reagent** - Optimization of reagent ensures maximizing the usage of optimum catalyst, which reduces the total cost of reaction, time as well as environmental pollution [10].

Many of these practices are followed in countries like USA, UK, China and others to minimize the environmental population without compromising on meeting market demand. Chemical industries in Europe are one of the

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strongest pillars of their GDP. They develop a plethora of products using raw materials such as natural gas, crude oil, minerals, and metals. The rise in demand for chemicals in the healthcare and automotive industry has introduced opportunities for chemical producers in Europe. Several European chemical industries have transitioned from hazardous chemicals to chemicals that are safe and sustainable. Energy efficiency is prioritized to meet the ambition of the European Green Deal. Using novel and cleaner industrial technologies and processes has helped them to lower environmental footprints and minimize the overall cost, thereby creating a market for sustainable chemical industry, and improving market readiness.

5. Conclusion

In this paper, a systematic and comprehensive review of the existing state of chemical industries in India is presented. The paper uses a previously conducted study as a basis to understand where chemical industries in the country, especially around Lucknow, stand. The analysis of the results of a waste water sample reveals the situation of industrial waste disposal and the necessity of sustainable business practices in the chemical sector. The paper discusses in detail different parameters like TDS, pH, TSS, DO, BOD, COD, alkalinity, hardness and chloride content – their importance in assessing water quality and related adverse effects based on the permissible limits set by the governmental bodies.

Following sustainable business practices for clean and green manufacturing is the best way to meet the ever-growing requirements without harming the environment. The paper presents seven prominent sustainable business practices for the chemical industries: reducing GHG emissions, reducing and recycling plastic, green and energy-efficient designs for manufacturing, using safer solvents, using bio-based feedstock, reducing catalyst usage and optimization of reagents. Several of these green industrial practices are being followed across the globe, especially in European nations, to ensure environmental security for a sustainable future.

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