



## CHEMICAL AND CHEMICAL INDUSTRIES SCENARIOS: AN EVALUATION

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### ABSTRACT

Since second half of the last century or so, industrialization and massive agriculture development, paralleled with increased health care have changed human life in various ways. Average life expectancy has increased due to lower infant mortality and better control of epidemics and infectious diseases. Coincidentally, the increased industrialization and agriculture development were the major causes of the hazards of chemical pollution and the indiscriminate use of persistent pesticides. Pesticides are designed and manufactured to kill pests, but pesticides also harm or kill humans and aquatic and terrestrial animals. Manufacturing of chemicals are a major source of contamination and hazards. The use of high technology has been usually associated with high risk and a lower level of safety. The use and misuse of high technology has brought the subject of safety fore-front. It is concerned primarily with the harmful effects of chemicals that are encountered by humans either directly or indirectly because they are in the atmosphere or come in contact during occupational or recreational activities or by ingestion as food additives or food residues. In order to increase crop yield, there has been many fold increase in the use of pesticides and fertilizers in the agriculture. Chemicals are inseparable from our daily life, so the best way to increase safety is to learn and apply the lessons from the chemical related accidents that have already occurred.

**KEYWORDS:** Industrialization and agriculture, chemicals, pesticides, risk, safety and lessons.

### INTRODUCTION

The economic development is based on both agriculture and industrial development of a nation. From the second half of last century rapid industrialization and agriculture revolution contributed increased health care have multifariously changed human life. The average life expectancy increased due to lower mortality and better control over epidemics and various infectious diseases. The root cause of deteriorating quality of the environment is the explosion of human population. Under the changed situations of industrialization and green revolution, triggering pollution and other environmental problems and hazards, the dimensions of total environment were enlarged that not in physical but its living factors. So man himself is responsible for the environmental problems he faces. Environment and environmental problems no more remained restricted to a region, country or continent but could become of global concern.<sup>[9]</sup> The leakage of toxic gas in the air from an industry in U.S.A. may be some extent also polluted the air over Europe. We Indians were alarmed due to oil spills in the Arabian Sea and Indian Ocean during Iraqi invasion of Kuwait (Gulf War).<sup>[15]</sup> Environmental pollution and related problems of environmental degradation, such as toxification, acidification,

desertification, deforestation, loss of biodiversity, emission, global warming, atmospheric ozone layer depletion, climate change etc urgently necessitated a rethinking and new approach to environmental problems and its source. Green Chemistry is a fundamental approach for preventing pollution up to a limit it has been defined as the invention, design and application of chemical products and processes to reduce or to eliminate the use and generation of hazardous substances for consumers. It aims not only for safer products but also less hazardous consequences to the environment.

#### 1. Initiation

The use of waterpower and then the steam engine to mechanize process such as cloth weaving in England in the second half of the 18<sup>th</sup> century marked the beginning of the factory system.<sup>[14]</sup> The factory system has thus changed substantially over 200 years, in response to new industrial processes changing sources of power and transport and new social needs. In Western Countries experienced major economic change and tremendous population growth during late 18<sup>th</sup> and 19<sup>th</sup> century. This industrial revolution process began in England in 18<sup>th</sup> century and spread to other part of the world.

India's first Prime Minister Jawaharlal Nehru declared on the eve of the departure of the British on 14 August 1947 that India's task in the future included "the ending of poverty, ignorance, disease and inequality of opportunity".<sup>[5,14]</sup> These measures indicating that the policies for growth of per capita income, alleviation of poverty and reduction of income inequalities are amongst the most vital indicators. Nehru believed a strong state with a centralized planned economy to be essential if the country is to industrialize rapidly and industrialization is the key to alleviating poverty. The Industries Regulation and Development Act (IRDA) 1951 laid the foundations for this administrative control on Industrial capacity.<sup>[5]</sup> Time and experience demonstrate that industrialization without safety measures could have catastrophic consequences.<sup>[7]</sup>

## 2. Influence

Increased industrialization and agriculture development were the chief causes of pollution were initiated decades ago. Today there have been identified more than four million chemicals which are either isolated from natural products or synthesized artificially. Human avidity to perform better and better in respect to production of food, energy and convenience product in order to ameliorate the way of life, led to tremendous growth in production of chemicals. Its result is toxic and hazardous wastes polluted environment. Since then numerous examples of dangers were demonstrated by accidents and calamities often caused by human negligence on one hand and slink deterioration due to exposure to low concentrations of persistent chemicals and pesticides on other hand. Increased chemical productions also lead to release of toxic and hazardous waste in to the environment in liquid, solid or gaseous forms became cosmopolitan problem of chemical pollution. Toxic chemicals enter ecosystems from agriculture runoff from land, contaminated ground water and bottom sediments, urban runoff, atmospheric fall out, manufacturing plant, hazardous waste disposal sites, municipal waste treatment plants etc. In general no chemical is completely safe and completely harmful.<sup>[15]</sup> But all chemicals are capable of producing a deleterious effect if a high concentration of the chemical comes in to contact with a biological membrane or system.<sup>[16]</sup>

## 3. Pesticides

The pesticides take in to account it create injuries, effects directly up on man and animals and their long term effects in the environment. After World War II there has been tremendous increase in use of pesticide and rapid increase of synthetic organic compounds. Exposure of man to pesticides may occur in manufacturing units and the laboratories, during application on crops and occupational places. Another rout is by respiratory tract due to contaminating environment after spray operations.

The toxic effect of pesticides, the point neither technology itself nor even that useful technological development can have undesirable consequences. The

question is what are the real costs and benefits of such technological innovation and on what basis is such an innovation made? Time after time country after country the evidence shows that such technology strengthens the highly lopsided relation of economic and political domination that prevails between developed countries that export it and their Third World purchasers. Rather than being a direct pathway to progress it creates new forms of oppression along with preserving many of the old. In lieu of being a key to a better life for these countries, it really perpetuates poverty and misery, the backwardness that Union Carbide, targets as the source of disaster like Bhopal as a dooms day.

Pesticides and fertilizers have a serious impact on whole biota of the ecosystem. They create disturbance in the equilibrium between insects, pests and their parasites, behavior abnormalities in birds and insects, effect on population of birds, wildlife, fishes etc, contamination of food and human bodies. These chemicals along with agricultural waste washed off land through irrigation rainfall etc reached in the water bodies, polluted water as well as damaged aquatic systems.

### 3.1. Glimpses of that dooms day

Union Carbide Corporation (UCC) of USA was founded in 1886 as a carbon company developed first dry cell battery named Eveready. Along with World Wars UCC became a contractor to the US government in nuclear weapons production.<sup>[12]</sup> The Company started its operations in India at 1905 for marketing Eveready batteries. Then it started manufacturing the batteries in India through Eveready India Company and changed its name Union Carbide India Limited (UCIL) in 1959. As a part of Green Revolution in India, UCC was permitted to set up a plant in Bhopal in 1969(UCIL) for the manufacture of pesticides Sevin and Temik. The first batch of Methyl Isocyanate (MIC) for production of pesticides was imported from USA in 1973 and the first complete production of Sevin took place in UCIL Bhopal in 1977.

It was a chilly winter night on 2<sup>nd</sup>/3<sup>rd</sup> December (00.15 am) 1984 this day may be regarded as one the blackest days in the industrial history. Approximately, 40 tons of highly toxic liquid MIC stored in tank No 610 suddenly escaped in a gaseous form in to the atmosphere, apparently precipitated by entry of water into the tank. The inhabitants of the Bhopal city were sleeping the city had been stuck with an unprecedented catastrophe. People gasping, falling, running, crying, intense irritation in their eyes and choking sensation in their lungs, gasping for fresh air rushed into the street make worse the matter they running helter-skelter, many died in their sleep. Very soon, the lanes, streets were littered with corpses and carcasses of animals the beautiful lake city appeared as the Doomsday. Next day the hospitals were swarmed with the victims. Dr. V.M. Katoch, then Director General, Indian Council of Medical Research, expressed "the helpless doctors were neither aware about

the nature of the Killer Gas, had escaped in to the air from UCIL factory nor did they have any idea about antidotes to be administered.<sup>[1]</sup> In hospital, lawns and compound corpses were piled one up on another. "People looking for their near and dear ones, were going from body to body and were lifting the pall from over head to identify was a heart rendering scene all around."<sup>[13, 9]</sup> It was estimated that, out of the total 800,000 population 520,000 persons were exposed, 8,000 died during first week and 200,000 having suffering permanent injuries.<sup>[4,12]</sup> "There is high physical morbidity in the population. Especially high prevalence of hypertension and diabetes with associated complications is stroke. Many of them started these problems very young age".<sup>[6]</sup>

The impact of the toxic chemical is continuing in these days, in terms of psychological and neurological disabilities, blindness, skin, vision, breathing and birth disorders (Bhopal gas Tragedy Relief and Rehabilitation Department, 2009). Now also people live in Bhopal with psyche and hemophilic heart.

This industrial behemoth known as Union Carbide Company of United State waved such a pattern on the Indian soil which later became knots of vipers for the inhabitants of Bhopal.

Whatever, its prime cause, the magnitude of its effects was the result of faulty design, poor maintenance and careless plant operation? It could and should have been prevented. The simplest and cheapest route to prevention would have been not to store high quantity of MIC at all. There are lesions here for the multinationals, the developed countries, the developing countries and the community.

#### 4. Radiation

Nuclear war materials, test explosions, made rush for power plants and radioisotope use in medicine, injury and research are the main, source of radioactive pollution that could threaten our environmental security. Nuclear Power is a modern means of generating electricity. The fuel of a nuclear electric generator is atomic pills of uranium metal. And a reactor is one in which fission of atomic fuel occurs. Producing large scale of nuclear energy is known as nuclear fission. This was discovered in 1939 by the German radio chemist, Otto Hahn and his co-worker Fritz Stressman<sup>[3]</sup>. An atom bomb in its simplest form contains two or more pieces of nearly pure fissionable material. A number of nuclear explosions have already been made during recent past in different part of the world. No nuclear plant is contamination proof. The radioactive wastes and leakage from nuclear plants may be in the form of gases, liquids or solids are radioactive. The phenomenon of radioactivity defined as "The spontaneous and self-disruptive activity exhibited by several of the heavy elements of atomic weights greater than about 206, occurring in nature".<sup>[3]</sup> In 1986 Chernobyl nuclear power plant in USSR was the worst

nuclear accident of the 20<sup>th</sup> century enormous plume of radiation that escaped from the plant contaminated over 38,000 square miles and exposed five million people to high level of radiation. Radiation caused cancer takes decades to develop. An estimated 4,000 to 9,000 deaths could eventually result from Chernobyl.<sup>[17, 8]</sup> When the radiation had large dose, it destroy the central nervous system and the red and white blood cells, leaving the victim unable to fight off infections more than that its effect stay for long both in current exposure people or to next generation as genetic impact factors.<sup>[16]</sup> There is no reliable method of storing the radioactive wastes, hundreds of tons being produced each year.

#### 5. The element of safety

The chemical process industry is noted for an excellent safety record, despite the fact that many of the materials it handles are outer most hazardous. Indeed, the standard maintained is substantially better than that in all the other industries. However, the public image of the chemical industry maintained a severe blow following a series of disasters in 1984, culminating in the nightmare of Bhopal. Two years later the severe pollution of the Rhine following the fire at the Sandoz factory at Basle (Rhine delta in The Netherlands)<sup>[15]</sup> brought more adverse publicity to the industry through the mass media. It is true that every accidents that bring the industry such a disastrous image. Actually we can learn valuable lesions from each accident and which will help us to avoid similar accidents in the future. The safety should be of concern interest to those in position of responsibility throughout the industry and not only to the experts and safety officers, so the responsibility in the hands of technical managers, plant managers and operating staff, central and state government officers for safety planning and implementations, all of whom, while aware of the issues involved, desire to be ever better informed and equipped in order that they may do their duty well.

##### 5.1. Who has lost whom?

Impacts of the accidents are damage and loss. The major disasters resulted in injury and death to human being as well as loss and damage to plant and property. The loss of plant and property has a replacement book value. But what of those who suffer injury or die? Who has lost whom and what? If put a price tag on human life then we get answer for all these questions. It is different from country to country and circumstances. It may be depending upon ones dependence, but nothing can compensate for the real loss of life are the natural resources of a country.

##### 5.2. Safety culture

The route to safe plants is to have a safety culture a safety culture is embodied in the program developed from the specific company experience. The one real and effective way to ensure that safety stands are being maintained is to have an ongoing safety program with safety training, motivation and careful continuing attention to discipline. The safety consciousness has to

be cultivated. Different companies have different approaches to safety and thus different programs. This culture is the sum total of the attitudes of the persons at all levels in the organization from the worker on the plant to the chairman himself. An unavoidable element of any safety culture is proper training especially in the diagnosis of abnormal situations, so that those involved will react appropriately in an emergency occurs.

It has to be accepted that safety cost money, but it cannot completely eliminate hazards. A good design and forethought can often bring increased safety at less cost.<sup>[9]</sup> We shall be concerned here with accidents in situations where we are assumed to be in control and where therefore an accident is judged preventable. Regarding the situation of Bhopal tragedy the operators were over confident and careless. The plant had been operating for years and they were lulled in to a false sense of security, despite the occurrence of a number of minor accidents that were sounding a warning. There is a well known saying 'A chain is no stronger than its weakest link'. Its full recognition is to the subject of safety.<sup>[9]</sup>

## 6. Technology

The use of high technology is usually combined with high risk and a lower level of safety in the public mind but it is not always necessarily true.<sup>[8]</sup> The use and misuse of high technology have brought the subject of safety very much in front. 'Safe technology' is an essential instrument for the prevention of the accidents that come as a result of handling new technology. Complex situations result in human mismanagement, which ultimately responsible for all damage and loss. The technical aspects in a context where one can readily understand by in design, construction, operation and management – who are all deeply concerned and closely involved with safety, but many lack the detailed knowledge of the expert. All of a sudden many alarms sounding and flashing lights going that the control room operators were totally confused. The simple alarm system is to be preferred and this is the message here for the plant designer that the operators will cope better.

### 6.1. Safe Operation

The review led to the installation of additional safety equipment and the formulation of tighter procedures to ensure safe operation. This was to ensure that each and every operation complied with company safety standard, emergency response organizations were fully capable of handling any possible accident, adequate safety equipment existed or installed. Giving information on risks and safety to people in terms that they can understand is a most difficult task, but at the same time it is decisive to continuing successful operation of the chemical industry. It includes not only governmental and local authority but also general public.

Government worldwide were similarly instigate to action by the Bhopal disaster (1984), reassessment on safety

and environmental standards, call for faster action on air pollutions, revival of controls on hazardous exports. Much of this action has of course been prompted by the embarrassing but the important question is why this mini Bhopals happened again and again? In August 1985 at a similar Union Carbide plant at West Virginia (USA) had an accident and 135 people were injured by toxic gas.<sup>[4]</sup> In 1985 at Kerala, India, chlorine leakage from a textile mill 40 workers were hospitalized. In 1987 at Gujarat, India 5,000 persons were injured because of gas leakage. In 1991 at Maharashtra, India, 100 persons were killed an explosion in a ship. In Union Carbide's Factory in USA and Europe more than 700 workers died, several had been injured and 17,000 had been evacuated because of accidents.<sup>[4,9]</sup>

When we learn other people's mistakes, once we know the mistake that they actually made, we know how they happened and it has been almost invariably human error, we want to devise a strategy that will avoid or minimize the effect of such errors in future.

## 7. Management

The one way to ensure safety is to avoid taking any risk, but that is just not possible. Since risk cannot be completely avoided it becomes the duty and responsibility of management to minimize risk. An accident may accidental with fault equipment, work procedure, lack of training and information, inadequacy of supervision or management on other hand it may be invited by the injured employee or sabotage. Human nature is complex and even irrational so that even then there will be some who deprive themselves of the encumbrance as soon as they start work. But irresponsibility on the part of the worker does not absolve by management. Management has to recognize human nature for what it is and act accordingly. Only Prevailing Pragmatism, not idealism. And for management simply to 'pass the buck' will amount to their escaping what is their real responsibility. A management man must be careful not to be blind to his own management's shortcomings, must have keen interest in occupational safety and have the uncommon common sense to arrive at a rational conclusion. Even when managements recognized their responsibility to educate, train and motivate the workforce to use safe procedures, it seems that they can only go so far. The administrative procedure was such that it was obligatory for every accident to be reported. Even in cases where an employee just collapsed at work place without any apparent reason this was registered as an accident and routinely investigated.

### 7.1. Loss Prevention

Companies are run to make a profit. The consideration of safety measure in terms of loss prevention appeals to management, which is necessarily motivated primarily by the need to make a profit. Management is always concerned to reduce company's losses and so increases its profits and to reduce risk to a minimum, by



identifying dangerous situations and remedying them. Other factors also influence safety policy, notably civil and criminal liability of management. Major technological development have been characteristic of past few decades or so in the chemical industries give rise to severe hazards. Hazard control, which is different from loss prevention, though complementary, is well developed in the nuclear and Pharmaceutical industries and the knowledge that has been valuable to the chemical industries as a whole. Loss prevention is considered in relation to developments in operational and diagnostic technology, to insurance and to regulatory control.

## 7.2. Plant Layout

The accident on Monday 19th November 1984, at 5.30am, Permex LPG (liquid petroleum gas) storage and distribution centre at Mexico city, which included devastating explosion, demonstrates the value of applying hazard assessment and loss prevention techniques to plant layout and storage hazards. There were 542 persons killed and more than 4000 injured.<sup>[18]</sup> This accident was short-living one, since just two weeks later the Bhopal tragedy put the Permex disaster into background. Both these experience showing that with proper planning and safety provision, the death toll would have been minimal and damage to property confined to the site itself. The fault in the bypass where by the design integrity of the plant was violated, very large quantities of hazardous material were stored on site without a license and without the knowledge of a local authority where not have been management procedures and system been sound in installation.

## 8. Waste

The problem of hazardous waste should be tackled at source with a proper waste audit. This can lead to cheaper and simpler solutions, such as recycling, material substitution and better housekeeping. But when plants are being built waste creation or better waste elimination should be considered before waste treatment and disposal. This approach may be time-consuming and costly initially but quite economical in the long run. There are variety of processes that can be used to upgrade waste products such as distillation, absorption, filtration and electrolysis and recycling all of which can be pursued at a profit. A better approach might be need for the chemical industry to regulate itself which not only pledge but experience.<sup>[10]</sup> Local authorities have an important role, but a national approach is essential for this matter.

## 9. Risk

The community faces risks and hazards from day by day around from continually. The application of new technology presents dilemmas in risk management in relation to the individual in the workforce and in the community. The need is for openness and full information and for a responsible regulatory authority. The approach to the risk assessment has moved from individual plant to industrial complexes and the

assessment not only within the plant but also to neighboring plants and the people who live in the area. The human factor is found to be the most significant, yet the most difficult to assess and evaluate. Safety should be seen as a defense that has to be maintained constantly by human effort. The risk will then be assessed and contained on a continuing basis through surveillance and constant monitoring. Properly designed, well engineered and correctly operated plants rarely suffer catastrophe because of equipment failure. High pressure seems to be the special prerogative of the chemical industry and from the beginning process engineers and design engineers have been aware of the hazardous presented by the use of high pressures in chemical reactions. Then failure is almost all due human and even regulatory bodies and the inspectorate cannot regulate this, for they themselves are human. But the possibility can and must be reduced we will have done the best we can, although it can never be eliminated.

## 10. Laws and Regulations

Laws and regulations are essential to a civilized society to reserve evil and protect the common man. Laws and regulations are different from country to country basically. Each and every country the objective is same that to make things safe or at least safer than they are now. The USA is perhaps the most highly regulated country and current practice Europe and other developed countries are similar. The situation in the developing countries leaves much to be noticed. A mounting number of rules and regulations are swamping in every organizations, a better approach for the chemical industries to regulate themselves, which requires not in pledge and record but in expertise.<sup>[9]</sup> Passing through our past experience demonstrate that non-regulatory methods of managing deserve serious consideration by local authority or governments. The move towards self-regulation seems to be an abscess momentum.

Most of the laws regulating the manufacture, distribution and use of chemicals and allied product are of relatively recent origin. There are wide variety of chemicals and many various situations in which they can be found and used the result is that no country has a single statute covering all chemical substances and their related problems. Because of the countries varying background very considerable differences exist between the relevant laws in this area. The Toxic Substance control Act (TSCA) is all-embracing, covering the regulation of both existing and new chemicals. TSCA as the name itself indicates regulates the manufacture, distribution and disposal of chemicals dangerous to health or the environment and its authority extends from industrial chemicals through pesticides to consumer product.<sup>[15,9]</sup> It covers almost all that happens at the workplace at home everywhere even in space and at the bottom of the ocean. Its implications are far reaching very far reaching and it needs to industry to furnish the Environmental Protection Agency (EPA) with both technical and business in relation to the manufacture of the chemical.<sup>[14]</sup> The result

is potentially harmful chemicals have to be made available in the market with a pre-manufacturing review for new chemicals. In all probability the USA is the most regulated country in this respect and thus provides us with most capacious examples. However, the company is aware that mere meeting of the rules and regulations is not an insurance or excuse if hazards occur, they must ensure that its safety provisions are sufficient and being observed and in practice and not in the records.<sup>[9]</sup> Employers, who should take full responsibility for health and safety at their premises, inspection then becomes a spur to self regulation and we are back to proper discipline at the workplace.

### CONCLUSION

The goals and objectives set out the industrialization in India are reduction of social and economic disparities, removal of poverty and attainment of self-reliance remain as valid today as they were at the time of Pandit Nehru.

Green Chemistry can be achieved by applying environmentally friendly technologies. Legislation will increasingly force industry and the users of chemicals to change – both through substitution of hazardous substances in their processes or products and through the reduction in the volume and hazardous of their waste.

Management must be able to motivate the workforce effectively it is get the best result. Accident prevention worldwide will benefit materially from exchange of information the transfer of technology and standardization of regulations that such cooperation would make possible. Every safety policy implies safety motivation of the manager and through him, of all the personal employed on a plant. However, this cannot be regulated, it can only be inculcated.

Safety should start at the top with senior management and pervade the whole company this is the 'company culture' concept. People at workplace have therefore to be motivated to make safety their priority. If we do not keep the subject safety continuously before our eyes, we will forget. Its impacts are incidents. Above all we must learn from other people's plenty of mistakes. Please learn for our own sake.

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