DRAFT FINAL REPORT FOR PROJECT ON ***"COMPUTATION OF SOCIETAL RISK ABATEMENT COST AND LONG RUN MARGINAL FINANCIAL COST WITH REGARD TO DIOXIN AND FURAN EMISSION STANDARDS FOR COMMON HAZARDOUS WASTE INCINERATOR".***

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DRAFT FINAL REPORT

FOR

PROJECT

ON

COMPUTATION OF SOCIETAL RISK ABATEMENT COST AND LONG RUN MARGINAL FINANCIAL COST WITH REGARD TO DIOXIN AND FURAN EMISSION STANDARDS FOR COMMON HAZARDOUS WASTE INCINERATOR

Submitted to
Central Pollution Control Board
Delhi

Prepared by
UPL environmental Engineers Limited

February, 2011

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EXECUTIVE SUMMARY

Polychlorinated dibenzodioxins (**PCDD**s), or simply **dioxins**, are a group of halogenated organic compounds which are significant because they act as environmental pollutants.

They are commonly referred to as dioxins for simplicity in scientific publications because every PCDD molecule contains a dioxin skeletal structure. Typically, the *p*-dioxin skeleton is at the core of a PCDD molecule, giving the molecule a dibenzo-*p*-dioxin ring system. Members of the PCDD family have been shown to bio-accumulate in humans and wildlife due to their lipophilic properties, and are known teratogens, mutagens, and suspected human carcinogens.

The word "dioxins" may also refer to a similar but unrelated compound, the polychlorinated dibenzofurans (PCDFs) of like environmental importance.

1. The Project

Incineration of hazardous wastes is one of the sources of dioxin in the ambient air. There are a number of well established technologies to handle hazardous wastes in the form of solids, liquids, sludges, tar etc. and having a high degree of variability in characteristics.

Based on the experience in other parts of the world, particularly in case of handling hazardous waste in solid form, the Central Pollution Control Board (CPCB) has adopted the technology consisting of rotary kilns followed by secondary combustion chambers as the incineration system for hazardous wastes.

Based on the above technology coupled with Air Pollution Control Devices (APCDs) for various pollutants, techno-economic feasibility and performance evaluation study, emission standards for Dioxin & Furans have been prescribed by the CPCB.

In evolving these standards, societal risk abatement cost and long term marginal cost aspect had not been considered by the CPCB. The present project has been taken up to consider these aspects.

The CPCB appointed UPL Environmental Engineers Limited to carry out the study. The proposal presented by UPL Environmental Engineers Limited and the letter of appointment issued by CPCB are presented in Annexure-I.

2. Objectives of the Project

The primary objectives of the study are

- To determine the long-run marginal financial cost and to find out what the user will need to pay for reaching the range of alternative levels of emissions of total dioxins & furans and
- Conduct a comparative study of societal risk abatement cost incurred by the Ministries / Departments concerned with mitigation of risk posed by epidemic, rail accidents and sewage exposure. These societal risk abatement costs (should be compared with that) corresponding to the environment standards (for dioxin & furan).

3. Scope of Services

The scope of work was divided into two parts and various tasks to be undertaken to achieve the above objectives were identified. These concepts were then presented to the CPCB and a consensus on the approach, methodology and tasks was arrived at. The tasks identified for the purpose are presented in Chapter 2.

4. Sources, Emissions and Pathways of Dioxin

4.1 Sources

Most significant sources in India are

- Municipal incinerators
- Common Hazardous Waste incinerators
- Incinerators in bulk drugs manufacturing sector
- Incinerators in dye and dye intermediates sector
- Incinerators in pesticide sector
- Incinerators in basic organic industries sector

There are no municipal incinerators installed in India, as municipal waste is disposed of by landfill or composted which may include recovery of refuse derived fuel (RDF). The RDF is used either in boilers for power generation or in cement kilns to utilize its calorific value. No data on emission arising from combustion of RDF is available.

Fourteen common hazardous waste incinerators have been installed in seven states and 127 individual incinerators have been installed in 12 states and one union territory. Total incineration capacity of these incinerators is 327705 tonnes per annum (TPA). In addition to these, there are proposals to install 9 common and captive incinerators with proposed total capacity of 256770 TPA. Data on installation of incinerators in various states is presented in Table ES 1.

Table ES 1: State wise Incineration Facilities for Management of Hazardous Waste [11]

S.No.	Name of State/UT	Nos. of Common Incinerator	Nos. of Captive Incinerator
1	Andhra Pradesh	2	26
2	Gujarat	4	35
3	Himachal Pradesh	-	7
4	Karnataka	3	7
5	Kerala	1	1
6	Madhya Pradesh	-	7
7	Maharashtra	2	-
8	Punjab	-	17
9	Pondicherry	-	1
10	Rajasthan	-	5
11	Uttar Pradesh	1	13
12	West Bengal	1	4
13	Damman, Diu, Dadra & Nagar haveli	-	4
Total	**12 states and 1 UT**	**14**	**127**

4.2 Emissions

The available data on dioxin emissions from incinerators is presented in Table ES 2.

Table ES 2: Dioxin Emission data for Common and Captive Incinerators [13]

S.No.	Name of Unit	Emission ng TEQ/Nm^3
	Common Incinerators	
1	Bharuch Enviro Infrastructure ltd. Ankaleshwar	0.0255
2	Mumbai Waste Management ltd. Taloja	8.621
3	Gujarat Enviro Protection & Infra.ltd. Surat	0.0352
	Drug Manufacturing Units	
1	M/s Ranbaxy Laboratories Ltd, Tonsa	0.1965
2	M/s Lupin limited, Ankleshwar, Gujarat	0.0156
3	M/s Natco Pharma Ltd, Mekaguda, AP	0.1866
	Dyes and Dye Intermediates Manufacturing units	
1	Color Synth Industries (P) ltd. Surat Gujarat	0.0203
2	Atul Ltd., Atul Gujarat	0.0684
3	Metrochem Industries (P) ltd., Baroda	0.051

Table ES 2 (contd.): Dioxin Emission data for Common and Captive Incinerators (13)

S.No.	Name of Unit	Emission ng TEQ/Nm^3
	Pesticides Manufacturing Units	
1	PI Industries ltd., Panoli	0.0195
2	Bayer Crop Science, Thane	0.50
3	Syngenta India ltd., Goa	0.38
	Basic Organic Chemicals manufacturing Units	
1	Jubilant Organosys ltd., Gajraula. UP	0.029
2	Chemplast Sanmar ltd., Tamil Nadu	1.36
3	Gwalior Chemical Industries ltd., Nagada	6.4717

4.3 Human Exposure

Polychlorinated dibenzo-p-dioxins (PCDDs) have been found throughout the world in practically air, soil, water and sediment. They are also found in biotic media such as birds, fish, shellfish and marine mammals. The levels of these chemicals in the biota, especially in the top-of-food-chain predators, such as marine mammals, are often higher compared to their surrounding environment because of bioaccumulation of these chemicals (3).

The scope of this report is restricted to the emissions from hazardous waste incinerators. These include common as well as individual industry incinerators. The subsequent Sections/ Chapters are, hence, focused on dioxin and its emission in the air environment in general and from hazardous waste incinerators in particular.

Limited data available on dioxin in the ambient air in India is presented in table ES 3.

5. Health Impacts

5.1 Toxicity

2,3,7,8- TCDD is considered to be an extremely toxic compound. The oral LD_{50} for experimental animals varied from 0.6 µg/kg body weight for sensitive female Guinea pig while mice and rabbits were hundred times less sensitive. Thus the lethal dose, as tested on experimental animals, varies significantly with the species probably due to varying sensitivity (12).

Information on lethal dose of 2,3,7,8- TCDD and related compounds to humans is not available.

Table ES 3: Level of dioxins & furans in ambient air respirable suspended particulate matter of Delhi for the period January 2008 to August 2008 [20]

S. No.	Location of monitoring	Level of dioxin & furan pg TEQ/Nm³
1	Nizamuddin (n=3)	0.036
2	S. Bagh (n=3)	0.141
3	Pitampura (n=5)	0.236
4	Sirifort (n=13)	0.529
5	Janakpuri (n=13)	0.535
6	I.T.O. (n=15)	0.851
7	Shahadra (n=10)	1.187
Average dioxin & furan (n=62)		**0.502**

5.2 Carcinogenicity

In February 1997, the program of the International Agency for Research on Cancer (IARC) Monographs on the Evaluation of Carcinogenic Risks to Humans, convened a Working Group of experts and observers from 11 countries in Lyon, France, to evaluate the evidence that polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) might be risk factors for human cancer [17].

The conclusion arrived by the Working Group was, after considering the human and animal cancer data together with all of the other experimental data and overall evaluations and classifications, that 2,3,7,8-tetra-chlorodibenzo-*p*-dioxin (TCDD) is carcinogenic to humans.

The only data on increased risk for all cancers combined due to exposure to TCDD is based on four cohorts studies of herbicide producers. These studies involve the highest exposures to TCDD among all epidemiologic studies. An increased risk for all cancers combined (approximately 1.4 fold) was seen in cohort studies. This risk factor is used in the present study for the health impact of dioxin [17].

6. Standards

In the guidelines published by the Central Pollution Control Board (CPCB) for incineration of hazardous wastes, combustion system considered appropriate is Rotary Kiln followed by Secondary Chamber. Air pollution control devices considered appropriate are quencher (air), injection of lime and activated carbon for controlling dioxin and furan; bag filters for removal of suspended particulate matter, wet scrubbers (caustic) for acidic gases and finally release of gases through a stack of adequate height. Since the operation of such facilities is considered important for proper treatment of waste as well as to control pollution, the guidelines also specify operating parameters.

These guidelines formed the basis for prescribing emission standards for common hazardous waste incinerators, keeping in view least possible emission of dioxins and furans into the environment. The practicability and affordability were also considered while fixing standards and consultation with stake holders was carried out.

The standards applicable for common hazardous waste facilities are given in **Annexure-II**. The standard prescribed for the emission of total dioxins and furans is 0.1 ng TEQ/Nm^3.

Japan is the only country which has specified an ambient air standard 0.6 pg per cubic meter in the atmosphere for dioxin [(18)].

7. Deaths and Reduction in Life Span

The primary objective of the present assignment was to compare the risks and societal costs of dioxin emission with the risks and societal costs of other events such as water borne diseases, rail and road accidents etc.

The basic approach adopted was to convert all the risks into reduction in life span of the total population. This then provides a common basis for comparison.

7.1 Methodology

The following are the steps followed to arrive at the reduction in life spans.

- Obtain the data on the deaths for various years due to a cause
- Find the average deaths for a period of 10 years
- Distribute the population by age group
- Obtain the data on average life span for the year for the total population
- Assuming that deaths reflect the population distribution by age, distribute deaths by age group and determine the life-years lost by each age group per year
- Determine the total life years lost by the whole population per year.
- Calculate the total reduction in the life span of the whole population in minutes per year per person.

Detailed calculations are presented in Chapter 7.

The summary of above calculations, for various causes of deaths, is presented in Table ES 4 and Figure ES 1. Deaths due to dioxin were calculated as 40% of deaths due to cancer considering the risk factor of 1.4 for cancer due to dioxin.

Table ES 4: Reduction in Life Span Due to Various Causes of Death

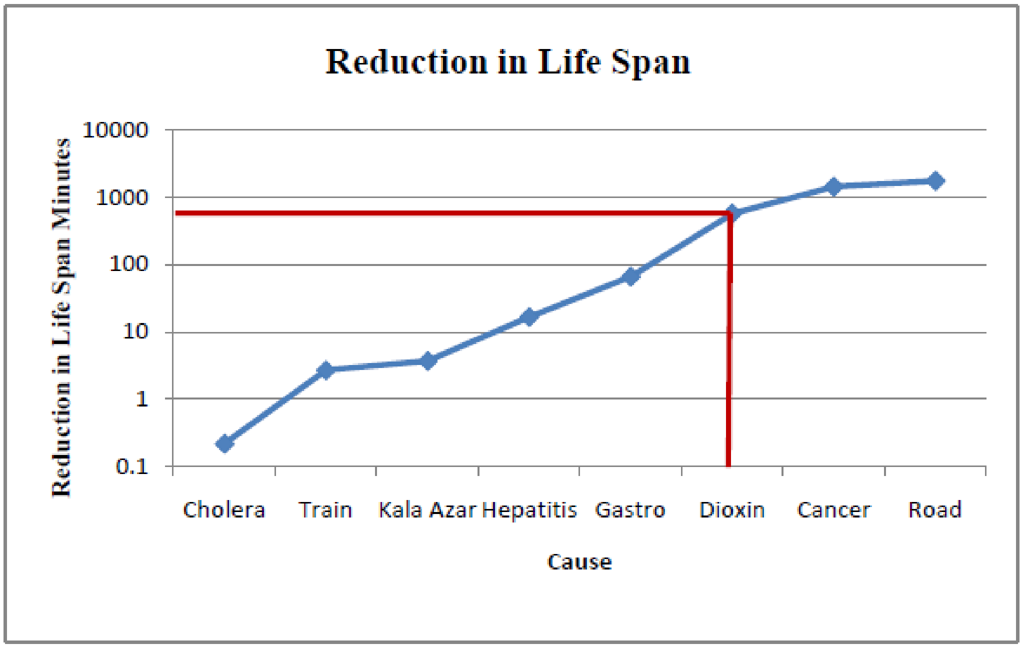
Cause	Reduction In Life Span Minutes/person/year
Cholera	0.22
Train	2.7
Kala Azar	3.7
Hepatitis	16.5
Gastro	65.4
Dioxin	566
Cancer	1414
Road	1724

8. Cost of Dioxin and Furan Emission Control

8.1. Methodology

Data on the stack emissions of dioxin was collected for various operating incinerators. Similarly data on capital costs and costs of operation and maintenance (O & M) were collected. The annual amortized cost on capital investment for various incinerators using different technologies for incineration and emission control was worked out assuming10 years as the life of incinerator and 10% interest on capital investment. This was added to the O&M cost per tonne (cost per day divided by total waste incinerated per day). These two costs i.e., amortized cost (Rs/tonne) and O&M cost (Rs/tonne) were added to arrive at the total cost (Rs/tonne). These costs were then plotted against the emission values to illustrate their relationship.

Figure ES 1: Reduction in Life Span



8.2 Estimated Costs and Emissions

The costs calculated for various incinerators installed by industries & common facilities are presented in Chapter 8 along with data on dioxin & furan emission from stack. The relationship between dioxin & furan emission and cost is presented in Figure ES 2 for captive incinerators and in Figure ES 3 for common hazardous waste incinerators. It should be recognized that these relations are based on limited data. It is necessary to collect data with repeated observations of emission, corresponding to feed quantity and its chlorine content. CPCB may consider this exercise of generating data as a separate project.

The data (Figure ES 2) indicates a reasonably significant statistical relation between emission and cost/tonne for the captive hazardous waste incinerators (R^2 = 0.78). On the other hand, the relation between emission and cost/tonne for the common hazardous waste incinerators (Figure ES 3) is not statistically significant (R^2 = 0.23).

It is to be recognized that these relationships are plotted only as a s part of the development of a conceptual approach. In reality there is no such relation because all technologies of incineration and emission control are designed to achieve, as far as possible, zero emission of dioxin. The variations in dioxin emission are due to a variety of reasons including O & M practices and not because of choosing a less expensive technology of incineration and emission control.

Figure ES 2: Relation between dioxin & furan emission and cost of incineration, for captive incinerators

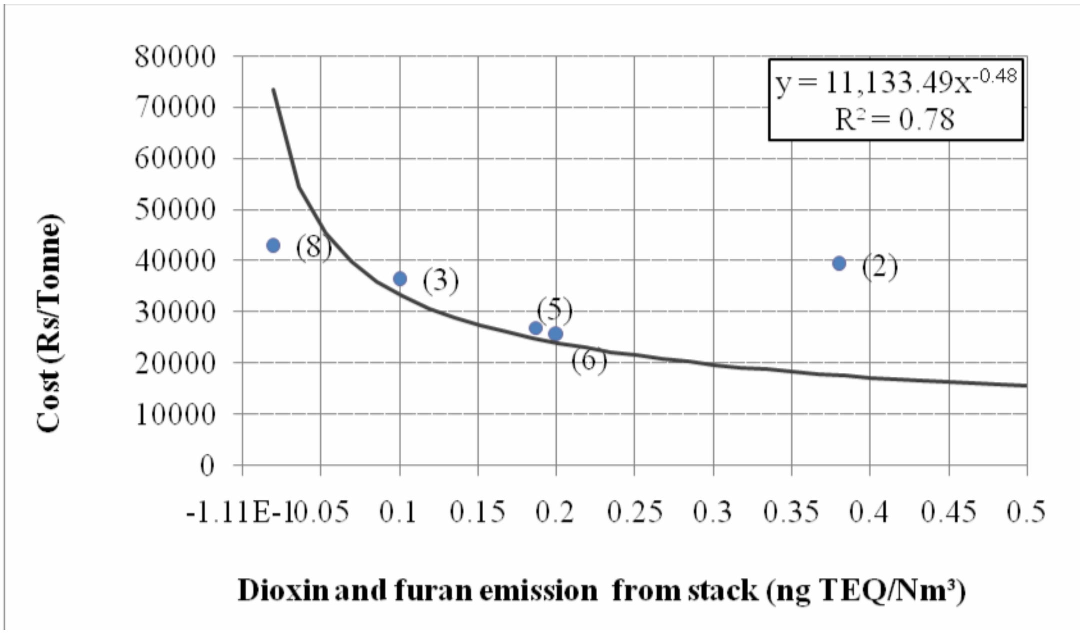
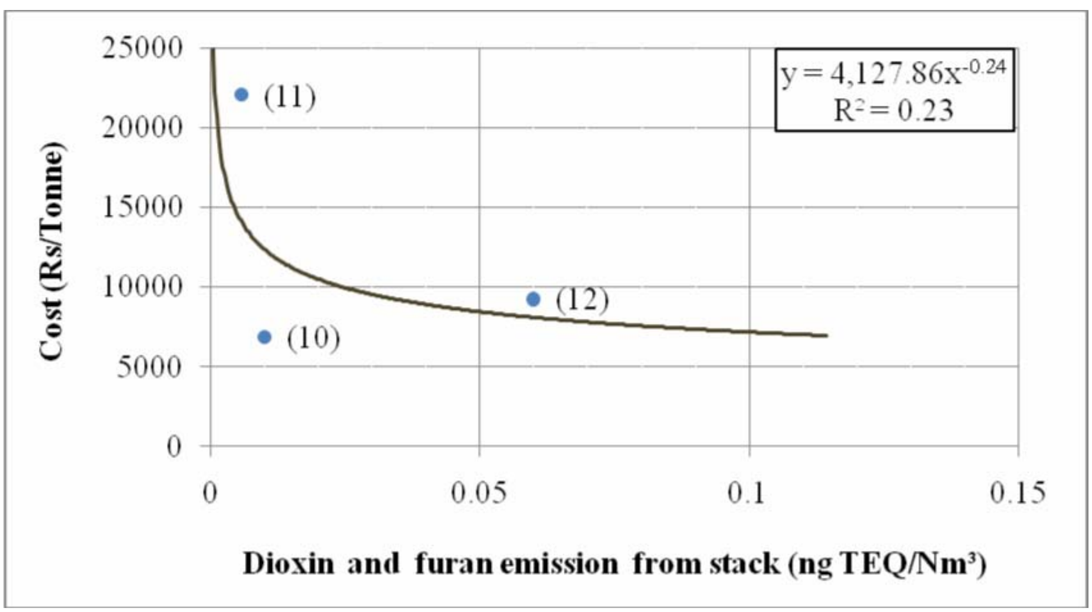


Figure ES 3: Relation between dioxin emission and cost of incineration, for common incineration facilities



9. Prediction of Ground Level Concentrations of Dioxin

The ground level concentrations (GLCs) have been calculated for different levels of dioxin (PCDDs) & furan (PCDFs) emission from stack of common facilities.

9.1 Methodology

The Maximum GLC was calculated using two models i.e. SCREEN model and ISCST model. Since meteorological data was not available for specific locations, the maximum possible GLCs of dioxin & furan were estimated under worst metrological conditions while using SCREEN model. The meteorological conditions used for modeling are described under each model in Chapter 9.

9.2 Ambient Air Quality Standards

The only standard specified for ambient air quality with respect to dioxin and furan is that of Japan which has specified 0.6 pg per cubic meter in the atmosphere.

WHO has specified a standard for Total Daily Intake (TDI) of 1-4 pg TEQ/kg body weight/day. Considering average body weight of 60 kg and air intake of 20 m^3/day (with 5% inhalation contribution), the allowable concentration levels were calculated to be 0.15 – 0.60 pg TEQ/m^3 in ambient air.

10. Emission Levels and Societal Costs

10.1 Ambient Air

The societal cost is linked with levels of dioxin and furan in the ambient air due to various point and non-point sources (including vehicles etc) around the hazardous waste incinerators as well as contribution of dioxin and furan due to stack emission from incinerators (impact on GLC). The data available on existing levels of dioxin and furan in the ambient air is presently rather limited and is only available for Delhi. The dioxin and furan levels in Delhi which were presented in Chapter 3, Table 3.6 are reproduced in Table ES 5 below along with calculated WHO Ambient Air standards.

The data shows that the ambient air concentrations of dioxin and furan around Delhi vary from 0.036 pg TEQ/m^3 to 1.187 pg TEQ/m^3 with average value of 0.502 pg TEQ/m^3 while the calculated WHO standards for ambient air are from minimum of 0.15 pg TEQ/m^3 to maximum of 0.60 pg TEQ/m^3. The data also indicates that dioxin and furan levels, in some areas of Delhi, exceed the WHO standard and that the average concentration of dioxin and furan at 0.502 pg TEQ/m^3 is very close to the maximum permissible WHO standard.

This indicates that many areas in the country may not have any cushion for further addition of dioxin and furan from hazardous waste incinerators. It is, hence, desirable that the emission standards for incinerators are kept as low as may be possible to achieve through best available technology and operating procedures.

Table ES 5: Level of dioxins & furans in ambient air respirable suspended particulate matter of Delhi for the period January 2008 to August 2008 [20]

S. No.	Location of monitoring	Level of dioxin & furan pg TEQ/Nm^3	WHO Allowable concentration in ambient air, pg TEQ/m^3
1	Nizamuddin (n=3)	0.036	0.15 to 0.60
2	S. Bagh (n=3)	0.141	0.15 to 0.60
3	Pitampura (n=5)	0.236	0.15 to 0.60
4	Sirifort (n=13)	0.529	0.15 to 0.60
5	Janakpuri (n=13)	0.535	0.15 to 0.60
6	I.T.O. (n=15)	0.851	0.15 to 0.60
7	Shahadra (n=10)	1.187	0.15 to 0.60
Average dioxin & furan (n=62)		**0.502**	

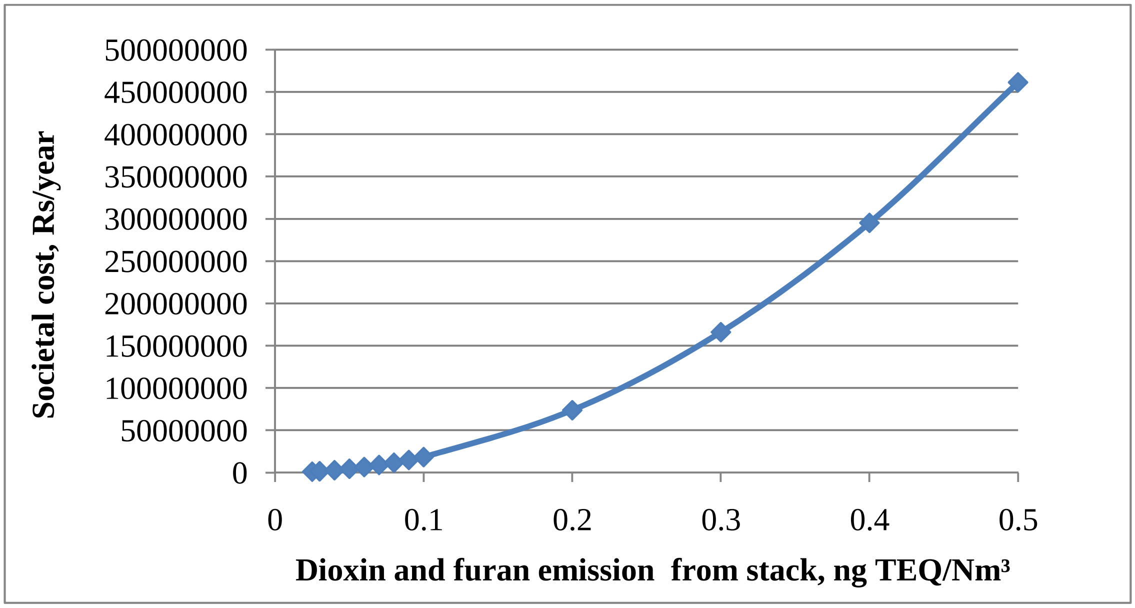
10.2 Methodology

Based on the consideration that there is no cushion for additional dioxin and furan in the ambient air, it was decided to consider 0.00015 pg TEQ/m^3 as the permissible addition of dioxin and furan into the ambient air from the stack emissions of incinerators. The following section describes the actual methodology used to determine the societal costs consequent to dioxin and furan emissions.

- The distance at which the ground level concentration (GLC) of 0.00015 pg TEQ/m^3 occurs from the stack was then calculated for various stack emissions ranging from 0.025 ng/Nm^3 to 0.5 ng/Nm^3 using ISCST-3 model for common incinerator installed at Ankleshwar. From this the area affected was calculated.
- Using the population density for district Bharuch in 2005 of 261 persons/sq. km., corresponding population affected was calculated for different emission levels and permissible GLC of 0.00015 pg TEQ/m^3. After the affected population was determined, the loss of life span of 566 minutes per year per person (Table 7.36) due to dioxin and furan was applied to the affected population to calculate the total loss of life years in the affected area.
- The societal cost was then calculated based on the average income of Rs. 23241 per person per year for the year 2005.

These calculations are presented in Chapter 10 and summarized here in Figure ES 4.

Figure ES 4: Relation between dioxin and furan emission from stack and societal cost of the affected population in the affected area



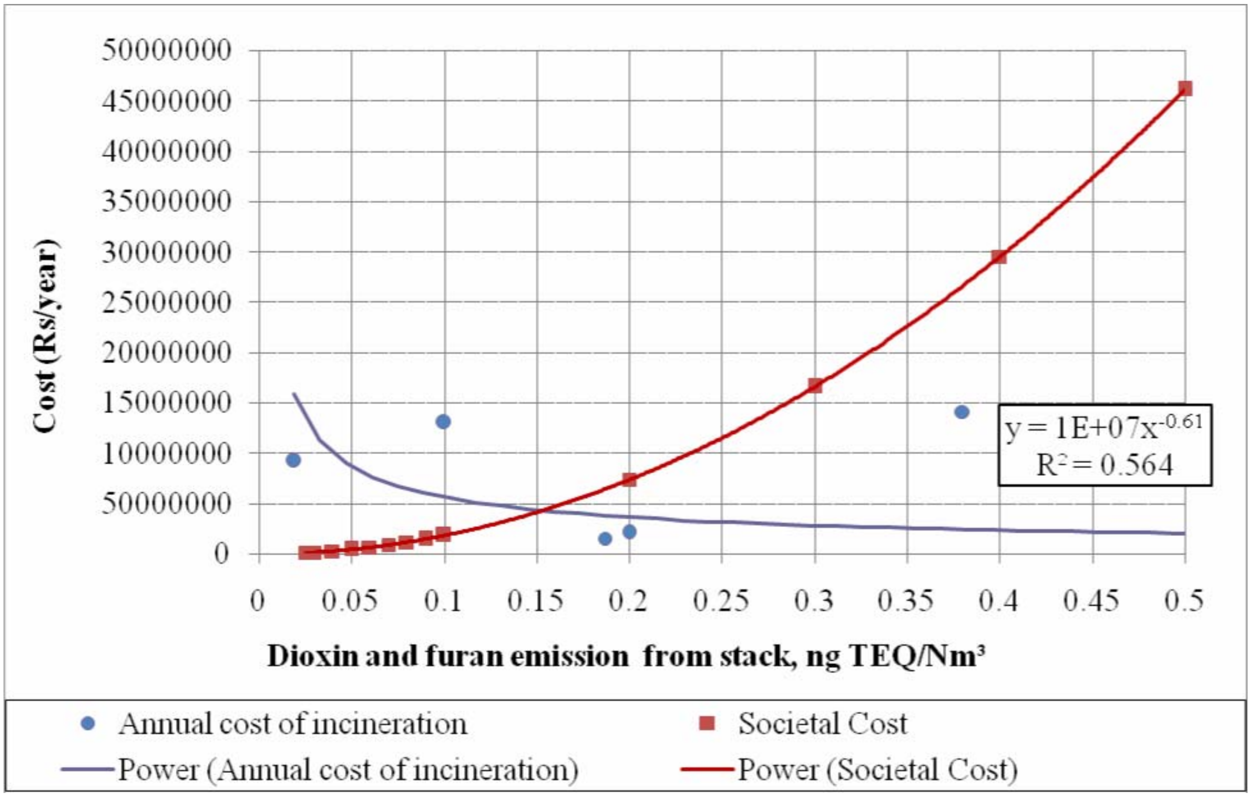
The data shows, as expected, that the societal cost rises exponentially as the emission levels are increased and consequently the distance for the selected GLC increases.

11. Comparison of Emission Control Costs and Societal Costs

The primary purpose of this study was to determine the “break even” standard for dioxin and furan emission where emission control costs and societal costs are equal to each other. This emission standard would then be considered “rational” as the societal costs justify the cost of control.

This combined curve is presented in Figure ES 5.

Figure ES 5: Comparison of annual cost of incineration and emission control of dioxin and furan with consequent societal costs at various emission levels



11. Conclusions

1. The two primary objectives of the study were
   - To compare the societal cost of a specific pollutant with societal cost of other causes of mortality.
   - To develop an approach that would attempt to relate the cost of pollution control to the societal cost consequent to a standard specified for the pollutant.

2. The present work has, in general and to a large extent, conceptualized an approach to achieve the above objectives.
   Specifically

   - The concept of life span reduction was developed which seems to be an effective tool to bring various causes of mortality to a common platform.
   - The concept also permits the computation of societal cost.

3. The societal costs, combined with costs associated with a given standard for emission control, can lead to a rational approach incorporating economic aspects in the development of standards.

4. The study also provided useful insight into the requirement of data for more rigorous study.
   For example

   - The need for more extensive and intensive data base for ambient air quality especially for specific pollutants.
   - Similarly more data on emissions from incinerators handling hazardous wastes coupled with meteorological data is also required

5. It must be emphasized that the present study should be considered more as a development of an approach, to be widely discussed, vetted and modified as required. It should not be taken as sacrosanct with respect to "numbers" which are generated using a number of assumptions in absence of real and valid data.

6. It is to be recognized that there is no relation in reality between emission of dioxin & furan and cost of incineration of hazardous wastes and control of emission of dioxin & furan. This is because all technologies of incineration and emission control are designed to achieve, as far as possible, zero emission of dioxin. The variations in dioxin emission are generally, due to a variety of reasons including O & M practices and not because of choosing a less expensive technology of incineration and emission control.

7. It should also be recognized that the societal costs calculated here are based only on mortality. The cost of treatment, hospitalization and consequent economic loss are not factored in as reliable and valid data on these aspects is difficult to obtain. This means that the societal costs as calculated here are lower than the real costs.

8. The health impact has only considered mortality directly attributable to dioxin and furan. It does not include synergistic or antagonistic health impacts due to other pollutants in the ambient air. This once again would impact the societal costs.

9. At a more fundamental level, the issue of sustainability of economic considerations in the framing and setting of standards is debatable. From a public health point of view, a policy that would balance the cost of "managing" health of the population impacted by the emission of a pollutant against the cost of control of the pollutant is unacceptable.

   The policy that mandates the control of pollution to prevent adverse health impact, irrespective of the cost of such control, should remain the guiding policy for framing standards of emission.

CHAPTER 1

INTRODUCTION

Polychlorinated dibenzodioxins (**PCDD**s), or simply **dioxins**, are a group of halogenated organic compounds which are significant because they act as environmental pollutants.

They are commonly referred to as dioxins for simplicity in scientific publications because every PCDD molecule contains a dioxin skeletal structure. Typically, the *p*-dioxin skeleton is at the core of a PCDD molecule, giving the molecule a dibenzo-*p*-dioxin ring system. Members of the PCDD family have been shown to bio-accumulate in humans and wildlife due to their lipophilic properties, and are known teratogens, mutagens, and suspected human carcinogens.

The word "dioxins" may also refer to a similar but unrelated compound, the polychlorinated dibenzofurans (PCDFs) of like environmental importance.

1.1 Chemical structure of dibenzo-*p*-dioxins

The skeletal formula and substituent numbering scheme of the parent compound dibenzo-*p*-dioxin is given below.

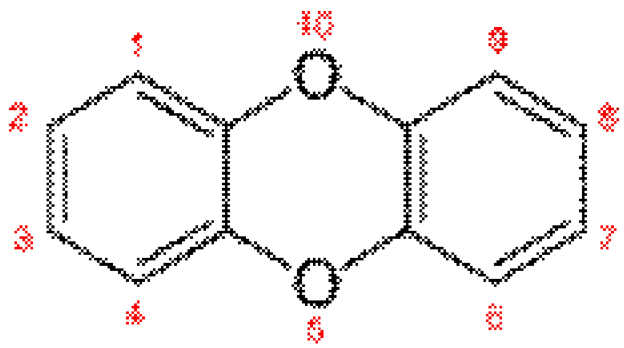


Figure 1.1: Chemical structure of dibenzo-p-dioxin

The structure of dibenzo-*p*-dioxin comprises of two benzene rings joined by two oxygen bridges. This makes the compound an aromatic diether. The name dioxin formally refers to the central dioxygenated ring, which is stabilized by the two flanking benzene rings.

In PCDDs, chlorine atoms are attached to this structure at any of 8 different places on the molecule, at positions 1-4 and 6-9. There are 75 different types of PCDD congeners (that is related dioxin compounds) [(1)]. The toxicity of PCDDs depends on the number and positions of the chlorine atoms. Congeners that have chlorines in the 2, 3, 7, and 8 positions have been found to be significantly toxic. In fact, 7 congeners have chlorine atoms in the relevant positions which were considered toxic by the NATO *Committee on the Challenges to Modern Society* (NATO/CCMS) international toxic equivalent (I-TEQ) scheme [(2)].

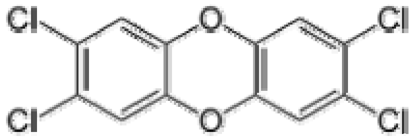


Figure 1.2 : Structure of *2,3,7,8-tetrachlorodibenzo-p-dioxin* (TCDD)

1.2 Chemical Structure of Polychlorinated dibenzofurans

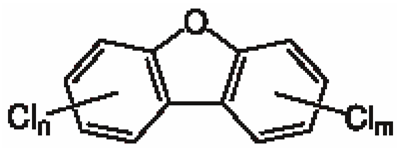


Figure 1.3: Structure of polychlorinated dibenzofurans

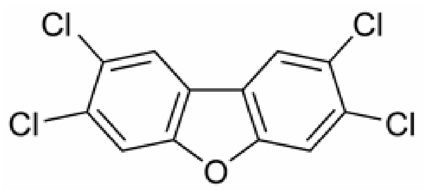


Figure 1.4: Structure of 2,3,7,8- Tetrachlorodibenzofuran (TCDF)

CHAPTER 2

THE PROJECT

Incineration of hazardous wastes is one of the sources of Dioxin in the ambient air. There are a number of well established technologies to handle hazardous wastes in the form of solids, liquids, sludges, tar etc. and having a high degree of variability in characteristics.

Based on the experience in other parts of the world, particularly in case of handling hazardous waste in solid form, the Central Pollution Control Board (CPCB) has adopted the technology consisting of rotary kilns followed by secondary combustion chambers as the incineration system for hazardous wastes.

Based on the above technology coupled with Air Pollution Control Devices (APCDs) for various pollutants, techno-economic feasibility and performance evaluation study, emission standards for Dioxin & Furans have been prescribed by the CPCB.

In evolving these standards, societal risk abatement cost and long term marginal cost aspect had not been considered by the CPCB. The present project has been taken up to consider these aspects.

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2.1 Objectives of the Project

The primary objectives of the study are

- To determine the long-run marginal financial cost and to find out what the user will need to pay for reaching the range of alternative levels of emissions of total Dioxins & Furans and
- Conduct a comparative study of societal risk abatement cost incurred by the Ministries / Departments concerned with mitigation of risk posed by epidemic, rail accidents and sewage exposure. These societal risk abatement cost (should be compared with that) corresponding to the environment standards (for Dioxin & Furan).

2.2 Scope of Services

The scope of work was divided into two parts and various tasks to be undertaken to achieve the above objectives were identified. These concepts were then presented to the CPCB and a consensus on the approach, methodology and tasks was arrived at. The tasks identified for the purpose are presented in the following sections.

PART I

- **Task 1**
  - Definition of dioxin & furan
  - Identification of sources of dioxin & furan
    - Point
    - Non point
  - Identification of the most significant point source in India
  - Estimation of the total emission of dioxin & furan in India from these point sources
- **Task 2**
  - Review of the international standards on dioxin & furan emission.
  - Review the rationale of Indian standards.
- **Task 3**
  - Estimate the costs of achieving different levels of dioxin & furan in stack emissions if possible.
  - Plot a curve of dioxin & furan standard and its cost
- **Task 4**
  - Calculate the equilibrium concentration of dioxin & furan in the ambient air for different atmospheric conditions
- **Task 5**
  - Review the health impact of dioxin & furan
  - Convert the health impacts to reduction in life span
  - Estimate the cost of health impacts (reduction in life spans)
- **Task 6**

- Construct combined curves of cost of emission control and health impacts

PART II

- **Task 1**
  - Review available data in India on various risks, e.g. rail accident, epidemic and sewage exposure etc.
- **Task 2**
  - Convert the data into reduction in life spans.
- **Task 3**
  - Determine the costs of the reduction in life spans and costs to the Ministries/ Departments.
- **Conclusion**
  - Compare the costs of these with the costs due to dioxin & furan emission standards.

CHAPTER 3

DIOXIN SOURCES, EMISSIONS AND PATHWAYS

Sources of dioxin may be classified as natural and man- made and point and non-point. The pathways include soil, water and air.

3.1 Natural Sources

Low concentrations of dioxins existed in nature prior to industrialization due to natural combustion and geological processes. These sources are generally non-point.

One possible natural source of dioxin is wood fires. Recently in the US, dioxin was found in millions of years old clay layers, not influenced by any man-made sources. The source of this dioxin is a biological process used by wood rotting fungi and some mushrooms to break down lignin with chlorinating and oxidizing compounds. This eventually leads to formation of dioxins resulting in high concentrations of dioxins in the soil in forests [3].

Similarly the biological destruction of municipal sludge and the biological composting of natural organic material also generate dioxins most probably through the same biological mechanism, which oxidizes the natural chloro-phenols [3].

3.2 Man-made Sources

3.2.1 Historical

Dioxins were first unintentionally produced as by-products from 1848 onwards as Leblanc process plants started operating in Germany. The first intentional synthesis of chlorinated dibenzodioxin was in 1872. Today, concentrations of dioxins are found in all humans, with higher levels commonly found in persons living in more industrialized countries. The most toxic dioxin, **2,3,7,8-tetrachlorodibenzo-*p*-dioxin** (TCDD), became well known as a contaminant of Agent Orange, an herbicide used in the Vietnam War [4]. Later, dioxins were found in Times Beach, Missouri [5] and Love Canal, New York [6] and Seveso, Italy [7]. More recently, dioxins have been in the news with the poisoning of President Viktor Yushrchenko of Ukraine in 2004,[8] the Naples Mozzarella Crisis [9] and the Irish pork crisis of 2008 [2].

3.2.2 Sources

(A) General

Dioxin is not produced commercially but is a by-product of chemical manufacturing processes such as chlorinated phenols and their derivatives particularly when reaction temperature is not well controlled [1]. Dioxins are produced in small concentrations when organic material is burned in the presence of chlorine, whether the chlorine is present as chloride ions or as organochlorine compounds, so they are widely produced in many contexts [10]. Dioxins are also generated in reactions that do not involve burning — such as bleaching fibers for paper or textiles [2].

In incineration, dioxins can also reform or form de novo in the atmosphere above the stack as the exhaust gases cool through a temperature window of 600 to 200 °C.

Dioxins are also in typical cigarette smoke. Dioxin in cigarette smoke was noted as "understudied" by the US EPA in its "Re-Evaluating Dioxin" (1995). In the same document, the US EPA acknowledged that dioxin in cigarettes is "anthropogenic" (man-made, "not likely in nature"). Nevertheless, the use of chlorine-containing tobacco pesticides and chlorine-bleached cigarette papers remains legal [2].

The United States Environmental Protection Agency Dioxin Reassessment Report is possibly the most comprehensive review of dioxins, but other countries now have substantial research. Australia, New Zealand and the United Kingdom all have substantial research into body burdens and sources [2].

According to the most recent US EPA data, the major sources of dioxins are:

- Coal fired utilities
- Municipal waste incinerators
- Metal smelting
- Diesel trucks
- Land application of sewage sludge
- Burning treated wood
- Trash burn barrels

These sources, together, account for nearly 80% of dioxin emissions in the US.

When the original US EPA inventory of dioxin sources was done in 1987, incineration represented over 80% of known dioxin sources. As a result, US EPA implemented new emissions requirements. These regulations have been very successful in reducing dioxin stack emissions from incinerators. Incineration of municipal solid waste, medical waste, sewage sludge, and hazardous waste together now produce less than 3% of all dioxin emissions [2].

(B) Summary

Various sources are summarized in Table 3.1A and 3.1B **[1]**

Table 3.1A: Point sources of dioxin and furan in environment [1]

S. No.	Combustion sources	Chemical manufacturing	Power / Energy Generation	Metal Smelting / Refining	Biological & Photochemical Process
1	Municipal solid waste incinerators	Chlorine bleaching in pulp & paper processing	Oil Combustion for industrial, residential and commercial purposes with stack	Non-ferrous metals	Pyrolysis of highly chlorinated dioxin and furan
2	Bio-medical waste incinerators	Organic chemicals (i.e. mono to tetra-chloro phenol, Penta-chloro phenol, Chlorobenzene, Tetra-chloro bis phenols, Alkaylamine tetra chloro phenate)	Coal combustion for industrial, residential and commercial purposes with stack	Iron and steel products	
3	Hazardous waste incinerator	Chloranil and elemental chlorine manufacturing	Wood combustion for industrial and residential purposes with stack	Ore sintering	
4	Industrial boilers and furnaces	Drugs & Pharmaceutical	Co-combustion in power plant	Ferrous foundries	
5	Petroleum refining	Dyes & dyes intermediates and pigments		Electric arc furnaces	
6	Biogas combustion	Petrochemicals for e.g. PVC manufacturing		Metal processing (Mg, Al, Pb, Ni, Cu etc.)	
7	Landfill gas combustion	Paint manufacturing			
8	Hot-mix plants with stack	Chlorinated pesticides			
9	Crematoriums with stack	Reactivation process of carbon			
10	Cement kilns (co incineration)				

Table 3.1B: Non-Point sources of dioxin and furan in environment [1]

S. No.	Combustion sources	Chemical manufacturing	Power / Energy Generation	Biological & Photochemical Process
1	Open burning of domestic waste	Printing inks	Motor vehicle fuel combustion (Diesel and gasoline)	Biotransformation of chloro-phenols
2	Forest fires	Sodium hypochlorite	Waste wood	Bioaccumulation and biomagnification
3	Cigarette smoking	PCB’s leak and spills		

4	Candles			

(C) Most Significant Sources in India

- Municipal incinerators
- Common Hazardous Waste incinerators
- Incinerators in bulk drugs manufacturing sector
- Incinerators in dye and dye intermediates sector
- Incinerators in pesticide sector
- Incinerators in basic organic industries sector

There are no municipal incinerators installed in India, as municipal waste is disposed of by landfill or composted which may include recovery of refuse derived fuel (RDF). The RDF is used either in boilers for power generation or in cement kilns to utilize its calorific value. No data on emission arising from combustion of RDF is available.

Fourteen common hazardous waste incinerators have been installed in seven states and 127 individual incinerators have been installed in 12 states and one union territory. Total incineration capacity of these incinerators is 327705 tonnes per annum (TPA). In addition to these, there are proposals to install 9 common and captive incinerators with proposed total capacity of 256770 TPA. Data on installation of incinerators in various states is presented in Table 3.2 [11].

Table 3.2: State wise incineration facilities for management of hazardous waste [11]

S.No.	Name of State/UT	Nos. of common incinerator	Nos. of captive incinerator
1	Andhra Pradesh	2	26
2	Gujarat	4	35
3	Himachal Pradesh	-	7
4	Karnataka	3	7
5	Kerala	1	1
6	Madhya Pradesh	-	7
7	Maharashtra	2	-
8	Punjab	-	17
9	Pondicherry	-	1
10	Rajasthan	-	5
11	Uttar Pradesh	1	13
12	West Bengal	1	4
13	Damman, Diu, Dadra & Nagar haveli	-	4
Total	**12 states and 1 UT**	**14**	**127**

3.3 Dioxin Emissions

Polychlorinated dibenzo-p-dioxins (PCDDs) have been found throughout the world in practically air, soil, water and sediment. They are also found in biotic media such as birds, fish, shellfish and marine mammals. The levels of these chemicals in the biota, especially in the top-of-food-chain predators, such as marine mammals, are often higher compared to their surrounding environment because of bioaccumulation of these chemicals [(3)].

In European countries food has been identified as the major route for human exposure to dioxin. Dietary intake of the population in these countries may contribute as much as 90 to 98% of the total daily intake of dioxin [(1)].

A study in Netherlands [(12)] has shown that major fraction of dioxin is released in the air environment and only minor fractions are directly released to the soil and water environment. The study, however, cautions that incineration processes will generate residues such as slag, filter ash and soot that may contain more dioxin as bound residue than the emissions in the air. The data on the annual dioxin emissions to the air in various countries is reproduced in Table 3.3 [(12)].

Table 3.3: Estimated annual dioxin emissions to air in various countries [(12)]

Sr. No.	Country	Basis year	Annual emission g TEQ/year
1	Austria	1987/88	115 (50-320)
2	Austria	1987/88	20-150
3	Belgium	1985	850
4	Belgium	1990	892
5	Belgium	1995	659
6	Germany	1990	67-926
7	Germany	1990	71-941
8	Japan	1990	4000-8400
9	Netherlands	1989	960
10	Netherlands	1990	610
11	Netherlands	1991	484
12	Sweden	1985	400-600
13	Sweden	1989/90	122-288
14	Sweden	1991	100-200
15	United Kingdom	1995	630-2400
16	United States	1994	3300-26000

When the original US EPA inventory of dioxin sources was done in 1987, incineration represented over 80% of known dioxin sources. As a result, US EPA implemented new emissions requirements. These regulations have been very successful in reducing dioxin stack emissions from incinerators. Incineration of municipal solid waste, medical waste, sewage sludge, and hazardous waste together now produce less than 3% of all dioxin emissions [2].

3.3.1 Indian Data

(A) Common Incinerators

The data on dioxin emissions from common incinerators is available for two common hazardous waste incinerators installed in Gujarat and one in Maharashtra.

Table 3.4A: Dioxin and furan emission data for common incinerators [13]

S.No.	Name of Unit	Emission ng TEQ/Nm^3
1	Bharuch Enviro Infrastructure ltd. Ankaleshwar	0.0255
2	Mumbai Waste Management ltd. Taloja	8.621
3	Gujarat Enviro Protection & Infra.ltd. Surat	0.0352

(B) Individual/Captive Incinerators

(i) Drug Manufacturing

The type of incinerable hazardous waste generated from bulk drug manufacturing industries are

a) Distillation residue
b) Spent carbon
c) Spent carbon mixed with filter aid and hyflow
d) Spent mixture solvents
e) Spent solvents
f) Process residue (organic)

The data on dioxin emissions from incinerators are available for three bulk drug manufacturing units [13].

Table 3.4B: Dioxin and furan emission data for drug manufacturing industries [13]

S.No.	Name of Unit	Emission ng TEQ/Nm^3
1	M/s Ranbaxy Laboratories Ltd, Tonsa	0.1965
2	M/s Lupin limited, Ankleshwar, Gujarat	0.0156
3	M/s Natco Pharma Ltd, Mekaguda, AP	0.1866

(ii) Dye and Dye Intermediates

The types of hazardous waste generated from the dye and dye intermediates industries are

a) Filter cake
b) Solid waste from physical-chemical waste water treatment
c) Solid waste from bio-chemical waste water treatment
d) Distillation residue
e) Polymeric by-products

These solid wastes constitute different types of sludges which contain highly toxic organic compounds. The data on dioxin emissions from incinerators are available for three dye and dye intermediates manufacturing industries [13].

Table 3.4C: Dioxin and furan emission data for dye and dye intermediates industries [13]

S.No.	Name of Unit	Emission ng TEQ/Nm^3
1	Color Synth Industries (P) ltd. Surat Gujarat	0.0203
2	Atul Ltd., Atul Gujarat	0.0684
3	Metrochem Industries (P) Ltd., Baroda	0.051

(iii) Pesticide manufacture

Types of incinerable hazardous waste generated from the pesticide industries are

a) Liquid organics solvents, waste oils, (high CV)
b) Aqueous waste / toxic (high TDS & low organics) (low CV)
c) Tarry waste highly viscous & non-pump able, solidified (very hard lumps) from distillation
d) Solid waste (process residues, packaging waste, etc.)
e) ETP sludge
f) Spent carbon
g) Spent catalyst

The data on dioxin emissions drawn from the incinerators are available for three pesticide industries [13].

Table 3.4D: Dioxin and furan emission data for pesticide manufacturing industries [13]

S.No.	Name of Unit	Emission ng TEQ/Nm^3
1	PI Industries ltd., Panoli	0.0195
2	Bayer Crop Science, Thane	0.50
3	Syngenta India ltd., Goa	0.38

(iv) Basic Organic Chemicals Manufacture

Waste stream types similar to that of pesticide sector are generated from basic organic chemicals manufacturing industries. The data on dioxin emissions from the incinerators are available for three basic organic chemicals manufacturing industries [13].

Table 3.4E: Dioxin and furan emission data for basic organic chemicals manufacturing industries [13]

S.No.	Name of Unit	Emission ng TEQ/Nm^3
1	Jubilant Organosys ltd., Gajraula. UP	0.029
2	Chemplast Sanmar ltd., Tamil Nadu	1.36
3	Gwalior Chemical Industries ltd., Nagada	6.4717

3.3.2 Estimation of total emission from these sources in India

Dioxin emission factors based on type of waste feed are not available for incinerators in India which defend on incineration technology adopted (coupled with pollution control devices). Therefore estimation of total emission is not possible due to lack of data.

3.4 Human Exposure

Occupational exposure is an issue for some in the chemical industry, or in the application of chemicals, notably herbicides. Inhalation has been a problem for people living near substantial point sources where emissions are not adequately controlled. In many developed nations there are now emissions regulations which have alleviated some concerns, although the lack of continuous sampling of dioxin emissions causes concern about the understatement of emissions. In Belgium, through the introduction of a process called AMESA, continuous sampling showed that periodic sampling understated emissions by a factor of 30 to 50 times. Few facilities have continuous sampling [2].

Children are passed substantial body burdens by their mothers, and breastfeeding increases the child’s body burden [14]. Children’s body burdens are often many times above the amount implied by tolerable intakes which are based on body weight. Breast fed children usually have substantially higher dioxin body burdens than non breast fed children until they are about 8 to 10 years old. The WHO still recommends breast feeding for its other benefits [15].

3.5 Dioxin in Air

The scope of this report is restricted to the emissions from hazardous waste incinerators. These include common as well as individual industry incinerators. The subsequent Sections/ Chapters are, hence, focused on dioxin and its emission in the air environment in general and form hazardous waste incinerators in particular.

The ambient air concentrations, aside from the emission concentrations, depend on the weather conditions like wind direction, wind velocity and ambient temperature. A Dutch study found that wind velocity was the most important factor [(12)].

Dioxin emissions in air comprise of a portion in the gaseous phase and a portion bound to particles. The dioxin in gaseous phase may be transported to hundreds or thousands of kilometers. The transport of the particulate fraction, on the other hand, depends on the particle size. For example particles larger than 20µ (a significant fraction in incinerator emissions) would travel a few kilometers while finer particles (less than 1µ) could be found in remote areas [(12)].

Removal of PCDDs from the gaseous phase is by chemical and photochemical degradation and deposition. The particulate fraction on the other hand is predominantly by dry or wet deposition. The concentrations of PCDDs in the air for various countries are presented in Table 3.5 [(12)].

The level of dioxins (PCDDs) & furans (PCDFs) in ambient air respirable suspended particulate matter of Delhi is given in Table 3.6 for the period January 2008 to August 2008.

Table 3.5: Dioxin in air in various countries [12]

S. No.	Country	Location	Dioxin Level pg TEQ/m^3
1	Australia	Sydney 4 Sites	0.02-0.06
2	Austria	6 sites (winter) – range of means	0.050-0.222
3	Austria	6 sites (summer) range of means	0.022-0.041
4	Belgium	6 Sites	0.02-0.59
5	Germany	Rural	<0.07
6	Germany	Urban	0.07-0.35
7	Germany	Close to major sources	0.35-1.6
8	Germany	Rural 1 Site 1991-92	0.019
9	Germany	Urban/Industrial sites 8 sites (N=11)	0.040-0.332
10	Japan	Urban (summer) mean (range)	0.79 (0.4- 1.3)
11	Japan	Urban (winter) mean (range)	1.46 (0.3-2.9)
12	Japan	3 sites (summer) mean (range)	0.38 (0.06-0.59)
13	Japan	3 sites (winter) mean (range)	0.45 (0.30-0.69)
14	Netherlands	Industrial close to MSWI mean (range)	0.062 (0.006-0.14)
15	Netherlands	Rural mean (range)	0.031 (0.009-0.063)
16	Netherlands	Urban (Near Belgium & German border) mean (range)	0.055 (026-0.099)
17	Netherlands	Urban (Conglomerate) mean (range)	0.018 (0.004-0.059)
18	Spain	8 sites in Catalunya range of means	0.08-0.55
19	Sweden	Urban/suburban	0.013-0.024
20	Sweden	Remote/coastal	0.003-0.004
21	United Kingdom	4 urban sites mean (range)	0.17 (nd-1.8)
22	United States	Coastal environment winter mean	0.10

Table 3.6: Level of dioxins & furans in ambient air respirable suspended particulate matter of Delhi for the period January 2008 to August 2008 [20]

S. No.	Location of monitoring	Level of dioxin & furan pg TEQ/Nm^3
1	Nizamuddin (n=3)	0.036
2	S. Bagh (n=3)	0.141
3	Pitampura (n=5)	0.236
4	Sirifort (n=13)	0.529
5	Janakpuri (n=13)	0.535
6	I.T.O. (n=15)	0.851
7	Shahadra (n=10)	1.187
Average dioxin & furan (n=62)		**0.502**

CHAPTER 4

TOXICITY AND HEALTH IMPACTS

Dioxins are absorbed primarily through dietary intake of fat, as this is where they accumulate in animals and humans. In humans, the highly chlorinated dioxins are stored in fatty tissues and are neither readily metabolized nor excreted. The estimated elimination half-life for highly chlorinated dioxins (4-8 chlorine atoms) in humans ranges from 7.8 to 132 years [(2) and (16)].

The persistence of a particular dioxin congener in an animal is thought to be a consequence of its structure. It is believed that dioxins with few chlorines, which thus contain hydrogen atoms on adjacent pairs of carbons, can more readily be oxidized by cytochromes P450 [(2)]. The oxidized dioxins can then be more readily excreted rather than stored for long time [(2)].

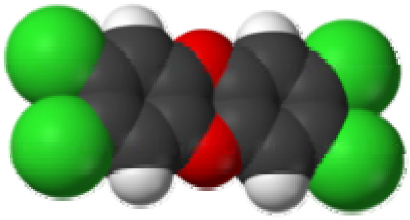

Figure 4.1: Space-filling model of 2,3,7,8- tetrachlorodibenzo-*p*-dioxin.

4.1 Toxicity

Dioxins are found to bring about a variety of biochemical and toxic responses in experimental animals which vary with the species, strain, gender, age and tissue of the animal being exposed. Various dioxin congeners tend to elicit a similar battery of responses although the congeners are differently potent. As the mechanisms of these impacts are still obscure rational risk assessment is difficult. A common denominator appears to be the so called Ah receptor (AhR), which mediates the biological effects of TCDD in cells [(3)]

2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) is the most toxic of the congeners. Other dioxin congeners (or mixtures thereof) are given a toxicity rating from 0 to 1, where TCDD = 1. This toxicity rating is called the Toxic Equivalency Factor, or TEF. TEFs are consensus values and, because of the strong species dependence for toxicity, are listed separately for mammals, fish, and birds. TEFs for mammalian species are generally applicable to human risk calculations. The TEFs have been developed from detailed assessment of literature data to facilitate both risk assessment and regulatory control. Many other compounds may also have dioxin-like properties, particularly non-ortho PCBs, some of which can have TEFs as high as 0.1.

The TEF values of various congeners are presented in Table 4.1 [(12)].

Table 4.1: TEF values of various congeners [12]

Congener (CDDs)	I-TEF	Congener (CDFs)	I-TEF
2,3,7,8-Cl_4DD	1	2,3,7,8-Cl_4DF	0.1
1,2,3,7,8-Cl_5DD	0.5	1,2,3,7,8-Cl_5DF	0.05
1,2,3,4,7,8-Cl_6DD	0.1	2,3,4,7,8-Cl_5DF	0.5
1,2,3,6,7,8- Cl_6DD	0.1	1,2,3,4,7,8-Cl_6DF	0.1
1,2,3,7,8,9-Cl_6DD	0.1	1,2,3,6,7,8- Cl_6DF	0.1
1,2,3,4,6,7,8-Cl_7DD	0.01	1,2,3,7,8,9-Cl_6DF	0.1
OCDD/Cl_8DD	0.001	2,3,4,6,7,8-Cl_6DF	0.1
		1,2,3,4,6,7,8-Cl_7DF	0.01
		1,2,3,4,7,8,9- Cl_7DF	0.001
		OCDF/Cl_8DF	0.001

The total dioxin toxic equivalency (TEQ) value expresses the toxicity as if the mixture were pure TCDD. It is the sum of the TEFs weighted with the concentration of the various compounds. The TEQ approach and current TEFs have been adopted internationally as the most appropriate way to estimate the potential health risks of mixture of dioxins. Recent data suggest that this type of linear scaling factor may not be the most appropriate treatment for complex mixtures of dioxins; further research into non-linear toxicity models is required to substantiate this hypothesis.

Dioxins and other persistent organic pollutants (POPs) are subject to the Stockholm Convention. The treaty obliges signatories to take measures to eliminate where possible, and minimize where not possible to eliminate, all sources of dioxin.

2,3,7,8- TCDD is considered to be an extremely toxic compound. The oral LD_{50} for experimental animals varied from 0.6 µg/kg body weight for sensitive female Guinea pig while mice and rabbits were hundred times less sensitive. Thus the lethal dose, as tested on experimental animals, varies significantly with the species probably due to varying sensitivity [12].

One characteristic of the toxicity of 2,3,7,8- TCDD is that the death is not instantaneous but occurs after long after the dosing. During the period before death, there is often a drastic reduction in weight (wasting syndrome) [12].

Information on lethal dose of 2,3,7,8- TCDD and related compounds to humans is not available.

4.2 Health Impacts

Short term exposure to high levels of dioxin may result in chloracne and other related skin disorders. It also causes immune system toxicity, gastrointestinal ulcers, and also may lead to neuro-toxic effects. It may cause choking of lungs and increases susceptibility to cancer [(1) and (12)].

Exposure to high levels of dioxins, may also cause mood alterations, reduced cognitive performance, diabetes, changes in white blood cells, dental defects, endometriosis, decreased male/female ratio of births and decreased testosterone and (in neonates) elevated thyroxin levels. Presently the effects have been proven only in the case of chloracne [(3)].

Long term exposures, even at low concentrations, alters reproductive functions including congenital and neonatal development abnormalities [(1)].

Carcinogenicity

In February 1997, the program of the International Agency for Research on Cancer (IARC) Monographs on the Evaluation of Carcinogenic Risks to Humans, convened a Working Group of experts and observers from 11 countries in Lyon, France, to evaluate the evidence that polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) might be risk factors for human cancer [(17)].

The conclusion arrived by the Working Group was, after considering the human and animal cancer data together with all of the other experimental data and overall evaluations and classifications, that 2,3,7,8-tetra-chlorodibenzo-*p*-dioxin (TCDD) is carcinogenic to humans.

The only data on increased risk for all cancers combined due to exposure to TCDD is based on four cohorts studies of herbicide producers. These studies involve the highest exposures to TCDD among all epidemiologic studies. An increased risk for all cancers combined (approximately 1.4 fold) was seen in cohort studies. This risk factor is used in the present study for the health impact of Dioxin [(17)].

CHAPTER 5

DIOXIN STANDARDS

Since the scope of the present report is limited to hazardous waste incinerators, the review of literature on standards is restricted to the standards for emissions from such incinerators.

5.1 International

5.1.1 Canada

The following standards are a step towards achieving virtual elimination for dioxins and furans.

For new or expanding facilities of any size, application of best available pollution prevention and control techniques, such as a waste diversion program, to achieve a maximum concentration* in the exhaust gases from the facility as follows:

- Municipal waste incineration 80pg I-TEQ/m^3
- Medical waste incineration 80pg I-TEQ/m^3
- Hazardous waste incineration** 80pg I-TEQ/m^3
- Sewage sludge incineration 80pg I-TEQ/m^3

*Stack concentrations of dioxins and furans will be corrected to 11% oxygen content for reporting purposes.

**Hazardous waste incinerators include all facilities that burn hazardous waste including low level radioactive waste; however they do not include facilities that use waste derived fuel or used oil.

For existing facilities application of best available pollution prevention and control techniques, to achieve a maximum concentration* in the exhaust gases from the facility as follows:

– Municipal waste incineration
    - > 26 Tonnes/year*** 80pg I-TEQ/m^3
    - < 26 Tonnes/year**** 80pg I-TEQ/m^3
– Medical waste incineration
    - > 26 Tonnes/year*** 80pg I-TEQ/m^3
    - < 26 Tonnes/year**** 80pg I-TEQ/m^3
– Hazardous waste incineration** 80 pg I-TEQ/m^3
– Sewage sludge incineration 100 pg I-TEQ/m^3

***Larger facilities must achieve this stack concentration as confirmed by annual testing.

****Smaller facilities must make determined efforts to achieve this stack concentration.

5.1.2 USEPA Standards [(10)]

Source	Standards for new facilities[b]	Standards for existing facilities[b]
Hazardous waste incinerators	0.11 ng I-TEQ/dscm for dry APCD and/or waste heat boiler sources 0.20 ng I-TEQ/dscm for all other incinerators	0.20 ng I-TEQ/dscm and temperature control <400°F at the APCD inlet 0.40 ng I-TEQ/dscm when PM control device operated >400°F
Cement kilns burning hazardous waste	0.20 ng I-TEQ/dscm and temperature control <400°F at the APCD inlet 0.40 ng I-TEQ/dscm when PM control device operated >400°F	0.20 ng I-TEQ/dscm and temperature control <400°F at the APCD inlet 0.40 ng I-TEQ/dscm when PM control device operated >400°F
Lightweight aggregate kilns burning hazardous waste	0.20 ng I-TEQ/dscm or rapid quench below 400°F at kiln exit	0.20 ng I-TEQ/dscm or rapid quench below 400°F at kiln exit

[a]Air emission standards promulgated September 30, 1999, and December, 2005.
[b]ng I-TEQ/dscm = nanogram I-TEQ per dry standard cubic meter of stack gas volume, corrected to 7% O_2.

APCD = Air pollution control device (dry = dry scrubber or fabric filter)
PM = Particulate matter

5.1.3 Japan

The law sets the tolerable daily intake (TDI) of dioxins for humans at no more than 4 picograms per kilogram of body weight.

A picogram (pg) is one-trillionth of a gram. To achieve this, dioxin levels are limited to

- 0.6 pg per cubic meter in the atmosphere
- 1.0 pg per liter of water and
- 1,000 pg per gram of soil.

Japan is the only country which has specified an ambient air standard for dioxin [(18)].

Daily intakes values of dioxin [3]

Country/Organization	Limit Values	Remarks
Canada	10 pg I-TEQ/kg bw/day	TDI
Germany	1-10 pg I-TEQ/kg bw/day	TDI
	1 pg I-TEQ/kg bw/day	Long-term objective
Japan	4 pg TEQ/kg bw/day	TDI
Netherlands	1-4 pg TEQ/kg bw/day	TDI used for risk assessment, which includes the PCDD/Fs and dioxin-like PCBs.
	1 pg/kg bw/day	Recommended limit of human exposure for 2,3,7,8-TCDD, and applicable to the intake of dioxin-like compounds expressed as TEQs.
Sweden	5 pg TEQ/kg bw/day	TDI; uses Nordic TEQ.
United Kingdom	10 pg I-TEQ/kg bw/day	TDI; the COT recommended it include PCDD/Fs and dioxin-like PCBs.
United States	0.006 pg 2,3,7,8-TCDD/kg bw/day	Risk-specific dose based on lifetime cancer risk. Interpreted as TEQ.
	1 pg TEQ/kg bw/day	Minimal risk level: chronic (365-day) oral exposure to 2,3,7,8-TCDD, and applicable for other dioxin like compounds expressed in total TEQs.
WHO	10 pg/kg bw/day	TDI for to 2,3,7,8-TCDD; revised in 1998.
	1-4 pg TEQ/kg bw/day	Revised TDI range that includes the PCDD/Fs and dioxin-like PCBs using the most recent WHO TEF values (Van den Berg et at., 1998).

5.1.4 Indian Standards with Rationale

Common hazardous waste incinerator facilities are required to treat varieties of hazardous wastes in different forms (liquid, solid, semi solid and tarry) through proper combustion as well as to control pollutants emitted from the combustion process. Among these pollutants most critical parameter is dioxins and furans. The system which fulfils such requirement has been recommended for incineration of hazardous waste in the guidelines for common hazardous waste facilities, published by the Central Pollution Control Board (CPCB). In the recommended system, combustion system considered appropriate is Rotary Kiln followed by Secondary Chamber. Air pollution control devices considered appropriate are quencher (air), injection of lime and activated carbon for controlling dioxin and furan; bag filters for removal of suspended particulate matter, wet scrubbers (caustic) for acidic gases and finally letting out of gases through a stack of adequate height. Since the operation of such facilities is considered important for proper treatment of waste as well as to control pollution, the guidelines also specify operating parameters.

The practically achievable level of pollutants by such system with minimum operating temperatures of 950 °C in Rotary Kiln and 1100 °C in the Secondary Chamber, with minimum retention time of two seconds formed the basis for prescribing emission standards for common hazardous waste incinerators, keeping in view least possible emission of dioxins and furans into the environment. The practicability and affordability were also considered while fixing standards and consultation with stake holders was carried out.

The standards applicable for common hazardous waste facilities are given in Annexure-II. The standard prescribed for the emission of total dioxins and furans is 0.1 ng TEQ/Nm^3.

CHAPTER 6

INCINERATORS AND EMISSION OF DIOXIN

The scope of this report is restricted to dioxin emission from incinerators for hazardous wastes. The following sections, hence, deal with control of dioxin emissions from hazardous waste incinerators.

Although incinerator design and operating practices can significantly reduce the amount of pollutants produced in incineration plants, some pollutants are inevitably generated. Emission control devices neutralize, condense, or collect these pollutants and prevent them from being emitted into the air. Most of these devices are placed at the back end of the incinerator, treating flue gases after they pass out of secondary combustion chamber.

Incinerators are typically equipped with a wide variety of air pollution control devices (APCDs), which range from no control (for devices burning low ash and low chlorine wastes) to sophisticated state-of-the-art units providing control for several pollutants.

Hot flue gases from the incinerators are cooled and cleaned of the air pollutants before they exit the stack. Cooling is mostly done by water quenching, wherein atomized water is sprayed directly into the hot gases. The cooled gases are passed through various pollution control devices to control PM, metals and organic emissions to desired or required levels.

Typical APCDs used for controlling different pollutants from an incinerator are:

For controlling	Type of APCDs Used
Acid gases, Mercury, Dioxin, and Furan Emissions	Packed towers, spray dryers, or dry injection (activated carbon, lime) scrubbers
Particulate and Heavy Metal Emissions	Venturi scrubbers, wet or dry ESPs or fabric filters
Nitrogen Oxide Emissions	Selective non-catalytic reduction (SNCR) and selective catalytic reduction (SCR)

Combustion processes are the main source of dioxin and furan emissions globally. Out of the known sources of Dioxin contamination, more than 95% emissions derive from combustion processes. Dioxin and furan are formed from the thermal breakdown of organic materials combined with transitional metals and chlorinated compounds. It is also known that dioxins are chemically formed at temperature above 200°C but completely destroyed at 800°C. Reformation of dioxin occurs, when the temperature lies between 200°C to 400°C. Chlorine availability and process temperature are the two important factors responsible for dioxin formation.

6.1 Incinerator Operation and Dioxin Emission Control

Modern incinerator plants can be designed and operated to achieve nearly complete destruction of the combustible portion of the waste with very low emission under normal operating conditions. Following are the practical measures to be adopted to reduce emission of dioxin and furan from hazardous waste incinerators.

- Good combustion chamber design to optimize the supply of air for achieving more complete destruction of waste.
- The secondary chamber operating at 1100° C to 1250° C should be capable to retain the flue gas for at least 2 seconds for hazardous waste incinerators for destruction of dioxin in the flue gas.
- The flue gas has to be abruptly cooled (quenching) to temperature below 200° C to reduce dioxin reformation.
- Regular cleaning of boiler tubes to prevent build up of fly ash, which can serve as a catalyst for dioxin reformation.
- Facilities for injection of activated carbon by powered injection system, which is operated in parallel with the alarm warning system to capture any dioxin, if reformed, for treatment.
- Regular monitoring of combustion products including dioxin emissions.
- Suspension of waste feeding operation to allow urgent trouble shooting and problem-fixing, when abnormal monitoring readings of air emissions or incinerator temperature is detected.
- The temperature at exit of waste heat boiler to be maintained about 400° C.
- Efficient functioning of wet scrubber to remove hydrogen chloride from flue gas.
- A fabric filters system to contain the fly ash emission along-with flue gas.

The best way to control dioxin and furan emissions is preventing their formation by reducing or eliminating the chlorine in the fuel and waste material being burned.

Type of incinerators in practice in various chemical industries are multiple hearth, fixed hearth, fluidized bed, pyrolysis and/or liquid injection followed by pollution control system which comprises quencher followed by scrubber with or without dust collection device and/or demister. In case of common incineration facilities, incineration system comprises rotary kiln followed by secondary chamber with pollution control system consisting of quencher with water or alkali water, dust collection system (cyclone or bag filters), scrubber (with caustic solution) and demister, with or without lime and carbon feeding or reagent injection.

6.2 APCDs for Controlling Acid gases, Mercury, Dioxin, and Furan Emissions

Scrubbers, followed by an efficient particulate control device, are the state-of-the-art equipment for controlling emissions of acids such as hydrogen chloride, sulfur dioxide.

Scrubbers generally use impaction, condensation, and acid-base reactions to capture acid gases in flue gas. Since greater removal efficiencies usually accompany greater condensation, devices that lower gas temperatures and thus increase condensation can enhance scrubber effectiveness. The lower temperatures also allow mercury, dioxins, and furnaces to condense so that they can subsequently be captured by a particulate device.

Three types of scrubbers are used, namely wet scrubbers, spray dry scrubbers, and dry injection scrubbers. In all cases, temperature and, for dry scrubbers, the amounts of lime are the key factors affecting scrubber effectiveness. In general, to maximize emission control, the scrubber should be adequately sized, operate at temperature below 130°C, and allow flue gas circulation through the scrubber for at least 10 - 15 sec.

(i) Wet Scrubbers

Wet scrubbers capture acid gas molecules onto water droplets; sometimes alkaline agents are added in small amounts to aid in the reaction. New designs report on removing over 99% of the hydrogen chloride and, in some cases, sulphur dioxide and over 80% of the dioxin, lead and mercury. The disadvantages include the added cost to treat the wastewater produced, corrosion of the metal parts, and incompatibility with the fabric type particulate control device. However, wet scrubbers collect gases as well as particulates, especially sticky ones.

(ii) Spray type (Dry or Semi-Dry) Scrubbers

With these scrubbers, acid gases are captured by impaction of the acid gas molecules onto alkaline slurry, such as lime. Here, the evaporation of water from the scrubbing liquid is carefully controlled so that when the material reaches the bottom of the tower, it is a dry powder (a dry fly ash and lime mixture). This method eliminates the scrubber water that must be treated or disposed. Additionally, the power requirements and corrosion potential are reduced. Emission tests have demonstrated control efficiencies of 99% or better for hydrogen chloride and sulphur dioxide removal under optimal conditions (temperatures below 150°C, sufficiently high lime/acid ratios, and sufficiently long gas residence time in the scrubber). Dioxins are also considerably reduced.

(iii) Dry Injection Scrubbers

Dry injection scrubbers inject dry powdered lime or another agent that reacts with the acid gases in flue gas. In one research test, removal efficiencies of 99% for hydrogen chloride and 96% for sulphur dioxide were measured under optimal temperature conditions (110°C). Dioxins were also considerably reduced.

6.3 The Indian Experience

Incineration system with pollution control system in individual industries and common facilities are provided in Table 6.1 along with dioxin (PCDDs) & furan (PCDFs) emission data and capital cost of incineration system.

Table 6.1: Details of incineration systems

S. No.	Name of Industry	Type of incinerator	Capacity with type of feed	Pollution control system	Installation cost, Lac	Dioxin emission ng TEQ/Nm^3	Remarks / other details
1	Syngenta India Ltd., Goa.- Solid waste incinerators	Multiple Hearth (Temp. >1100 °C)	Solid waste: Non-Chlorinated, 90 kg/hr	(i) Quencher (with water) (ii) Scrubber (with water and caustic)	150* (Installation cost is 100 lac in 1993)	0.048	Revamped in 2004
2	Syngenta India Ltd., Goa.- Liquid waste incinerators (TO1)	Fixed Hearth (Vertical, cylindrical down fire furnace, Temp. >1100 °C)	Liquid waste: Non-Chlorinated and Chlorinated, 6000 kg/hr	(i) Quencher (with water) (Ii) Dust collection system (iii) Scrubber (with caustic sol.)	3250	<0.003 [0.38]	Installed in 2005
3	Syngenta India Ltd., Goa.- Liquid waste incinerators (TO2)	Fixed Hearth (Vertical, cylindrical down fire furnace, Temp. >1100 °C)	This unit is designed to handle all wastes handled in existing TO1 unit with same capacity	(i) Quencher (with water) (Ii) Dust collection system (iii) Scrubber (with caustic sol.)	4100	<0.1	Under commissioning
4	Baroda Textile Effects Pvt. Ltd, Umraya	Fluidized Bed (Temp. 1180-1250 °C)	Liquid Waste: Non-Chlorinated , 3000 kg/hr	(i) Dust collection system (cyclone) (ii) Scrubber (with caustic)	302	0.06	Installed in 2008
5	Natco Pharma Ltd, Andhra	(i) Pyrolysis (SP: 800-900 °C, SDP:	Liquid, Solid, Semi-Solid	(i) Quencher (with air & water	100	[0.1866]	Installed in 2009

S. No.	Name of Industry	Type of incinerator	Capacity with type of feed	Pollution control system	Installation cost, Lac	Dioxin emission ng TEQ/Nm^3	Remarks / other details
	Pradesh	500-800 °C) (ii) Other/ PCC (1000-1100 °C)	waste: Non-Chlorinated, 100 kg/hr	(ii) Scrubber (with caustic (iii) Demister			
6	Lupin Limited, Ankleshwar	(i) Fixed Hearth (Temp. 1100-1150 °C) (ii) Pyrolysis (Temp. 800-850 °C)	Solid, Liquid Waste: Non-Chlorinated, 6.12 MT/day	(i) Quencher (with water) (ii) Dust collection system (cyclone) (iii) Scrubber (water with caustic)	210	<0.2 [0.0156]	Installed in 2000
7	Ranbaxy Laboratories ltd., Punjab	(i)Fixed Hearth (Temp. 1100±50 °C) (ii) Multiple Hearth (iii) Pyrolysis	Liquid, Solid Waste: Non-Chlorinated, 1010 kg/hr	(i) Quencher (with water) (ii)Dust collection System (multiple cyclone) (iii) Scrubber (with caustic)	600	0.01 [0.0196]	Installed in 2003
8	Chemplast Sanmar Ltd, Mettur Dam	Pyrolysis (Temp. 1250 °C)	Liquid, Gaseous Waste: Chlorinated, 635 kg/hr	(i) Quencher (ii) Scrubber (iii) Demister	900	0.019 [1.36]	Installed in 1998
9	Lanxess India Pvt. Ltd, Nagda, M.P.	Liquid Injection (Temp. above 1100 °C)	Liquid Waste: Chlorinated, 150 kg/hr (Approx.)	Scrubber (with caustic sol.)	25	[6.5]	Installed in 1995. Currently not Working
10	Gujarat Enviro Protection & Infrastructure ltd, Surat	(i) Rotary kiln (Temp. 850±50 °C) (ii) Secondary Furnace (Temp.	Liquid, Solid, Semi-Solid Waste: Chlorinated and Non-	(i)Quencher (with Alkali water) (ii) Dust collection system (Cyclone) (iii)Scrubber (water with	125	<0.01 [0.0352]	Installed in 2003

S. No.	Name of Industry	Type of incinerator	Capacity with type of feed	Pollution control system	Installation cost, Lac	Dioxin emission ng TEQ/Nm^3	Remarks / other details
		1200 °C)	Chlorinated, 1900 kg/hr	caustic) (iv) Demister			
11	Mumbai Waste Management Ltd, Taloja	Rotary kiln (Temp. at primary chamber- 850- 950 °C and secondary chamber- 1100- 1200 °C)	Liquid, Solid, Semi-Solid: Chlorinated, 2000-2500 kg/hr each plant	(i)Spray Dryer/Evaporative cooler with water & Leachate (ii) Reagent Injection system (iii) Bag filters (iv) Scrubber (with caustic sol.)	2550	0.0058 [8.621]	Installed INC-I in 2004 and INC-II in 2008
12	Bharuch Enviro Infrastructure ltd, Ankaleshwar	Rotary kiln (Temp. 900°C in RK, 1100°C in Secondary chamber	All type Waste: Chlorinated & Non-Chlorinated, 2500 kg/hr	(i) Quencher (with water) (ii) Lime/ Carbon feeding (iii) Dust collection system (iv) Scrubber (with caustic) (v) Demister	1600	0.02 [0.0255]	Installed in 2004

* Revamp cost of old incinerator using old incinerator components including Pollution control system

Note: Dioxin and furan emission data in parenthesis has been taken from CPCB [(13)]

CHAPTER 7

DEATHS AND REDUCTION IN LIFE SPAN

The primary objective of the present assignment is to compare the risks and societal costs of dioxin emission with the risks and societal costs of other events such as water borne diseases, rail and road accidents etc.

The basic approach adopted was to convert all the risks into reduction in life span of the total population. This then provides a common basis for comparison.

7.1 Methodology

The following are the steps followed to arrive at the reduction in life spans.

- Obtain the data on the deaths for various years due to a cause
- Find the average deaths for a period of 10 years
- Obtain the latest data on the total, male and female population
- Distribute the population by age group
- Obtain the data on average life span for the year for the total population
- Assuming that deaths reflect the population distribution by age, distribute deaths by age group
- Determine the life-years lost by each age group
- Determine the life- years lost by person per age group per year
- Convert the life span reduction in minutes per age group
- Find the total reduction in the life span of the whole population

7.2 Incidence and Deaths

7.2.1 Cholera

The incidence and deaths due to Cholera are presented in Table 7.1 and Figures 7.1 and 7.2 [19].

Table 7.1: Cholera Cases and Deaths

Cholera Incidence		
(1980 to 2005)		
Year	**Cases**	**Deaths**
1980	8717	309
1981	6073	200
1982	4693	217
1983	9202	432
1984	2642	68
1985	5813	154
1986	4211	71
1987	11423	224
1988	8957	215
1989	5044	72
1990	3704	87
1991	7088	150
1992	6911	55
1993	9437	53
1994	4973	32
1995	3432	9
1996	4425	34
1997	3173	18
1998	7151	10
1999	3839	6
2000	3879	18
2001	4178	6
2002	3455	10
2003	2893	2
2004	4695	7
2005*	3156	6
*Provisional		

The average deaths due to Cholera from 1996 to 2005 are 11.7 say 12.

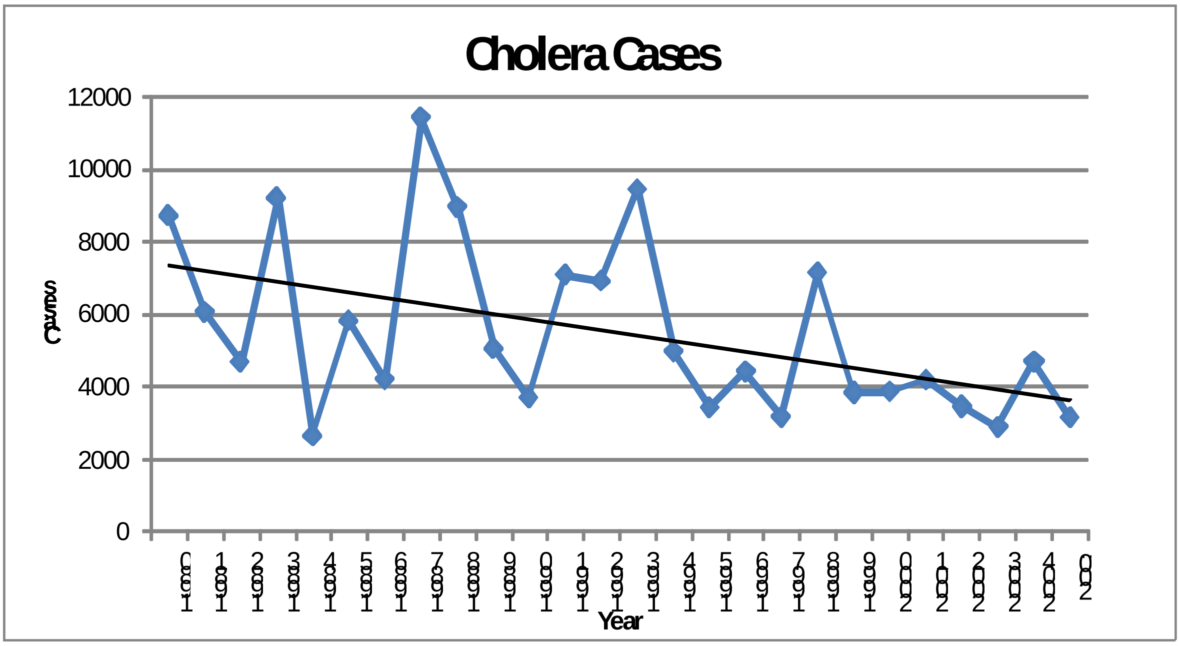

Figure 7.1: Cholera cases

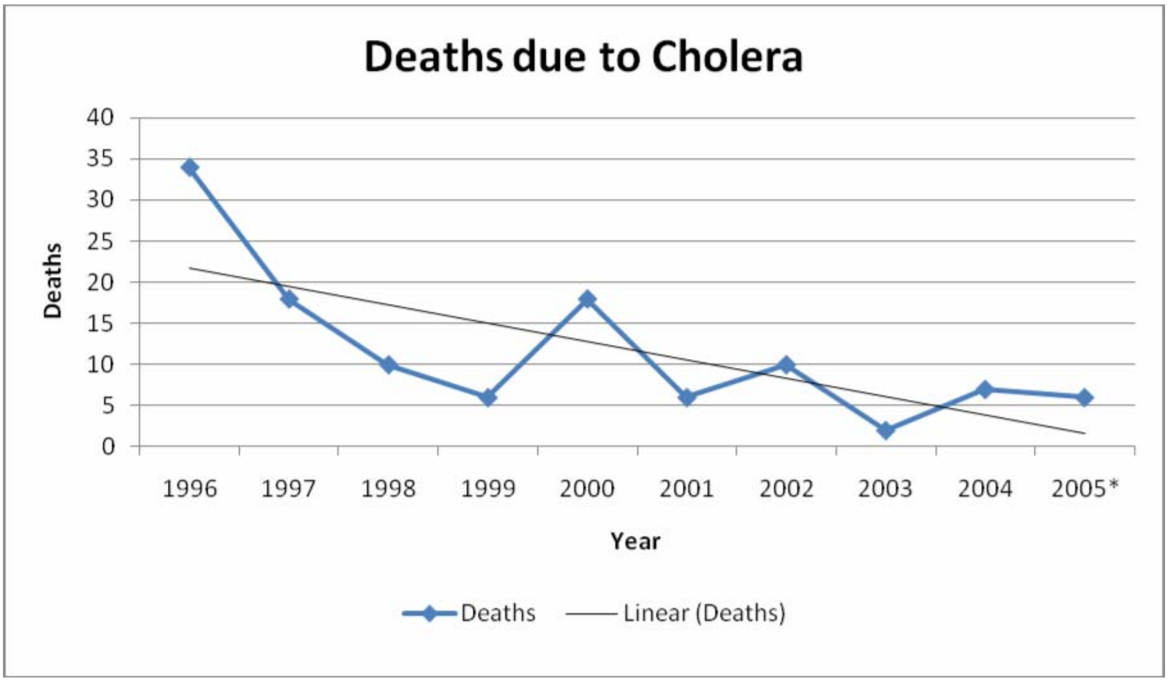

Figure 7.2: Deaths due to Cholera

7.2.2 Diarrhoea including Gastro-enteritis

The incidence and deaths due to Diarrhoea including Gastro-enteritis are presented in Table 7.2 and Figures 7.3 and 7.4. (19)

Table 7.2: Cases and Deaths due to Acute Diarrhoeal Diseases

Number of Reported Cases and Deaths due to Acute Diarrhoeal Diseases (Including Gastro-Enteritis) in India (1991 to 2005)		
Year	**Cases**	**Deaths**
1991	9280945	7493
1992	9528037	6499
1993	7262755	3609
1994	9380215	5915
1995	9215353	6667
1996	9076480	4269
1997	8156688	3418
1998	9634787	7152
1999	8215296	3594
2000	8870507	2918
2001	9289558	2787
2002	9441456	3475
2003	10510476	3433
2004	10487238	2939
2005	10759128	2040

The average deaths due to Diarrhoea from 1996 to 2005 are 3602.5 say 3603

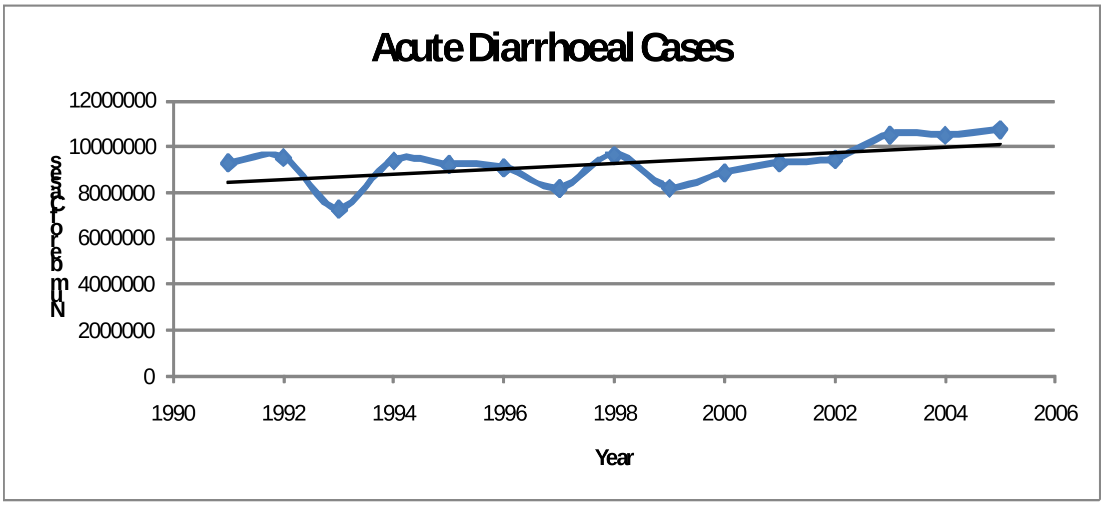

Figure 7.3: Acute Diarrhoeal Cases

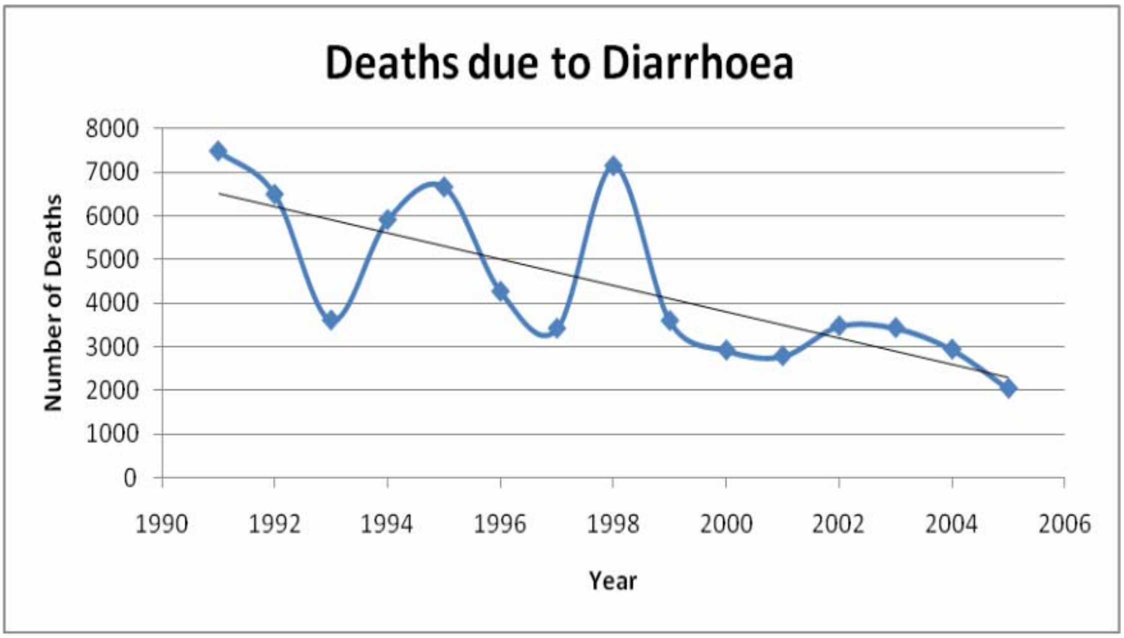

Figure 7.4: Deaths due to Diarrhoea

7.2.3 Hepatitis

The available data on incidence and deaths due to Hepatitis is presented in Table 7.3 and Figures 7.5 and 7.6. (19)

Table 7.3: Incidence of and Deaths due to Hepatitis

Year	Cases	Deaths
1996		801
1997		1098
1998		668
1999		411
2000	153034	1038
2001	149262	1147
2002	135859	914
2003		
2004	236493	1186

Average deaths due to Hepatitis from 1996 to 2004 are 908.

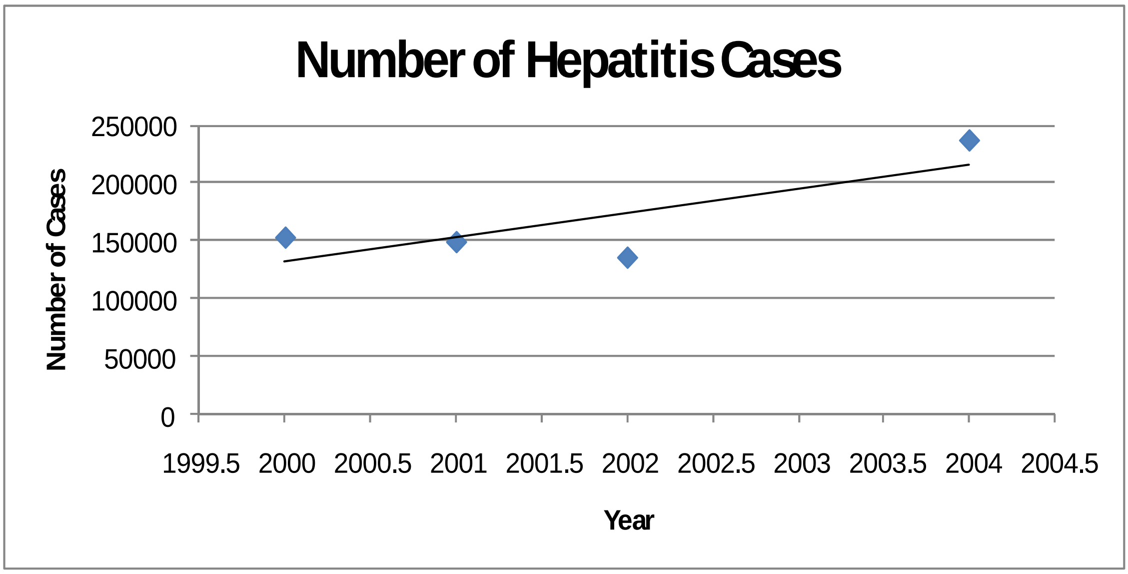

Figure 7.5: Numbers of Hepatitis Cases

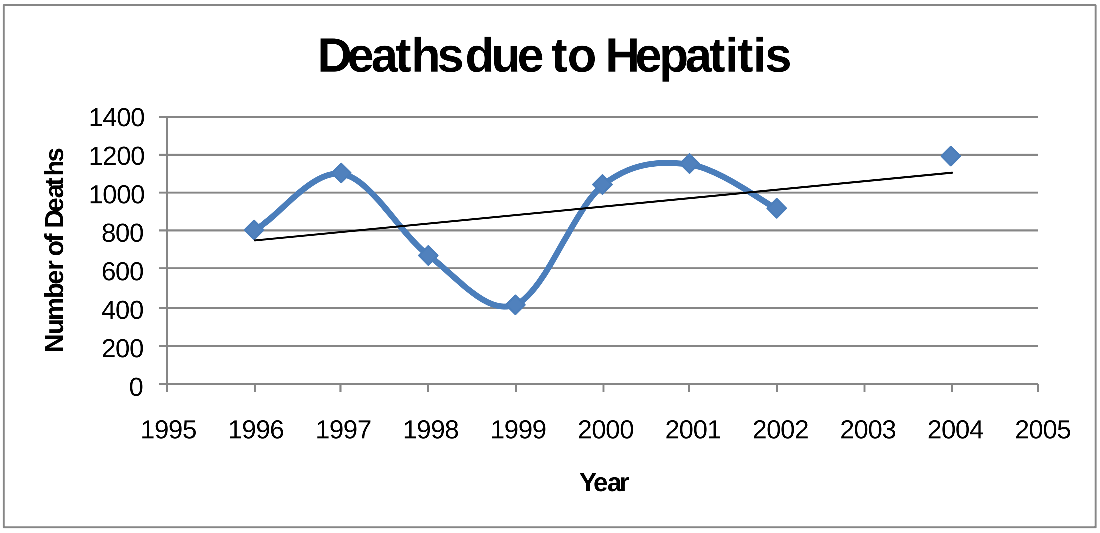

Figure 7.6: Deaths due to Hepatitis

7.2.4 Kala Azar

The available data on incidence of and deaths due to Kala Azar is presented in Table 7.4 and Figures 7.7 and 7.8. (19)

Table 7.4: Incidence of and Deaths due to Kala Azar

Year	Cases	Deaths
1992	77102	1419
1993	45459	710
1994	25652	384
1995	22625	277
1996	27049	687
1997	17429	255
1998	13627	226
1999	12886	297
2000	14753	150
2001	12239	213
2002	12140	168
2003	18214	210
2004	24479	155
2005	32803	157
2006	30285	187

Average deaths due to Kala Azar from 1997 to 2006 are 202

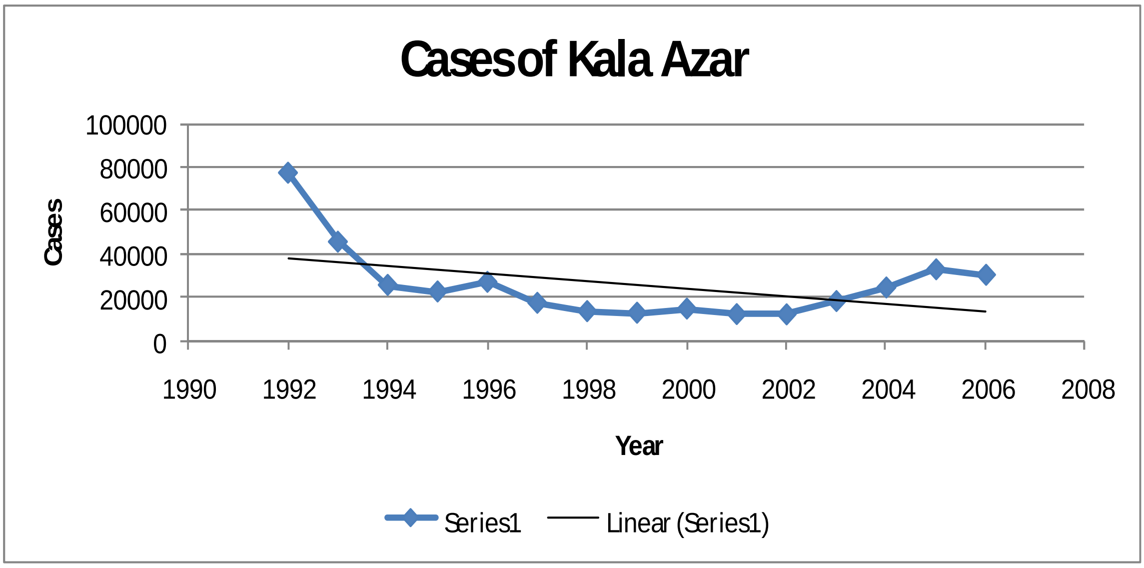

Figure 7.7: Cases of Kala Azar

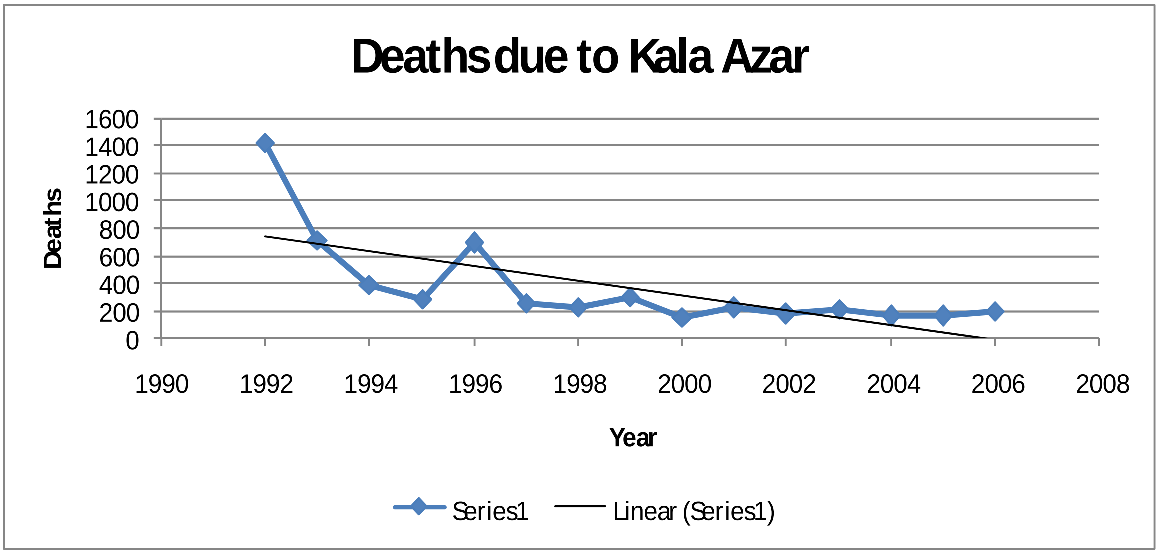

Figure 7.8: Deaths due to Kala Azar

7.2.5 Cancer

The available data on deaths due to Cancer is presented in Table 7.5 [(19)]

Table 7.5: Deaths due to Cancer

Age	Average	Males	Females	Total
0 - 4	2	2253	1167	3420
5 - 14	9.5	2492	1043	3535
15 - 54	34.5	36547	27214	63671
55+	55	56676	29776	86452
Total		97968	59200	157168

7.2.6 Dioxin

Considering dioxin risk factor for cancer to be 1.4, the additional deaths due to dioxin were computed based on the cancer data. This data is presented in Table 7.6

Table 7.6: Estimated deaths due to dioxin

Age	Total Cancer deaths	Dioxin factor	Additional due to dioxin
0 – 4	3420	0.4	1368
5 – 14	3535	0.4	1414
15 – 54	63671	0.4	25468
55+	86452	0.4	34581
Total	157168		60049

7.2.7 Train Accidents

The available data on deaths due to train accidents is presented in Table 7.7 and Figure 7.9.

Table 7.7: Deaths due to train accidents

Year	Killed
1996	83
1997	171
1998	280
1999	338
2000	55
2001	114
2002	157
2003	135
2004	50
2005	168
2006	38

Average deaths due to train accidents from 1997 to 2007 are 151.

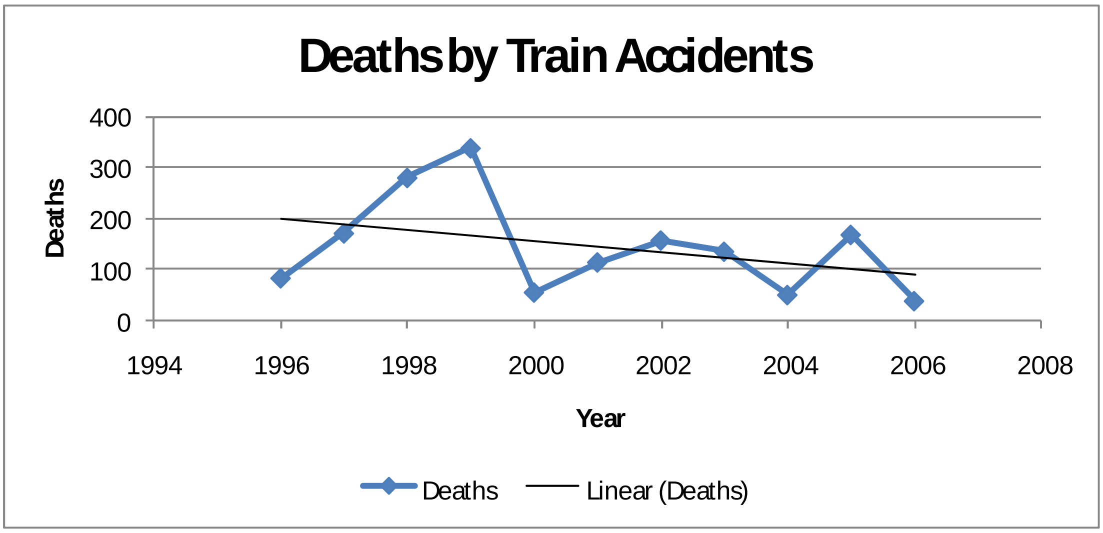

Figure 7.9: Deaths by Train Accidents

7.2.8 Road accidents

The available data on total number of road accidents and deaths due to road accidents is presented in Table 7.8 and Figures 7.10 and 7.11.

Table 7.8: Road accidents and deaths due to road accidents

Year	Total no. of road accidents (No)	Total no. of persons killed (No)
1970	114100	14500
1980	153200	24000
1990	282600	54100
1991	295131	56278
1992	275541	60113
1993	284646	60380
1994	325864	64463
1995	351999	70781
1996	371204	74665
1997	373671	76977
1998	385018	79919
1999	386456	81966
2000	391449	78911
2001	405637	80888
2002	407497	84674
2003	406726	85998
2004	429910	92618
2005	439255	94968
2006	460920	105749

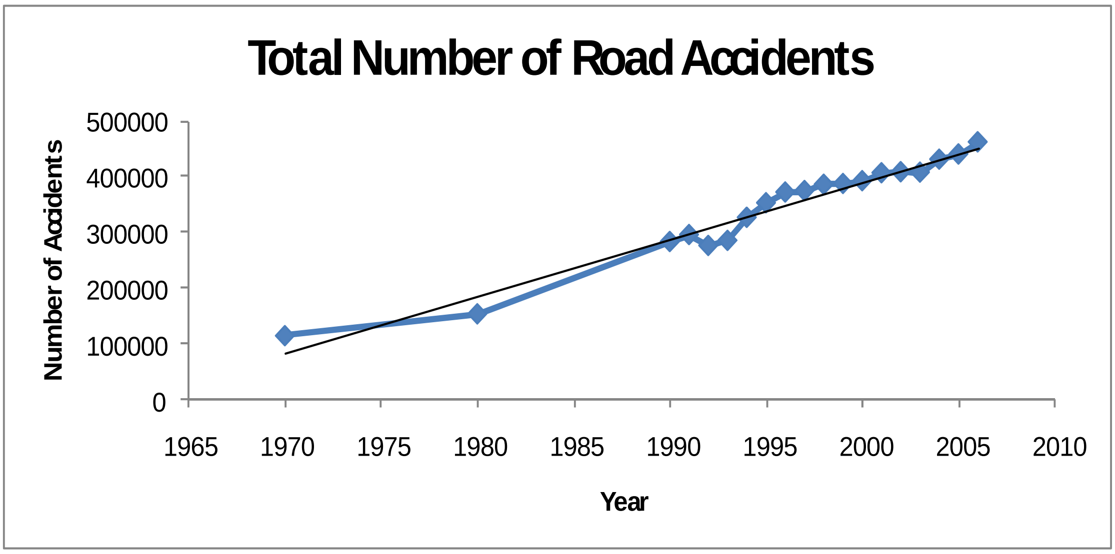

Figure 7.10: Total number of road accidents

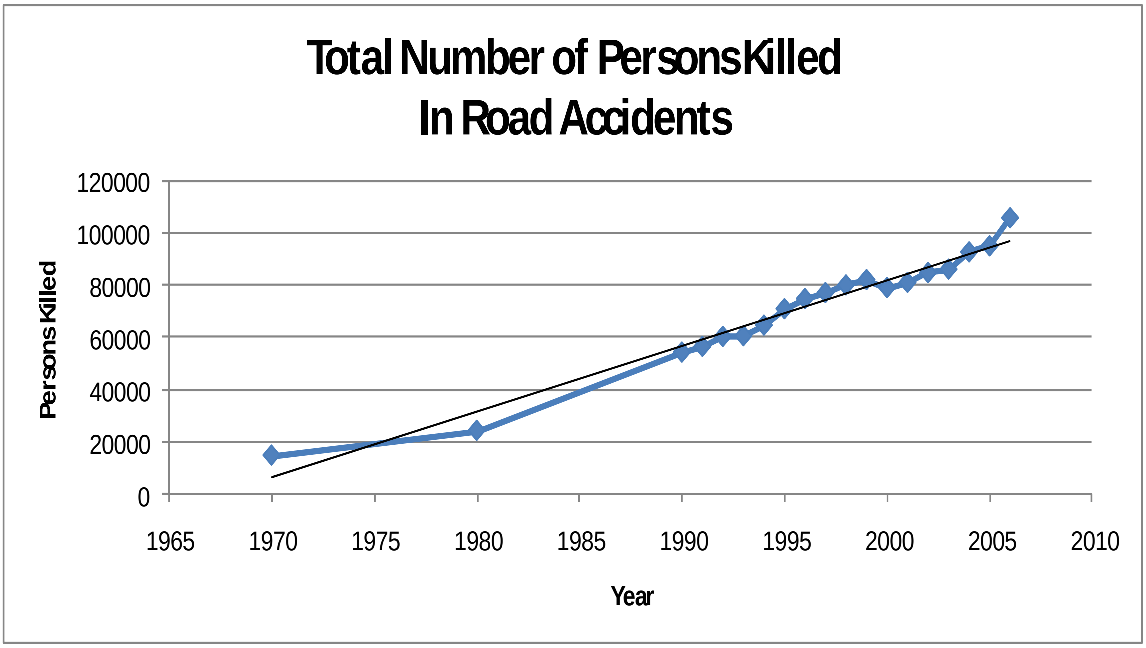

Figure 7.11: Total number of persons killed in road accidents

7.2.9 Summary of Average Deaths

Average deaths due to various causes are summarized in Table 7.9.

Table 7.9: Average deaths due to various causes

Sr. No.	Cause	Period	Male	Female	Total
1	Cancer	2000	97968	59200	157168
2	Cholera	1996-2005	6.2	5.8	12
3	Diarrhoea	1996-2005	1874	1729	3603
4	Hepatitis	1996-2004	472	436	908
		(Excuding 2003)			
5	Kala Azar	1997- 2006	105	97	202
6	Road Accidents	2005	49883	45585	94968
7	Train Acvcidents	1997-2007	79	72	151

7.3 Population Data

Population data to be used in the report is presented in Table 7.10. The percentage distribution of the population by age group is presented in Table 7.11.

All the calculations have been made for the year 2005 except for Cancer for which the year 2001 is used.

Population data for the year 2005 is as follows [19]

Population numbers in thousands

Total	1105535
Male	572073
Female	533462

Population data or the year 2001 is as follows.[(19)]

Population numbers in thousands

Total	1039701
Male	537574
Female	502126

Table 7.10: Projected population

Projected total population by sex in India			
(As on 1st October, 2001 to 2026)			
(In ' 000)			
Year	**Persons**	**Males**	**Females**
2001	1039701	537574	502126
2002	1055563	546129	509435
2003	1072344	554837	517508
2004	1089007	563487	525519
2005	1105535	572073	533462
2006	1121914	580584	541330
2007	1138169	589035	549134
2008	1154311	597432	556879
2009	1170307	605757	564550
2010	1186146	614003	572142
2011	1201810	622161	579649
2012	1217327	630245	587082
2013	1232705	638261	594444
2014	1247914	646191	601723
2015	1262940	654028	608912
2016	1277770	661763	616006
2017	1292228	669302	622926
2018	1306550	676774	629776
2019	1320606	684106	636500
2020	1334351	691274	643077
2021	1347742	698254	649488
2022	1360319	704773	655546
2023	1372719	711206	661513
2024	1384582	717342	667239
2025	1395786	723113	672673
2026	1406212	728449	677763

Table 7.11: Percentage distribution of the population

Percentage distribution of projected population by age-group and sex in India (As on 1st March, 2001, 2006 and 2011)									
Age group	**2001**			**2006**			**2011**		
	Persons	**Males**	**Females**	**Persons**	**Males**	**Females**	**Persons**	**Males**	**Females**
0-4	11.8	11.8	11.8	10.4	10.6	10.1	9.6	9.8	9.4
5-9	12	12.1	11.9	10.7	10.7	10.7	9.5	9.7	9.3
10-14	11.7	11.9	11.4	11	11.1	10.9	9.9	9.9	10
15-19	10.1	10.4	9.9	10.7	10.9	10.5	10.2	10.3	10.1
20-24	8.9	8.9	8.8	9.3	9.5	9	9.9	10.1	9.7
25-29	8.1	7.9	8.3	8.1	8.1	8.1	8.5	8.8	8.3
30-34	7.4	7.2	7.6	7.4	7.2	7.6	7.5	7.5	7.5
35-39	6.6	6.6	6.7	6.7	6.5	6.9	6.8	6.6	7
40-44	5.6	5.7	5.5	6	5.9	6.1	6.2	6	6.4
45-49	4.6	4.7	4.4	5	5.1	5	5.5	5.4	5.6
50-54	3.6	3.7	3.5	4.1	4.1	4	4.5	4.6	4.5
55-59	2.9	2.9	3	3.1	3.2	3.1	3.6	3.6	3.6
60-64	2.5	2.4	2.6	2.5	2.4	2.6	2.7	2.7	2.7
65-69	2	1.9	2.1	2	1.9	2.2	2	1.9	2.2
70-74	1.6	1.5	1.6	1.5	1.4	1.6	1.6	1.4	1.7
75-79	0.5	0.5	0.5	1.1	1	1.2	1.1	1	1.2
80+	0.3	0.3	0.3	0.4	0.4	0.4	0.8	0.7	0.9
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

7.4 Life Expectancy

The life expectancy from the year 1901 to 2015 is presented in Table 7.12. The life expectancy for the period 2001 to 2006 is estimated to be 64.8 years (19).

Table 7.12: Life Expectancy

Projected values of expectation of life at birth in India (1901-1910 to 2021-2025)			
Periods	**Males**	**Females**	**Combined**
1901-10	22.6	23.3	22.9
1911-20	19.4	20.9	20
1921-30	26.9	26.6	26.8
1931-40	32.1	31.4	31.8
1941-50	32.4	31.7	32.1
1951-60	41.9	40.6	41.3
1961-70	46.4	44.7	45.6
1970-75	50.5	49	49.7
1976-80	52.5	52.1	52.3
1980 (Base Year)	54.1	54.7	54.4*
1981-85	55.4	55.7	55.4
1981-86	55.6	56.4	56.0*
1986-90	57.7	58.1	57.7
1986-91	58.1	59.1	58.6*
1991-96	60.6	61.7	61.2
1996-01	62.3	65.3	NA
2001-05	63.8	66.1	NA
2001-06	64.1	65.8	64.8*
2006-10	65.8	68.1	NA
2006-11 (P)	65.6	67.2	NA
2011-15	67.3	69.6	NA
2011-16 (P)	66.9	68.8	NA
2016-20	68.8	71.1	NA
2021-25	69.8	72.3	NA
Abbr. : P : Projected.			
NA : Not Available.			
Note : * : Estimated by taking Sex Ratio as 105 Males to 100 Females.			

7.5 Reduction in Life Span

The tables in the following sections are based on the data presented above.

7.5.1 Cholera

The calculations leading to the reduction in life span due the cholera are presented in Tables 7.13, 7.14 and 7.15.

The calculated reduction in life span due to cholera is 0.22 minutes/person/year. This means that the entire population looses 0.22 minutes every year due to cholera.

7.5.2 Diarrhoea including Gastroenteritis

The calculations leading to the reduction in life span due the diarrhoea are presented in Tables 7.16, 7.17 and 7.18.

The calculated reduction in life span due to diarrhoea is 65.4 minutes/person/year. This means that the entire population looses 65.4 minutes every year due to diarrhoea.

7.5.3 Hepatitis

The calculations leading to the reduction in life span due the hepatitis are presented in Tables 7.19, 7.20 and 7.21.

The calculated reduction in life span due to hepatitis is 16.5 minutes/person/year. This means that the entire population looses 16.5 minutes every year due to hepatitis.

7.5.4 Kala Azar

The calculations leading to the reduction in life span due the kala azar are presented in Tables 7.22, 7.23 and 7.24.

The calculated reduction in life span due to kala azar is 3.7 minutes/person/year. This means that the entire population looses 3.7 minutes every year due to kala azar.

7.5.5 Road accidents

The calculations leading to the reduction in life span due the road accidents are presented in Tables 7.25, 7.26 and 7.27.

The calculated reduction in life span due to road accidents is 1723.5 minutes/person/year. This means that the entire population looses 1723.5 minutes every year due to road accidents.

7.5.6 Train Accidents

The calculations leading to the reduction in life span due the train accidents are presented in Tables 7.28, 7.29 and 7.30.

The calculated reduction in life span due to train accidents is 2.7 minutes/person/year. This means that the entire population looses 2.7 minutes every year due to train accidents.

7.5.7 Cancer

The calculations leading to the reduction in life span due the cancer are presented in Tables 7.31, 7.32 and 7.33.

The calculated reduction in life span due to cancer is 1,414 minutes/person/year. This means that the entire population looses 1,414 minutes every year due to cancer

7.5.8 Dioxin

For dioxin additional cancer deaths using the risk factor of 1.4 were calculated. These calculations are presented in Tables 7.34. 7.35 and 7.36.

The calculated reduction in life span due to dioxin is 566 minutes/person/year. This means that the entire population looses 566 minutes every year due to dioxin.

Table 7.13: Reduction in Life Years due to Cholera

Age Group	Average Age	Total Deaths	% in Age Group	Multiplier	Death in the Age Group	Life Expectancy	Years Lost	Life Years Lost
0-4	2	12	10.4	0.104	1.25	64.8	62.8	78.4
5-8	6.5	12	10.7	0.107	1.28	64.8	58.3	74.9
9-14	11.5	12	11	0.11	1.32	64.8	53.3	70.4
15-19	17	12	10.7	0.107	1.28	64.8	47.8	61.4
20-24	22	12	9.3	0.093	1.12	64.8	42.8	47.8
25-29	27	12	8.1	0.081	0.97	64.8	37.8	36.7
30-34	32	12	7.4	0.074	0.89	64.8	32.8	29.1
35-39	37	12	6.7	0.067	0.80	64.8	27.8	22.4
40-44	42	12	6	0.06	0.72	64.8	22.8	16.4
45-49	47	12	5	0.05	0.60	64.8	17.8	10.7
50-54	52	12	4.1	0.041	0.49	64.8	12.8	6.3
55-59	57	12	3.1	0.031	0.37	64.8	7.8	2.9
60-64	62	12	2.5	0.025	0.30	64.8	2.8	0.8
65-69	67	12	2	0.02	0.24	64.8	-2.2	
70-74	72	12	1.5	0.015	0.18	64.8	-7.2	
75-79	77	12	1.1	0.011	0.13	64.8	-12.2	
80+	80	12	0.4	0.004	0.05	64.8		

Table 7.14: Reduction in Life Span by Age due to Cholera

Average Age	Life Years Lost	Population	Days in a Year	Hours in a day	Minutes per Hour	Minutes in a Year	Life Minutes Lost	Reduction in Life Span /Person in Minutes
2	78.4	114975640	365	24	60	525965	41235656	0.36
6.5	74.9	118292245	365	24	60	525965	39394779	0.33
11.5	70.4	121608850	365	24	60	525965	37027936	0.30
17	61.4	118292245	365	24	60	525965	32294251	0.27
22	47.8	102814755	365	24	60	525965	25141127	0.24
27	36.7	89548335	365	24	60	525965	19302916	0.22
32	29.1	81809590	365	24	60	525965	15305582	0.19
37	22.4	74070845	365	24	60	525965	11781616	0.16
42	16.4	66332100	365	24	60	525965	8625826	0.13
47	10.7	55276750	365	24	60	525965	5627826	0.10
52	6.3	45326935	365	24	60	525965	3313580	0.07
57	2.9	34271585	365	24	60	525965	1525299	0.04
62	0.8	27638375	365	24	60	525965	420772	0.02
67		22110700	365	24	60	525965		
72		16583025	365	24	60	525965		
77		12160885	365	24	60	525965		
80		4422140	365	24	60	525965		

Table 7.15: Overall Reduction in life Span due to Cholera

Total Life Yers	Days in Year	minutes in a	Life Minutes	population	Minutes lost per

Lost/year		day	lost		person/year
458.1	365	1440	240777360	1105535000	0.217792616

Table 7.16: Reduction in Life-years due to Diarrhoea

Age Group	Average Age	Total Deaths	% in Age Group	Multiplier	Death in the Age Group	Life Expectancy	Years Lost	Life Years Lost
0-4	2	3603	10.4	0.104	374.71	64.8	62.8	23531.9
5-8	6.5	3603	10.7	0.107	385.52	64.8	58.3	22475.9
9-14	11.5	3603	11	0.11	396.33	64.8	53.3	21124.4
15-19	17	3603	10.7	0.107	385.52	64.8	47.8	18427.9
20-24	22	3603	9.3	0.093	335.08	64.8	42.8	14341.4
25-29	27	3603	8.1	0.081	291.84	64.8	37.8	11031.7
30-34	32	3603	7.4	0.074	266.62	64.8	32.8	8745.2
35-39	37	3603	6.7	0.067	241.40	64.8	27.8	6710.9
40-44	42	3603	6	0.06	216.18	64.8	22.8	4928.9
45-49	47	3603	5	0.05	180.15	64.8	17.8	3206.7
50-54	52	3603	4.1	0.041	147.72	64.8	12.8	1890.9
55-59	57	3603	3.1	0.031	111.69	64.8	7.8	871.2
60-64	62	3603	2.5	0.025	90.08	64.8	2.8	252.2
65-69	67	3603	2	0.02	72.06	64.8	-2.2	
70-74	72	3603	1.5	0.015	54.05	64.8	-7.2	
75-79	77	3603	1.1	0.011	39.63	64.8	-12.2	
80+	80	3603	0.4	0.004	14.41	64.8		

Table 7.17: Reduction in Life Span by Age due to Diarrhoea

Average Age	Life Years Lost	Population	Days in a Year	Hours in a day	Minutes per Hour	Minutes in a Year	Life Minutes Lost	Reduction in Life Span/person/year in Minutes
2	23531.9	114975640	365	24	60	525965	12376955784	107.65
6.5	22475.9	118292245	365	24	60	525965	11821536744	99.94
11.5	21124.4	121608850	365	24	60	525965	11110695046	91.36
17	18427.9	118292245	365	24	60	525965	9692430424	81.94
22	14341.4	102814755	365	24	60	525965	7543074451	73.37
27	11031.7	89548335	365	24	60	525965	5802288091	64.80
32	8745.2	81809590	365	24	60	525965	4599669118	56.22
37	6710.9	74070845	365	24	60	525965	3529698519	47.65
42	4928.9	66332100	365	24	60	525965	2592428889	39.08
47	3206.7	55276750	365	24	60	525965	1686611966	30.51
52	1890.9	45326935	365	24	60	525965	994547219	21.94
57	871.2	34271585	365	24	60	525965	458220708	13.37
62	252.2	27638375	365	24	60	525965	132648373	4.80
67		22110700	365	24	60	525965		
72		16583025	365	24	60	525965		
77		12160885	365	24	60	525965		
80		4422140	365	24	60	525965		

7.18: Overall Reduction in life Span due to Diarrohea

Total Life Years Lost/year	Days in Year	minutes in a day	Life Minutes Lost	population	Minutes lost per person/year

137539.1	365	1440	72290550960	1105535000	65.38965

Table 7.19: Reduction in Life-years due to Hepatitis

Age Group	Average Age	Total Deaths	% in Age Group	Multiplier	Death in the Age Group	Life Expectancy	Years Lost	Life Years Lost
0-4	2	908	10.4	0.104	94.43	64.8	62.8	5930.3
5-8	6.5	908	10.7	0.107	97.16	64.8	58.3	5664.2
9-14	11.5	908	11	0.11	99.88	64.8	53.3	5323.6
15-19	17	908	10.7	0.107	97.16	64.8	47.8	4644.1
20-24	22	908	9.3	0.093	84.44	64.8	42.8	3614.2
25-29	27	908	8.1	0.081	73.55	64.8	37.8	2780.1
30-34	32	908	7.4	0.074	67.19	64.8	32.8	2203.9
35-39	37	908	6.7	0.067	60.84	64.8	27.8	1691.2
40-44	42	908	6	0.06	54.48	64.8	22.8	1242.1
45-49	47	908	5	0.05	45.40	64.8	17.8	808.1
50-54	52	908	4.1	0.041	37.23	64.8	12.8	476.5
55-59	57	908	3.1	0.031	28.15	64.8	7.8	219.6
60-64	62	908	2.5	0.025	22.70	64.8	2.8	63.6
65-69	67	908	2	0.02	18.16	64.8	-2.2	
70-74	72	908	1.5	0.015	13.62	64.8	-7.2	
75-79	77	908	1.1	0.011	9.99	64.8	-12.2	
80+	80	908	0.4	0.004	3.63	64.8		

Table 7.20: Reduction in Life Span by Age due to Hepatitis

Average Age	Life Years Lost	Population	Days in a Year	Hours in a day	Minutes per Hour	Minutes in a Year	Life Minutes Lost	Reduction in Life Span/person in Minutes
2	5930.3	114975640	365	24	60	525965	3119130240	27.1
6.5	5664.2	118292245	365	24	60	525965	2979170953	25.2
11.5	5323.6	121608850	365	24	60	525965	2800027274	23.0
17	4644.1	118292245	365	24	60	525965	2442634057	20.6
22	3614.2	102814755	365	24	60	525965	1900942703	18.5
27	2780.1	89548335	365	24	60	525965	1462235297	16.3
32	2203.9	81809590	365	24	60	525965	1159174264	14.2
37	1691.2	74070845	365	24	60	525965	889512008	12.0
42	1242.1	66332100	365	24	60	525965	653301127	9.8
47	808.1	55276750	365	24	60	525965	425032317	7.7
52	476.5	45326935	365	24	60	525965	250622323	5.5
57	219.6	34271585	365	24	60	525965	115501914	3.4
62	63.6	27638375	365	24	60	525965	33451374	1.2
67		22110700	365	24	60	525965		
72		16583025	365	24	60	525965		
77		12160885	365	24	60	525965		
80		4422140	365	24	60	525965		

Table 7.21: Overall Reduction in life Span due to Hepatitis

Total Life Yers	Days in Year	Minutes in a day	Life Minutes	population	Minutes lost per

Lost/year			Lost		person/year
34661.5	365	1440	18218084400	1105535000	16.47898

Table 7.22: Reduction in Life-years due to Kala Azar

Age Group	Average Age	Total Deaths	% in Age Group	Multiplier	Deaths in the Age Group	Life Expectancy	Year Lost	Life Years Lost
0-4	2	202	10.4	0.104	21.01	64.8	62.8	1319.3
5-8	6.5	202	10.7	0.107	21.61	64.8	58.3	1260.1
9-14	11.5	202	11	0.11	22.22	64.8	53.3	1184.3
15-19	17	202	10.7	0.107	21.61	64.8	47.8	1033.1
20-24	22	202	9.3	0.093	18.79	64.8	42.8	804.0
25-29	27	202	8.1	0.081	16.36	64.8	37.8	618.5
30-34	32	202	7.4	0.074	14.95	64.8	32.8	490.3
35-39	37	202	6.7	0.067	13.53	64.8	27.8	376.2
40-44	42	202	6	0.06	12.12	64.8	22.8	276.3
45-49	47	202	5	0.05	10.10	64.8	17.8	179.8
50-54	52	202	4.1	0.041	8.28	64.8	12.8	106.0
55-59	57	202	3.1	0.031	6.26	64.8	7.8	48.8
60-64	62	202	2.5	0.025	5.05	64.8	2.8	14.1
65-69	67	202	2	0.02	4.04	64.8	-2.2	
70-74	72	202	1.5	0.015	3.03	64.8	-7.2	
75-79	77	202	1.1	0.011	2.22	64.8	-12.2	
80+	80	202	0.4	0.004	0.81	64.8		

Table 7.23: Reduction in Life Span by Age due to Kala Azar

Average Age	Life Years Lost	Population	Days in a Year	Hours in a day	Minutes per Hour	Minutes in a Year	Life Minutes Lost	Reduction in Life Span/person in Minutes
2	1319.3	114975640	365	24	60	525965	693905625	6.04
6.5	1260.1	118292245	365	24	60	525965	662768497	5.60
11.5	1184.3	121608850	365	24	60	525965	622900350	5.12
17	1033.1	118292245	365	24	60	525965	543374442	4.59
22	804	102814755	365	24	60	525965	422875860	4.11
27	618.5	89548335	365	24	60	525965	325309353	3.63
32	490.3	81809590	365	24	60	525965	257880640	3.15
37	376.2	74070845	365	24	60	525965	197868033	2.67
42	276.3	66332100	365	24	60	525965	145324130	2.19
47	179.8	55276750	365	24	60	525965	94568507	1.71
52	106	45326935	365	24	60	525965	55752290	1.23
57	48.8	34271585	365	24	60	525965	25667092	0.75
62	14.1	27638375	365	24	60	525965	7416107	0.27
67		22110700	365	24	60	525965		
72		16583025	365	24	60	525965		
77		12160885	365	24	60	525965		
80		4422140	365	24	60	525965		

Table 7.24: Overall Reduction in life Span due to Kala Azar

Total Life Years Lost/year	Days in Year	minutes in a day	Life Minutes Lost	population	Minutes lost per person/year
7711	365	1440	4052901600	1105535000	3.666009

Table 7.25: Reduction in Life-years due to Road Accidents

Age Group	**Average Age**	**Total Deaths**	**% in Age Group**	**Multiplier**	**Death in the Age Group**	**Life Expectancy**	**Years Lost**	**Life Years Lost**
0-4	2	94968	10.4	0.104	9876.67	64.8	62.8	620255
5-8	6.5	94968	10.7	0.107	10161.58	64.8	58.3	592420
9-14	11.5	94968	11	0.11	10446.48	64.8	53.3	556797
15-19	17	94968	10.7	0.107	10161.58	64.8	47.8	485723
20-24	22	94968	9.3	0.093	8832.02	64.8	42.8	378011
25-29	27	94968	8.1	0.081	7692.41	64.8	37.8	290773
30-34	32	94968	7.4	0.074	7027.63	64.8	32.8	230506
35-39	37	94968	6.7	0.067	6362.86	64.8	27.8	176887
40-44	42	94968	6	0.06	5698.08	64.8	22.8	129916
45-49	47	94968	5	0.05	4748.40	64.8	17.8	84522
50-54	52	94968	4.1	0.041	3893.69	64.8	12.8	49839
55-59	57	94968	3.1	0.031	2944.01	64.8	7.8	22963
60-64	62	94968	2.5	0.025	2374.20	64.8	2.8	6648
65-69	67	94968	2	0.02	1899.36	64.8	-2.2	
70-74	72	94968	1.5	0.015	1424.52	64.8	-7.2	
75-79	77	94968	1.1	0.011	1044.65	64.8	-12.2	
80+	80	94968	0.4	0.004	379.87	64.8		

Table 7.26: Reduction in Life Span by Age due to Road Accidents

Average Age	Life Years Lost	Population	Days in a Year	Hours in a day	Minutes per Hour	Minutes in a Year	Life Minutes Lost	Reduction in Life Span/person in Minutes
2	620255	114975640	365	24	60	525965	326232421075	2837.40
6.5	592420	118292245	365	24	60	525965	311592185300	2634.09
11.5	556797	121608850	365	24	60	525965	292855734105	2408.18
17	485723	118292245	365	24	60	525965	255473297695	2159.68
22	378011	102814755	365	24	60	525965	198820555615	1933.77
27	290773	89548335	365	24	60	525965	152936420945	1707.86
32	230506	81809590	365	24	60	525965	121238088290	1481.95
37	176887	74070845	365	24	60	525965	93036370955	1256.05
42	129916	66332100	365	24	60	525965	68331268940	1030.14
47	84522	55276750	365	24	60	525965	44455613730	804.24
52	49839	45326935	365	24	60	525965	26213569635	578.32
57	22963	34271585	365	24	60	525965	12077734295	352.41
62	6648	27638375	365	24	60	525965	3496615320	126.51
67		22110700	365	24	60	525965		
72		16583025	365	24	60	525965		
77		12160885	365	24	60	525965		
80		4422140	365	24	60	525965		

7.27: Overall Reduction in life Span due to Road Accidents

Total Life Yers Lost/year	Days in Year	Minutes in a day	Life Minutes Lost	Population	Minutes lost per person/year

3625261	365	1440	1905437181600	1105535000	1723.543

Table 7.28: Reduction in Life-years due to Train Accidents

Age Group	Average Age	Total Deaths	% in Age Group	Multiplier	Death in the Age Group	Life Expectancy	Years Lost	Life Years Lost
0-4	2	151	10.4	0.104	15.70	64.8	62.8	986.2
5-8	6.5	151	10.7	0.107	16.16	64.8	58.3	942.0
9-14	11.5	151	11	0.11	16.61	64.8	53.3	885.3
15-19	17	151	10.7	0.107	16.16	64.8	47.8	772.3
20-24	22	151	9.3	0.093	14.04	64.8	42.8	601.0
25-29	27	151	8.1	0.081	12.23	64.8	37.8	462.3
30-34	32	151	7.4	0.074	11.17	64.8	32.8	366.5
35-39	37	151	6.7	0.067	10.12	64.8	27.8	281.3
40-44	42	151	6	0.06	9.06	64.8	22.8	206.6
45-49	47	151	5	0.05	7.55	64.8	17.8	134.4
50-54	52	151	4.1	0.041	6.19	64.8	12.8	79.2
55-59	57	151	3.1	0.031	4.68	64.8	7.8	36.5
60-64	62	151	2.5	0.025	3.78	64.8	2.8	10.6
65-69	67	151	2	0.02	3.02	64.8	-2.2	
70-74	72	151	1.5	0.015	2.27	64.8	-7.2	
75-79	77	151	1.1	0.011	1.66	64.8	-12.2	
80+	80	151	0.4	0.004	0.60	64.8		

Table 7.29: Reduction in Life Span by Age due to Train Accidents

Average Age	Life Years Lost	Population	Days in a Year	Hours in a day	Minutes per Hour	Minutes in a Year	Life Minutes Lost	Reduction in Life Span/person in Minutes
2	986.2	114975640	365	24	60	525965	518706683	4.51
6.5	942	118292245	365	24	60	525965	495459030	4.19
11.5	885.3	121608850	365	24	60	525965	465636815	3.83
17	772.3	118292245	365	24	60	525965	406202770	3.43
22	601	102814755	365	24	60	525965	316104965	3.07
27	462.3	89548335	365	24	60	525965	243153620	2.72
32	366.5	81809590	365	24	60	525965	192766173	2.36
37	281.3	74070845	365	24	60	525965	147953955	2.00
42	206.6	66332100	365	24	60	525965	108664369	1.64
47	134.4	55276750	365	24	60	525965	70689696	1.28
52	79.2	45326935	365	24	60	525965	41656428	0.92
57	36.5	34271585	365	24	60	525965	19197723	0.56
62	10.6	27638375	365	24	60	525965	5575229	0.20
67		22110700	365	24	60	525965		
72		16583025	365	24	60	525965		
77		12160885	365	24	60	525965		
80		4422140	365	24	60	525965		

7.30: Overall Reduction in life Span due to Train Accidents

Total Life Yers Lost/year	Days in Year	minutes in a day	Life Minutes Lost	population	Minutes lost per person/year

5764.2	365	1440	3029663520	1105535000	2.74045

Table 7.31: Reduction in Life-years due to Cancer

Age Group	Average Age	Death in the Age Group	Life Expectancy	Years Lost	Life Years Lost
0-4	2	3420	64.8	62.1	214776.0
5-14	9.5	3535	64.8	54.6	195485.5
15-54	34.5	63671	64.8	29.6	1929231.3
55+	59.5	86452	64.8	4.6	458195.6

Table 7.32: Reduction in Life Span by Age due to Cancer

Average Age	Life Years Lost	Population	Days in a Year	Hours in a Day	Minutes in an Hour	Minutes in a year	Reduction in Life Span in Minutes	Reduction in minutes per person/year
2	214776.0	122684718	365	24	60	525600	1.12886E+11	920.1
9.5	195485.5	246409137	365	24	60	525600	1.02747E+11	417.0
34.5	1929231.3	568716447	365	24	60	525600	1.014E+12	1783.0
59.5	458195.6	101890698	365	24	60	525600	2.40828E+11	2363.6

Table 7.33: Overall Reduction in life Span due to Cancer

Total Life Years lost/year	Days in Year	Minutes in a day	Life Minutes Lost	population	Minutes lost per person/year
2797688.4	365	1440	1.47047E+12	1039701000	1414.3153

Table 7.34: Reduction in Life-years due to Dioxin

Age Group	Average Age	Death in the Age Group	Life Expectancy	Years Lost	Life Years Lost
0-4	2	1368	64.8	62.1	85910
5-14	9.5	1414	64.8	54.6	78194
15-54	34.5	25468	64.8	29.6	771680
55+	59.5	34581	64.8	4.6	183279

Table 7.35: Reduction in Life Span by Age due to Dioxin

Average Age	Life Years Lost	Population	Days in a Year	Hours in a day	Minutes in an hour	Minutes in a year	Reduction in Life Span in minutes	Reduction min/person/year
2	85910	122684718	365	24	60	525600	45154506240	368.1
9.5	78194	246409137	365	24	60	525600	41098871520	166.8
34.5	771680	568716447	365	24	60	525600	405595218240	713.2
59.5	183279	101890698	365	24	60	525600	96331600080	945.4

Table 7.36: Overall Reduction in life Span due to Dioxin

Total Life Yers Lost/year	Days in Year	minutes in a day	Life Minutes Lost	Population	Minutes lost per person/year
1119064	365	1440	588180196080	1039701000	565.7205

7.5.9 Deaths due to Various Causes

Deaths due to various causes are summarized in Table 7.37.

Table 7.37: Average Deaths due to various causes

Sr. No.	Cause	Period	Male	Female	Total
1	Cancer	2000	97968	59200	157168
2	Cholera	1996-2005	6.2	5.8	12
3	Diarrhoea	1996-2005	1874	1729	3603
4	Dioxin	2000 (Estimated)	-	-	62831
5	Hepatitis	1996-2004	472	436	908
		(Excuding 2003)			
6	Kala Azar	1997- 2006	105	97	202
7	Road Accidents	2005	49883	45585	94968
8	Train Acvcidents	1997-2007	79	72	151

7.5.10 Reduction in Life Span

Reduction in life span due to various causes is summarized in Table 7.38 and Figure 7.12.

The data shows that reduction in life span due to dioxin is significant.

Table 7.38: Reduction in Life Span

S.No.	Cause	Reduction In Life Span Minutes/person/year
1	Cholera	0.22
2	Train	2.7
3	Kala Azar	3.7
4	Hepatitis	16.5
5	Gastro	65.4
6	Dioxin	566
7	Cancer	1414
8	Road	1724

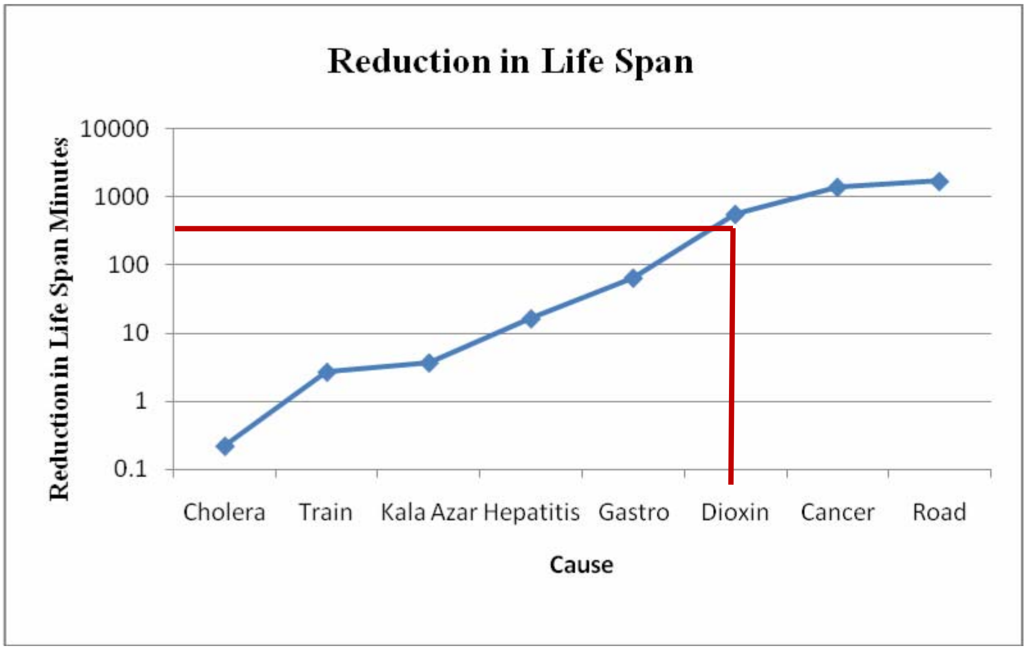

Figure 7.12: Reduction in Life Span

CHAPTER 8

COST OF CONTROL OF DIOXIN AND FURAN EMISSIONS FROM INCINERATOR STACKS

In the following sections an attempt is made to relate dioxin and furan emission from incinerator stacks and the cost of emission control.

8.1. Methodology

Data on the stack emissions of dioxin and furan was collected for various operating incinerators. Similarly data on capital costs and costs of operation and maintenance (O & M) were collected. The annual amortized cost on capital investment for various incinerators using different technologies for incineration and emission control was worked out assuming 10 years as the life of incinerator and 10% interest on capital investment. This was added to the O&M cost per tonne (cost per day divided by total waste incinerated per day). These two costs i.e., amortized cost (Rs/tonne) and O&M cost (Rs/tonne) were added to arrive at the total cost (Rs/tonne). These costs were then plotted against the emission values to illustrate their relationship.

8.2 Estimated Costs and Emissions

The costs calculated for various incinerators installed by industries & common facilities are presented in Table 8.1 along with data on dioxin & furan emission from stack.

Table 8.1: Cost calculation for hazardous waste incineration system

S. No.	Industry name	Installation cost, Lac (Year of Installation)	Total Feed (tonne/yr)	Total annual amortized cost (Rs/tonne)	O&M Cost (Rs/tonne)	Total cost of incineration (Rs/tonne)	Total cost of incineration (Rs/year)	Dioxin & furan emission (ng TEQ/Nm³)
1	Syngenta India ltd., Goa (Solid Waste Unit)	100 (1993)	648	11540	40055	51595	33433747	0.048
2	Syngenta India ltd., Goa (TO1)	3250 (2005)	3600	21511	17806	39317	141541148	0.003 [0.38]
3	Syngenta India ltd., Goa (TO2)	4100 (2009)	3600	18535	17806	36341	130827212	0.1
4	Baroda Textile Effects Pvt. Ltd, Umraya	302 (2008)	6000	901	6797	7698	46188402	0.06
5	Natco Pharma ltd, A.P.	100 (2009)	576	2825	24133	26958	15528062	[0.1866]
6	Lupin ltd, Ankleshwar	210 (2000)	825	9768	15780	25548	21077148	0.2 [0.0156]
7	Ranbaxy Laboratories ltd, Punjab	600 (2003)	1980	8737	5223	13960	27640344	0.01 [0.0196]
8	Chemplast Sanmar ltd, Mattur Dam	1300 (1998)	2160	27946	14900	42846	92547109	0.019 [1.36]
9	LanxessIndia Pvt. Ltd, Nagda, M.P.	25 (1995)	900	1717	1067	2784	2505363	[6.5]
10	Gujarat Enviro Protection & Infrastructure Ltd., Surat	158 (2003)	11520	395	6500	6895	79435352	0.01 [0.0352]
11	Mumbai waste Managementt ltd, Taloja	2550 (2004)	16200	4126	17896	22022	356751487	0.0058 [8.621]
12	Bharuch Enviro Infrastructure Ltd., Ankleshwar	1600 (2004)	15510	2704	6540	9244	143371894	0.02 [0.0255]

Note: The data given in the parenthesis have been taken from the CPCB report which is prepared by NPC [13]

The relationship between dioxin & furan emission and cost of incineration is presented in Figure 8.1 for captive incinerators and in Figure 8.2 for common hazardous waste incinerators. Once again, it should be recognized that these relations are based on limited data. It is necessary to collect data with repeated observations of emission, corresponding to feed quantity and its chlorine content. CPCB may consider this exercise of generating data as a separate project.

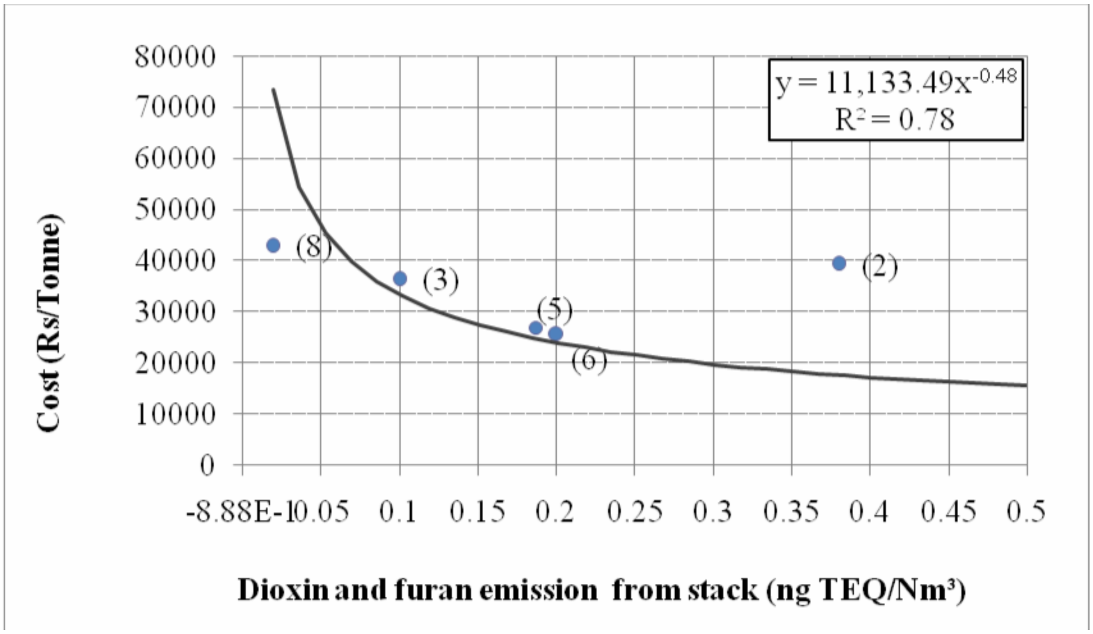

Figure 8.1: Relation between dioxin emission and cost of incineration, for captive hazardous waste incinerators

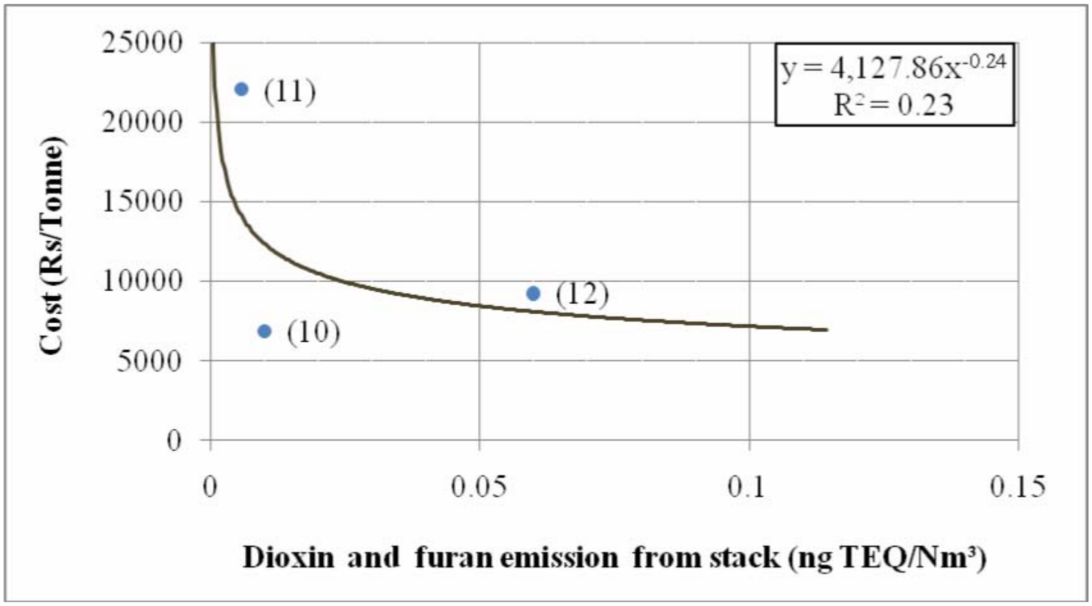

Figure 8.2: Relation between dioxin emission and cost of incineration, for common hazardous waste incinerators

The data (Figure 8.1) indicates a reasonably significant statistical relation between emission and cost/tonne for the captive hazardous waste incinerators (R^2 = 0.78). On the other hand, the relation between emission and cost/tonne for the common hazardous waste incinerators (Figure 8.2) is not statistically significant (R^2 = 0.23).

It is to be recognized that there is no such relation in reality because all technologies of incineration and emission control are designed to achieve, as far as possible, zero emission of dioxin. The variations in dioxin emission are due to a variety of reasons including O & M practices and not because of choosing a less expensive technology of incineration and emission control.

CHAPTER 9

PREDICTION OF GROUND LEVEL CONCENTRATION OF DIOXIN & FURAN

The ground level concentrations (GLCs) have been calculated for different levels of dioxin (PCDDs) & furan (PCDFs) emission from stack of common facilities.

9.1 Methodology

The Maximum GLC was calculated using two models i.e. SCREEN model and ISCST model. Since meteorological data was not available for specific locations, the maximum possible GLCs of dioxin & furan were estimated under worst metrological conditions. The meteorological conditions used for modeling are described under each model in the following sections.

9.2 Ambient Air Quality Standards

The only standard specified for ambient air quality with respect to dioxin and furan is that of Japan which has specified 0.6 pg per cubic meter in the atmosphere.

WHO has specified a standard for Total Daily Intake (TDI) of 1-4 pg TEQ/kg body weight/day. Considering average body weight of 60 kg and air intake of 20 m^3/day (with 5% inhalation contribution), the allowable concentration levels were calculated to be 0.15 – 0.60 pg TEQ/m^3 in ambient air.

9.3 SCREEN model

The input data used for SCREEN model, in respect of three common hazardous waste incinerators, have been given in Table 9.1. The maximum possible GLCs of dioxin and furan using SCREEN model for these common hazardous waste incinerators are presented in Tables 9.2, 9.3 and 9.4. The maximum GLCs were calculated under the worst meteorological condition. The estimated GLCs have been compared with WHO guidelines to check whether air quality levels are within acceptable limits.

Meteorological Conditions

All wind speeds and stability classes were considered to identify worst case meteorological conditions, i.e., the combination of wind speed and stability that results in maximum ground level concentrations.

Table 9.1: Input data for SCREEN model for the common hazardous waste incinerators

S.No	Common waste incinerator	Height of stack, m	Diameter of stack, m	Temperature of exit gas, ^oC	Exit gas velocity, m/s	Flow rate, Nm^3/hr
1	Mumbai Waste Management Ltd, Taloja	33.5	0.85	73.0	10.63	18710
2	Bharuch Environ Infrastructure Ltd, Bharuch, Gujarat	45.0	1.7	80.3	6.5	44741
3	Gujarat Enviro Protection and Infrastructure Ltd, Surat, Gujarat	30.8	0.6	65.0	4.5	4003

Table 9.2: Predicted maximum GLCs at Mumbai Waste Management Ltd, Taloja, using SCREEN model

Dioxin and furan concentration in stack, ng TEQ/Nm³	Emission rate (ng/sec ≈ 10^{-9} gm/sec) based on assumed concentration	Critical distance from stack (m)	Maximum GLC (pg TEQ/m^3)	Allowable concentration in ambient air, pg TEQ/m^3
0.025	0.13	255	0.0085	0.15 to 0.60
0.05	0.26	255	0.017	0.15 to 0.60
0.1	0.52	255	0.034	0.15 to 0.60
0.2	1.04	255	0.068	0.15 to 0.60
0.3	1.56	255	0.103	0.15 to 0.60
0.4	2.04	255	0.135	0.15 to 0.60
0.5	2.6	255	0.172	0.15 to 0.60

Source: *Central Pollution Control Board*

Table 9.3: Predicted maximum GLC at Bharuch Enviro Infrastructure Ltd, Bharuch, Gujarat, using SCREEN model

Dioxin and furan concentration in stack, ng TEQ/Nm³	Emission rate (ng/sec ≈ 10^{-9} gm/sec) based on assumed concentration	Critical distance from stack (m)	Maximum GLC (pg TEQ/m^3)	Allowable concentration in ambient air, pg TEQ/m^3
0.025	0.31	347	0.007	0.15 to 0.60
0.05	0.62	347	0.014	0.15 to 0.60
0.1	1.24	347	0.028	0.15 to 0.60
0.2	2.48	347	0.056	0.15 to 0.60
0.3	3.72	347	0.084	0.15 to 0.60
0.4	4.96	347	0.112	0.15 to 0.60
0.5	6.2	347	0.14	0.15 to 0.60

Source: *Central Pollution Control Board*

Table 9.4: Predicted maximum GLC at Gujarat Enviro Protection and Infrastructure Ltd, Surat, Gujarat, using SCREEN model

Dioxin and furan concentration in stack, ng TEQ/Nm³	Emission rate (ng/sec ≈ 10^{-9} gm/sec) based on assumed concentration	Critical distance from stack (m)	Maximum GLC (pg TEQ/m^3)	Allowable concentration in ambient air, pg TEQ/m^3
0.025	0.028	151	0.005	0.15 to 0.60
0.05	0.055	151	0.010	0.15 to 0.60
0.1	0.111	151	0.021	0.15 to 0.60
0.2	0.222	151	0.042	0.15 to 0.60
0.3	0.333	151	0.064	0.15 to 0.60
0.4	0.444	151	0.085	0.15 to 0.60
0.5	0.555	151	0.105	0.15 to 0.60

Source: *Central Pollution Control Board*

9.4 ISCST Model

The maximum GLCs for different levels of dioxin and furan emission from stack were calculated under actual metrological conditions using ISCST-3 model for Bharuch Enviro Infrastructure Ltd, Bharuch, Gujarat.

9.4.1 Meteorological Conditions

Various meteorological data and conditions used in ISCST-3 model are given below

(a) Hourly meteorological data

Data recorded at the continuous weather monitoring station on wind speed, direction, and temperature at one-hour interval in post-monsoon season (Sep-Dec, 2009) were used as meteorological input.

(b) Mixing height

As site specific mixing heights were not available, mixing heights based on Indian Meteorological Department publication “Atlas of Hourly Mixing Height and Assimilative Capacity of Atmosphere in India” have been considered for Industrial Source Complex model to establish the worst case scenario. The mixing heights considered are presented in Table 9.5.

Table 9.5: Mixing height

Hour of Day	Mixing height in Meter Post-monsoon (Sep-Dec)
7	60.0
8	110.0
9	355.0
10	637.5
11	900.0
12	1225.0
13	1507.5
14	1902.5
15	1697.5
16	1330.0
17	1252.5
18	890.0
19	665.0

For remaining hours mixing height has been considered as 50 m

(c) Stability classification

The percentage occurrence of stability classes, for the monitoring period used for the model, is presented in Table 9.6**.**

Table 9.6: Frequency of stability class

Stability class	Frequencies of occurrence
A	12.4
B	19.4
C	21.1
D	18.2
E	15.2
F	13.7

9.4.2 Ground Level Concentration Predictions

The predicted maximum GLCs, using the ISCST-3 model, for Bharuch Enviro Infrastructure Ltd, Bharuch, Gujarat are presented in Table 9.7.

Table 9.7: Predicted maximum GLC at Bharuch Enviro Infrastructure Ltd, Bharuch, Gujarat, using ISCST-3 model

Dioxin and furan concentration in stack, ng TEQ/Nm³	Emission rate (ng/sec ≈ 10^{-9} gm/sec) based on assumed concentration	Critical distance from stack (m)	Maximum GLC (pg TEQ/m^3)	Allowable concentration in ambient air, pg TEQ/m^3
0.025	0.3075	500	0.000725	0.15 to 0.60
0.05	0.615	500	0.00145	0.15 to 0.60
0.1	1.23	500	0.0029	0.15 to 0.60
0.2	2.46	500	0.0058	0.15 to 0.60
0.3	3.69	500	0.0087	0.15 to 0.60
0.4	4.92	500	0.0116	0.15 to 0.60
0.5	6.15	500	0.0145	0.15 to 0.60

CHAPTER 10

SOCIETAL COST OF DIOXIN AND FURAN EMISSIONS

The societal cost is linked with levels of dioxin and furan in the ambient air due to various point and non-point sources (including vehicles etc) around the hazardous waste incinerators as well as contribution of dioxin and furan due to stack emission from incinerators (impact on GLC). The data available on existing levels of dioxin and furan in the ambient air is presently rather limited and is only available for Delhi. The dioxin and furan levels in Delhi which were presented in Chapter 3, Table 3.6 are reproduced in Table 10.1 below along with calculated WHO Ambient Air standards.

Table 10.1: Level of dioxins & furans in ambient air respirable suspended particulate matter of Delhi for the period January 2008 to August 2008 [20]

S. No.	Location of monitoring	Level of dioxin & furan pg TEQ/Nm³	WHO Allowable concentration in ambient air, pg TEQ/m³
1	Nizamuddin (n=3)	0.036	0.15 to 0.60
2	S. Bagh (n=3)	0.141	0.15 to 0.60
3	Pitampura (n=5)	0.236	0.15 to 0.60
4	Sirifort (n=13)	0.529	0.15 to 0.60
5	Janakpuri (n=13)	0.535	0.15 to 0.60
6	I.T.O. (n=15)	0.851	0.15 to 0.60
7	Shahadra (n=10)	1.187	0.15 to 0.60
Average dioxin & furan (n=62)		**0.502**	

The data shows that the ambient air concentrations of dioxin and furan around Delhi vary from 0.036 pg TEQ/m^3 to 1.187 pg TEQ/m^3 with average value of 0.502 pg TEQ/m^3 while the calculated WHO standards for ambient air are from minimum of 0.15 pg TEQ/m^3 to maximum of 0.60 pg TEQ/m^3. The data also indicates that dioxin and furan levels, in some areas of Delhi, exceed the WHO standard and that the average concentration of dioxin and furan at 0.502 pg TEQ/m^3 is very close to the maximum permissible WHO standard.

This indicates that many areas in the country may not have any cushion for further addition of dioxin and furan from hazardous waste incinerators. It is, hence, desirable that the emission standards for incinerators are kept as low as may be possible to achieve through best available technology and operating procedures.

10.1 Methodology

Based on the consideration that there is no cushion for additional dioxin and furan in the ambient air, it was decided to consider 0.00015 pg TEQ/m^3 as the permissible addition of dioxin and furan into the ambient air from the stack emissions of incinerators. The following section describes the actual methodology used to determine the societal costs consequent to dioxin and furan emissions.

- The distance at which the ground level concentration (GLC) of 0.00015 pg TEQ/m^3 occurs from the stack was then calculated for various stack emissions ranging from 0.025 ng/Nm^3 to 0.5 ng/Nm^3 using ISCST-3 model for common incinerator installed at Ankleshwar. From this the area affected was calculated.
- Using the population density for district Bharuch in 2005 of 261 persons/sq. km.[(21)], corresponding population affected, was calculated for different emission levels and permissible GLC of 0.00015 pg TEQ/m^3. After the affected population was determined, the loss of life span of 566 minutes per year per person (Table 7.36) due to dioxin and furan was applied to the affected population to calculate the total loss of life years in the affected area.
- The societal cost was then calculated based on the average income of Rs. 23241 per person per year for the year 2005 [(22)].

These calculations are presented in Table 10.2 and Figure 10.1.

The data shows, as expected, that the societal cost rises exponentially as the emission levels are increased and consequently the distance for the selected GLC increases.

Table 10.2: Dioxin and furan emission, affected area and corresponding population with societal cost, for incinerator installed at Ankleshwar

Dioxin and furan emission from stack, ng TEQ/Nm^3	Desired ground level concentration, pg TEQ/m^3	Predicted distance from the stack (m)	Area affected, sq. km	Population in affected area	Reduction in life span due to dioxin (year)	Societal cost for dioxin and furan (Rs/year)
0.025	0.00015	7500	177	46099	49.6	1153742
0.03	0.00015	9000	254	66383	71.5	1661388
0.04	0.00015	12000	452	118014	127.1	2953579
0.05	0.00015	15000	707	184397	198.6	4614967
0.06	0.00015	18000	1017	265531	285.9	6645552
0.07	0.00015	21000	1385	361417	389.2	9045334
0.08	0.00015	24000	1809	472055	508.3	11814314
0.09	0.00015	27000	2289	597445	643.4	14952492
0.1	0.00015	30000	2826	737586	794.3	18459866
0.2	0.00015	60000	11304	2950344	3177.1	73839465
0.3	0.00015	90000	25434	6638274	7148.5	166138796
0.4	0.00015	120000	45216	11801376	12708.5	295357860
0.5	0.00015	150000	70650	18439650	19857.0	461496656

* The per capita per year gross income taken is Rs. 23,241[(22)]

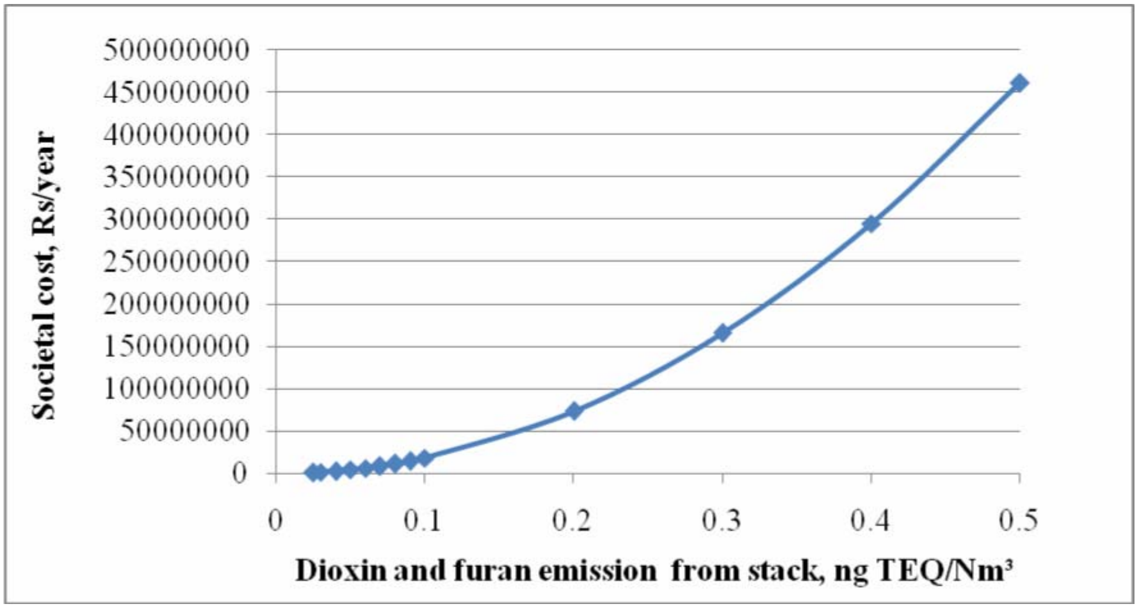

Figure 10.1: Relation between dioxin and furan emission from stack and societal cost of the affected population in the affected area

CHAPTER 11

COMPARISON OF EMISSION CONTROL COSTS AND SOCIETAL COSTS

The primary purpose of this study was to determine the “break even” standard for dioxin and furan emission where emission control costs and societal costs are equal to each other. This emission standard would then be considered “rational” as the societal costs justify the cost of control.

This combined curve is presented in Figure 11.1

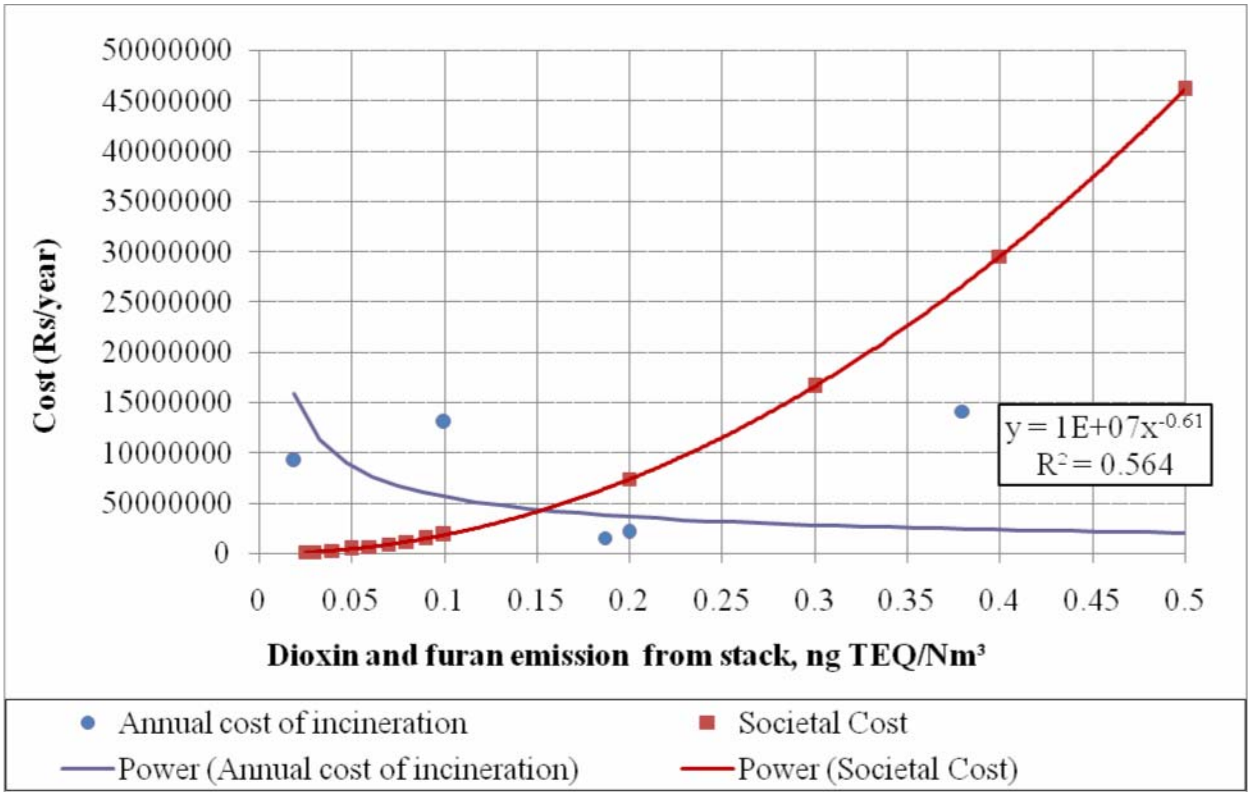

Figure 11.1: Comparison of annual cost of incineration and emission control of dioxin and furan with consequent societal costs at various emission levels

The data shows that the “break even” point occurs at emission level of about 0.15 ng TEQ/Nm³

It is essential that while evaluating this study and/or utilizing it for framing of policy the following significant aspects and limitations of the study are considered.

- This study is basically an attempt to develop a conceptual approach to consider societal cost as one of the determinants for setting an emission standard and not to justify or reject an existing standard. This is because the numbers are based on a variety of assumptions in absence of valid and reliable data and, hence, should not be taken as sacrosanct.

- It is to be recognized that there is no relation in reality between emission of dioxin & furan and cost of incineration of hazardous wastes and control of emission of dioxin & furan. This is because all technologies of incineration and emission control are designed to achieve, as far as possible, zero emission of dioxin. The variations in dioxin emission are, generally, due to a variety of reasons including O & M practices and not because of choosing a less expensive technology of incineration and emission control.

- The societal costs calculated here are based only on mortality. The cost of treatment, hospitalization and consequent economic loss are not factored in as reliable and valid data on these aspects is difficult to obtain. This means that the societal costs as calculated here are lower than the real costs.

- The health impact has only considered mortality directly attributable to dioxin and furan. It does not include synergistic or antagonistic health impacts due to other pollutants in the ambient air.

CHAPTER 12

CONCLUSIONS

1. The two primary objectives of the study were
   - To compare the societal cost of a specific pollutant with societal cost of other causes of mortality.
   - To develop an approach that would attempt to relate the cost of pollution control to the societal cost consequent to a standard specified for the pollutant.

2. The present work has, in general and to a large extent, conceptualized an approach to achieve the above objectives.
   Specifically
   - The concept of life span reduction was developed which seems to be an effective tool to bring various causes of mortality to a common platform.
   - The concept also permits the computation of societal cost.

3. The societal costs, combined with costs associated with a given standard for emission control, can lead to a rational approach incorporating economic aspects in the development of standards.

4. The study also provided useful insight into the requirement of data for more rigorous study.
   For example
   - The need for more extensive and intensive data base for ambient air quality especially for specific pollutants.
   - Similarly more data on emissions from incinerators handling hazardous wastes coupled with meteorological data is also required

5. It must be emphasized that the present study should be considered more as a development of an approach, to be widely discussed, vetted and modified as required. It should not be taken as sacrosanct with respect to "numbers" which are generated using a number of assumptions in absence of real and valid data.

6. It is to be recognized that there is no relation in reality between emission of dioxin & furan and cost of incineration of hazardous wastes and control of emission of dioxin & furan. This is because all technologies of incineration and emission control are designed to achieve, as far as possible, zero emission of dioxin. The variations in dioxin emission are, generally, due to a variety of reasons including O & M practices and not because of choosing a less expensive technology of incineration and emission control.

7. It should also be recognized that the societal costs calculated here are based only on mortality. The cost of treatment, hospitalization and consequent economic loss are not factored in as reliable and valid data on these aspects is difficult to obtain. This means that the societal costs as calculated here are lower than the real costs.

8. The health impact has only considered mortality directly attributable to dioxin and furan. It does not include synergistic or antagonistic health impacts due to other pollutants in the ambient air. This once again would impact the societal costs.

9. At a more fundamental level, the issue of sustainability of economic considerations in the framing and setting of standards is debatable. From a public health point of view, a policy that would balance the cost of "managing" health of the population impacted by the emission of a pollutant against the cost of control of the pollutant is unacceptable.

   The policy that mandates the control of pollution to prevent adverse health impact, irrespective of the cost of such control, should remain the guiding policy for framing standards of emission.

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ANNEXURE-I

PROPOSAL FOR SOCIETAL COST STUDY
SUBMITTED TO
THE CENTRAL POLLUTION CONTROL BOARD (CPCB)
NEW DELHI

1. Objective

The primary objectives of the study are

- To determine the long-rung (range?) marginal financial cost to find out what the user will need to pay for reaching the range of alternative levels of emissions of total dioxins & furans and
- Conduct a comparative study of societal risk abatement cost incurred by the Ministries / Departments concerned with mitigation of risk posed by epidemic, rail accidents and sewage exposure. These societal risk abatement cost (should be compared with that) corresponding to the proposed environmental standards (for Dioxin).

2. Understanding of the Objectives

The primary purpose of the study is to determine the cost of achieving different standards for Dioxin and inter alia the cost to the society due to the health impacts of these different levels of Dioxin emissions.

These are than to be compared with the cost to the society in mitigation of risks posed by epidemics, rail accidents and sewage exposure.

It must be recognized that data for such studies are difficult to find and eventually the study would have to depend on considerable amount of assumptions.

One of the major problems is that the term "Dioxin" includes a wide variety of compounds with different toxicities. Also there are a number of sources which either are current or are reservoirs. So ambient concentrations as emitted by incinerators become only part of the overall environmental pollutant.

Different environmental conditions such as weather will also have an impact on the ambient concentrations and these will in turn have different health impacts.

The nature of the data on the health impacts of Dioxin is expected in terms of its carcinogenicity. Whether this data would provide health impacts with varying concentrations of Dioxin is to be determined.

Similarly data on risks involved in train travel, epidemics etc. and their costs are difficult to determine.

The only possibility is to translate these risks due to Dioxin and train travel etc. into reduction in life spans and then assign some costs to them. Although this conversion of risks to reduction in life spans seems feasible for rail accidents and epidemics, for Dioxin the exercise might be difficult if not impossible.

The study should, hence, be considered as a project to achieve the objective in quantitative terms as far as possible but mostly in qualitative terms.

3. Work Plan
Based on the understanding of the objectives as described above, the following Work Plan is proposed.

Part I
Task 1

- Definition of Dioxin
- Identify sources of Dioxin
  Point
  Non point
- Identify the most significant point source in India
- Estimate the total emission of Dioxin in India from point sources

This data may, eventually be restricted to the data available from the 15 hazardous chemical waste incinerators to be provided by the Central Pollution Control Board (CPCB)

Task 2

- Review international standards on Dioxin emission
- Review the rationale of Indian Standards

Task 3

- Estimate the costs of achieving different levels of Dioxin in the stack emissions
  Since the present technologies aim to remove ***all*** the Dioxin, the question is whether this is possible to do.
  Plot a curve of Dioxin standard and its cost

Task 4

- Calculate the ambient equilibrium concentration of Dioxin in ambient air for different atmospheric conditions

Task 5

- Review the health impact of Dioxin
- Convert the health impacts to reduction in life span
  Again the question is whether this would be possible.
- Estimate the cost of health impacts (reduction in life spans)

Task 6

- Construct combined curves of cost of emission control and health impacts

Part II
Task 1

- Review available data in India on various risks, e. g. rail travel etc.

Task 2

- Convert the data into reduction in life spans.

Task 3

- Determine the costs of the reduction in life spans and costs to the Ministries/Departments

Conclusion

- Compare the costs of these with the costs due to Dioxin standards

4. Analysis of the Work Plan

The following is an analysis of the Work Plan to determine, first the possibility of execution and then the requirements in terms of data, manpower and time.

Sr. No.	Item	What is Required	Is it Available	Source
	Part I			
Task				
1	Dioxin Definition/Sources	Literature	Yes	EPA/ CPCB
2	Standards and Their Rationale	Literature/Information	Yes	EPA/ CPCB
3	Cost of achieving different levels of Dioxin in the stack emissions	Literature/Information	Not sure	UPL Environmental and other sources of data
4	Modelling of stack emission and ambient air level	Literature	Yes	UPL Environmental
5	Health Effects	Literature	Yes	EPA/ CPCB
	Conversion of health effects	Literature	Not sure	Will have to generate
6	Combination curves of control and health costs	Literature	Not sure	Will have to generate
	Part II			
Task				
1	Data on risks	Literature/Information	Not sure	Other countries/Ministries
2	Conversion of data	Literature	Not sure	Will have to generate
3	Costs	Literature/Information	Not sure	Other countries/Ministries
	Conclusion			
Task				
1	Comparison of costs			Will have to generate

5. Time Period

The time estimated to complete the entire study is 4 months. Considering the uncertainties mentioned above, it is proposed to carry out the study in two phases of 3 months and 1 month respectively. At the end of the first phase the work done would be presented as an Interim Report. The decision to carry on the study further should be taken on the basis of the Interim Report.

6. Staffing

The study would be carried out under the overall direction of Dr. Deepak Kantawala with Mr. N. K. Verma. They will be supported by the technical staff of UPL Environmental.

7. Expected Deliverables

Interim Report

Part I

For Part I the interim report would have completed Tasks 1, 2 and 4. It would also report on the type of data available for Tasks 3 and 5 and the possibility or otherwise of completing Task 6

Part II

Similarly for Part II the Interim Report would have completed Task 1 and would report on the possibility of completion of Tasks 2, 3 and the conclusion.

8. Assistance to be Provided by CPCB

- Data on

    Rationale for the Dioxin Standards

    Significant sources of Dioxin to be considered and their locations

The CPCB will provide letters requesting information on railway accidents, epidemics, water borne diseases etc. addressed to the respective Ministries.

- A person assigned to the study to act as the nodal person to be contacted by the consultant for data or any other assistance.

केन्द्रीय प्रदूषण नियंत्रण बोर्ड
CENTRAL POLLUTION CONTROL BOARD
(पर्यावरण एवं वन मंत्रालय, भारत सरकार)
(MINISTRY OF ENVIRONMENT & FORESTS, GOVT. OF INDIA)

B-30049/01/2k4(CWI)/PCI-I

April 21, 2009

TO WHOMSOEVER IT MAY CONCERN

The Central Pollution Control Board has taken-up a project on "Computation of Societal Risk Abatement Cost and Long Run Marginal Financial Cost with regard to Emission Standards for Common Hazardous Waste Incinerator". The study has been initiated with the objective to determine the long-run marginal financial cost the user will need to pay for reaching the range of alternative levels of emissions of total dioxins & furans and also a study of societal risk abatement cost incurred by the Ministries / Departments concerned for mitigation of risk posed by epidemic, rail accidents and sewage exposure.

The above said project has been awarded to M/s UPL Environmental Engineers Limited having Regional office at 26-28, Indra Palace, H Block, Connaught Circus, New Delhi-110 001 and Corporate office at Village Bil, Near Bhaili Rly Station and Banco Products, Padara Road, Vadodara-391410. The study would be carried out under the overall direction of Dr. Deepak Kantawala and Er. N. K. Verma of M/s UPL Environmental Engineers Limited, for which the consultant will conduct in-depth study including actual monitoring & analysis of gaseous emission. The study will cover nature & source of emission and reduction of pollutants through control system adopted.

All the concerned Ministries/Department, industries and organisations are requested to extend their co-operation to the consultant in providing required information and collection of samples. The information provided by the industries will be kept confidential and used only to enable the consultant to give realistic picture to the Central Board.

Validity of this certificate is up to March 31st, 2010.

(J.S Kamyotra)
Member Secretary

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ANNEXURE-II

Guidelines for Common Hazardous Waste incineration		
Parameter	**Emission standard**	
Particulates	50 mg/Nm^3	Standard refers to half hourly average value
HCl	50 mg/Nm^3	Standard refers to half hourly average value
SO_2	200 mg/Nm^3	Standard refers to half hourly average value
CO	100 mg/Nm^3	Standard refers to half hourly average value
	50 mg/Nm^3	Standard refers to daily average value
Total Organic Carbon	20 mg/Nm^3	Standard refers to half hourly average value
HF	4 mg/Nm^3	Standard refers to half hourly average value
NO_x (NO and NO_2 expressed as NO_2)	400 mg/Nm^3	Standard refers to half hourly average value
Total dioxins and furans	0.1 ng TEQ/Nm^3	Standard refers to 6-8 hours sampling. Please refer guidelines for 17 concerned congeners for toxic equivalence values to arrive at total toxic equivalence.
Cd + Th + their compounds	0.05 mg/Nm^3	Standard refers to sampling time anywhere between 30 minutes and 8 hours.
Hg and its compounds	0.05 mg/Nm^3	Standard refers to sampling time anywhere between 30 minutes and 8 hours.
Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V +	0.5 mg/Nm^3	Standard refers to sampling time anywhere between 30 minutes and 8 hours.

Note: All values corrected to 11% oxygen on a dry basis.

Operating Standards

- All the facilities shall be designed to achieve a minimum temperature of 1100°C in secondary combustion chamber and with a gas residence time in secondary combustion chamber not less than 2 (two) seconds.
- The incineration facilities after initial operation of minimum one year, as per the guidelines and standards, can submit a proposal for relaxation in temperature and retention time requirement if it can be demonstrated that the flue gas standards and operation standards can be complied with at lower temperatures and residence times. The State Pollution Control Board / Pollution Control Committee, upon successful demonstration of compliance with flue gas standards by the facility, can recommend the proposal made by the incineration facility for relaxation in temperature and residence time, but in any case not less than 950 °C and 1.5 seconds, for the consideration and approval of the Central Board.

- Incineration plants shall be operated (combustion chambers) with such temperature, retention time and turbulence, so as to achieve Total Organic Carbon (TOC) content in the slag and bottom ashes less than 3%, or their loss on ignition is less than 5% of the dry weight of the material.
- Guidelines published by the Central Board from time to time for common incineration facilities shall be referred for implementation.
- All the project proposals submitted for establishment of the common incineration facilities shall be examined and cleared by the Task Force constituted by the Central Board.
- Notification of compliance: The operator of the incinerator shall undertake comprehensive performance test. Within 90 days of completion of comprehensive performance test, the operator shall issue a notification of compliance documenting compliance or non-compliance, as the case may be, for public information / notice.