HAZARDOUS WASTE MANAGEMENT BY TSDF

A Dissertation

submitted in partial fulfilment of the requirement

for the award of degree of

Masters in Technology

in

Environmental Science and Technology

Submitted by

Supriya kumari

Roll No. 601401011

Under the Guidance of

Dr. A.S.Reddy
Professor

School of Energy and Environment
Thapar University, Patiala
Punjab (India)

Brig SS Bhatia, VSM [Retd]
Managing director
Nimbua Greenfield (Punjab) limited

SCHOOL OF ENERGY AND ENVIRONMENT
THAPAR UNIVERSITY, PATIALA
(Declared as Deemed-to-be-University u/s 3 of the UGC Act, 1956)

JULY 2016

CERTIFICATE

This is to certify that thesis entitled, **"Hazardous Waste Management by TSDF"** submitted by **Supriya Kumari** in partial fulfilment of the requirements for the award of degree of **Masters of Technology** in **Environmental Science** at **Thapar University, Patiala** is an authentic work carried out by her under my supervision and guidance.

To the best of my knowledge, the matter embodied in this thesis has not been submitted in part or full to any other university/ institute for award of any Degree.

Dr. A.S. Reddy
Professor
School of Energy and Environment
Thapar University, Patiala
Punjab (India)

Dr. Tejo Prakash
Head
School of Energy and Environment
Thapar University, Patiala
Punjab (India)

Brig SS Bhatia VSM[Retd]
Managing Director
Nimbua Greenfield(Punjab) Limited

Dr. S. S. Bhatia
Dean
Academic Affairs
Thapar University, Patiala

NIMBUA GREENFIELD (PUNJAB) LIMITE
Village Nimbua, Tehsil Dera Bassi, District Moha
Phone : (01762) 653074, 9216731666,
9041544466, 9216730666
Website : www.ngpl.co.in,
E-mail : ngplpunjab@yahoo.co.in

NGPL/MD/2k16-2k17/

14 June, 2016

To Whom It May Concern

This is to certify that **Ms Supriya Kumari D/o Mr Paritosh Kumar** has been with this organization from 15 June 2015 to 14 June 2016 as Internship Trainee. During her tenure with the Company she has been diligent, sincere and made a positive contribution by her performance.

We wish her all success in life.

Brig S S Bhatia, VSM (Retd)
Managing Director
Nimbua Greenfield (Punjab) Limited

ACKNOWLEDGEMENT

I acknowledge my sincerest gratitude to my supervisor, Dr. A.S. Reddy, Professor, School of Energy and Environment, Thapar University for their cooperation and valueable suggestions. I am also thankful to all my faculty members of the department for their support.

I would like to express my sincere thanks to Brig S.S. Bhatia, VSM[Retd], Managing Director, Nimbua Greenfield [Punjab] Limited for allowing me to work in the organization and for his support .

I owe my thanks to Mr. Kartar Singh , Lab head, for their technical guidance, motivation and encouragement. Also I am thankful to Mrs. Radha Pathak, assistant lab manager for helping me immensely throughout the project period for successful completion of the project. I acknowledge my thanks to Mr. Amit Yadav sir, Environmental Site Engineer and Mr. Lakhwinder sir for their cooperation and help during my project work.

I am deeply grateful to my beloved family for their moral support, love and encouragement without which it would not have been possible to reach at this stage of my life.

DECLARATION

I, the undersigned, hereby declare that the research work presented in this thesis entitled **"Hazardous Waste Management by TSDF"** submitted for the award of the degree of Masters in Technology has been carried out by me under the supervision and guidance of **Dr. A. S. Reddy, School of Energy and Environment, Thapar University, Patiala.**

Further, I declare that no part of this Dissertation has been submitted for a degree or any other qualification of any other university or examining body in India or abroad.

Supriya kumari
(Reg. No.601401011)
M.Tech , School of Energy and Environment
Thapar University
Patiala

ABSTRACT

The study describes the overall view and the facilities available at the TSDF site as well as the detailed TSDF operating procedures were discussed starting from receiving of the hazardous waste from the generator to the final disposal into the landfill. In this study several different samples of hazardous waste were collected and analysed. Both Comprehensive and finger print analysis were performed for each sample. From the Comprehensive analysis, the characterization of waste was determined which decides the flow pathways of waste that whether it is sent for direct landfill, landfill after treatment or incineration. Multiple trials of Reciepe development was conducted for the 'landfill after treatment' method and the best reciepe having all contaminant parameters lying within the permissible limit was chosen for stabilization.

TABLE OF CONTENTS

List of table

List of Figure

Chapter 1

INTRODUCTION

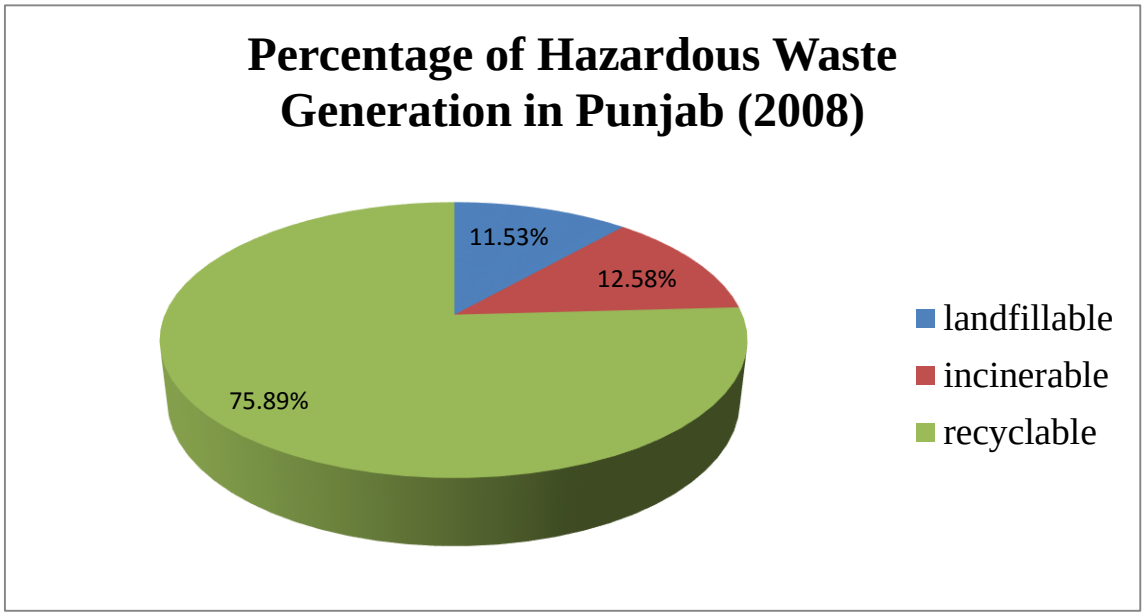
For most of the Asian countries the management of hazardous waste is a new concept. In the past, there is the scarcity of the resources such as technical and economical resources for the control on the management of hazardous waste and so this result in the serious problem both the mankind and plant life.

Since India is an industrializing country and so its contribution to the production of hazardous waste is being taken significant. Various forms of hazardous waste is generated in this country and so for their management it proves to a challenge both for industry and government. The main Sources of Hazardous waste obtained form the metal plating industries, mining process, fertilizers and pesticides industries, etc. industrial operations produce large amount of hazardous waste and for Industrialzing Countries such as India , the generation of hazardous waste from industries is largest. Since industrial units are spread all over the country, the impacts are region-wide. As the industrial areas are spread every-where in country so the outcomes are region-wide.

1.1Background

The total hazardous waste generation in Punjab during the year 2008 was 117913 metric tons per annum. Category wise hazardous waste generation in Punjab is shown below in the figure. Landfillable 11.53%, Incinerable 12.58% and Recyclable 75.89%.

The percentage share of the districts in hazardous waste generation is discussed below. According to the National Inventory of Hazardous Waste Generating Indusrties , the district wise data on waste quantification as per given in national inventory of hazardous of hazardous waste revealed that Ludhiana, Amritsar, Patiala and Jalandhar districts are the major contributors to the total waste generated in the state. Ludhiana district alone contributed almost 40% of the total waste generated in Punjab. It was followed by Amritsar [13%] and Patiala [12%].It may be because of presence of major sectors in textile, manufacturing and automobile in these districts.



Source: http://www.cpcb.nic.in/Updated_Inventory_HW_Generation.pdf

figure 1.1 Percentage of Hazardous Waste Generation in Punjab(2008)

Chapter 2

LITERATURE REVIEW

In depth the literature review study was done on the following aspects:

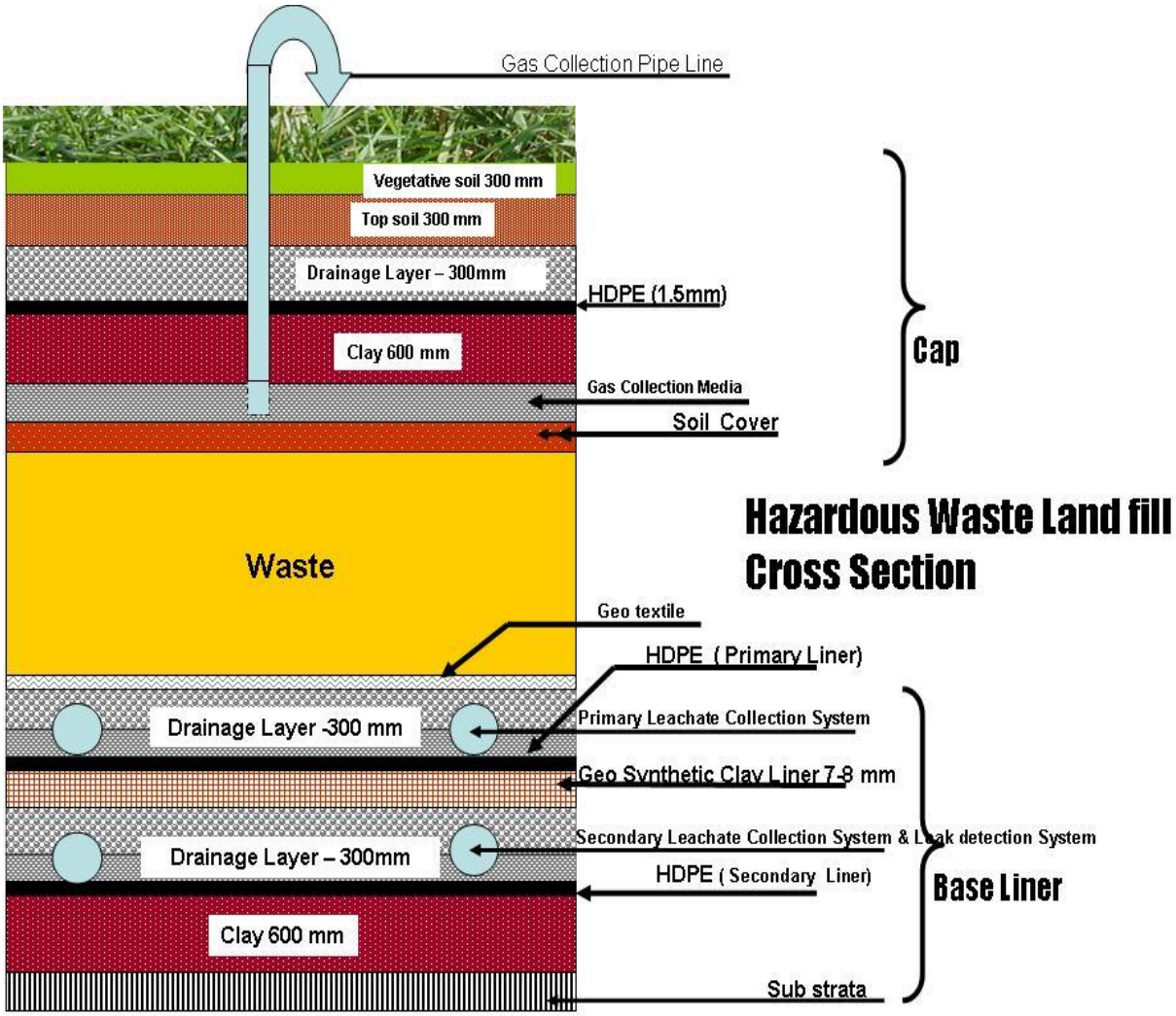
- Treatment, storage and disposal facilities
  - Design
  - Case studies related to accidents during transportation and handling of hazardous waste.
  - Collection, transportation, receiving, storage, treatment and disposal
- Characterization of hazardous waste.
- Various methods of treatment of hazardous waste
  - Waste for pre-treatment.
  - Incineration.
  - Stabilization.
  - Effects of various binding agents on the hazardous waste.
- Leachate handling and management.

2.1 TSDF

According to the CPCB protocol for common hazardous waste TSDF, the capacity of secured landfill at common hazardous waste TSDF changes from 0.25 million metric tons to a maximum total capacity of 12 million tons. Before designing the landfill, a geo physical investigations were conducted which confirms the hydro-geological settings and provides a basic understanding of the soil type and ground water conditions at the site (Sonkamble, S., Sethurama, S., Krishnakumar, K., Dhunde, P., Amarender, B., & Kumar, V. S.et.al., 2013).

Hazardous waste landfill is designed with the objective of full containment of the waste materials placed in it. The key design feature of the landfill is the liner system at bottom and the sides of the landfill, which is impermeable and prevents contaminants from coming in contact with the surrounding soil and water. Any leachate generation from wet waste and precipitation is contained in the liner system and pumped for collection and treatment. A double liner system with perforated

pipes is provided to ensure leachate does not migrate in soil and ground water (Daniel, D. E. (Ed.) et.al.,2012). The perforated piping is connected to a system of sumps, from which the leachate are pumped or drained to treatment facilities. A leachate detection system containing perforated pipes is also provided between the first and second liner, so that any leachate escaping the first membrane is intercepted and removed for treatment.



Source: http://ramkyenviroengineers.blogspot.in/

Figure 2.1: Cross section of hazardous waste landfill

A secure hazardous waste landfill must have these essential components:

- Liner system at the base and sides to prevent leachate and gas from migrating to the surrounding soils.

- Leachate collection and treatment facility.
- Gas collection.
- Final cover system.
- Surface water drainage system.
- Environmental monitoring system.

2.2 Case study related to transportation and handling of hazardous waste

A number of incidents happened because of mismanagement in handling and transportation of hazardous waste. In California, a 6000 foot long train crashed and more than thousands of gallons (approx. 19000) of the Metam sodium compound drawn into the Sacramento River. When it interfaces with water, it separates rapidly into a few side effects, including methyl isothiocyanate [MITC], methylamine and hydrogen sulfide. The next day, it proves to be danger for aquatic life by the spill. There were dead fish in the stream and the harm brought about by the spill took various diverse structures. Also air borne contaminants goes down the waterway, many plants and creatures in its way were uncovered and were killed in a fraction of second including fish, green growth, microscopic fish and other life form. This also affected to the life of mankind, laborers who were working close to the waterway get various problems such as lung sickness, asthma diseases and more over skin rashes on the feet and lower legs. [B.M.Steven et al., 2000]

Figure 2.2: Train Derailment near Dunsmuir, California, July 14, 1991.

Another Incident happened due to improper handling and mixing of incompatibles when more than two distinctive organic waste streams were blended and used as fuel for bond heaters. On august 9, 2005, the three waste streams were brought into a tremendous vertical blending tank. A runaway exothermic response happened inside the tank while blending. At 9:15PM, the tank split and conveyed on a fire which spread to the drum stockpiling and get readily extents. Nine hundred homes were cleared. The EPA performed air checking and gave facts concerning the fire and impact in a report.[B.M.Steven et al., 2000]

Fig: 2.3 *:* Photographs during and after the 2005 EQ Romulus fuel blending fire.

2.3 Collection, Transportation, Receiving, Storage, Treatment and Disposal of hazardous waste.

Collection of hazardous waste and its proper packaging and labelling is the responsibility of waste generator for the safe handling and transportation to the TSDF.[EIA guidance manual, 2010]. Packing should be done in a manner suitable for storage and transport and the labelling should be easily visible and packaging was able to withstand physical conditions and climatic factors during transportation. Packaging and labelling of hazardous waste shall be in accordance with the provisions of the rules issued by the Central Government under the Motor vehicles act, 1988.There are various guidelines which are followed before handling the waste for transportation.

- Requirement of six copies of manifest must be ensured as per Form 13 of the Hazardous Waste Rules for proper collection, transportation, storage, treatment and disposal.
- General label must be assured to all Hazardous waste containers.[as given in Form 8 in Hazardous Waste Rules 1989].
- The generator shall obtain " No Objection Certificate " from the concerned SPCB in case of interstate transportation of waste for the treatment, storage and disposal facility.

After transportation waste is received by the operator of the facility.

Characterization of hazardous waste

Any waste is said to be hazardous if it displays any of the characteristics such as corrosive, ignitable, toxicity, reactive and explosive [Khopkar S.M., 2007].

Corrosivity – Waste exhibits the property of corrosivity if it has pH less than or equal to 2 or more than 12.5 and which can corrode steel at a rate more than 6.35mm per year at a temperature 55 degC. (Technical EIA guidance manual for TSDF, 2010).

Reactivity – These property of waste are unstable and readily undergoes chemical reactions. They are explosive in nature when mixed with water and produce toxic gases when cyanide or sulphide bearing waste exposed to pH between 2 and 12.5.

Ignitable – Waste having the property, liquid other than aqueous solution having less than 24% organic solvents by volume and has flash point less than 60 ºC.

Toxicity – Waste exhibits the property of toxicity if the leachate of the waste sample exceeds the concentration limit of contaminant in the TCLP test method (given by the CPCB protocol for performance evaluation and monitoring of the common hazardous waste TSDF).

2.3 Various methods of treatment of hazardous waste

The objective of the treatment of hazardous waste is to convert it into nonhazardous substances that can be disposed of directly into the landfill satisfying the concentration limits given by SPCB (Dutta, S. K., Upadhyay, V. P., & Sridharan, U. et. al.,2006) .Due to this process it will not create a hazard when exposed to the environment.

Treatment of hazardous waste is dependent of physio-chemical characteristic of the waste. For example, organic waste with high heat valve requires incineration whereas toxic metal waste shall be stabilized prior to disposal in a secured landfill. Broadly the treatment and disposal options are classified into the following categories:

- Storage – blending, mixing and dewatering
- Incineration
- Neutralization, Cyanide reduction and Chrome reduction
- Solidification/ stabilization

2.3.1 Waste for Pre-treatment

Pre-treatment is required for certain waste. This process reduces the reactivity of toxic elements/compounds, thus making waste suitable for stabilization/solidification process. Pre-treatment primarily consists of neutralization, dewatering, sludge separation, oil-water separation etc (Pichtel, J .et al, 2005). The pre-treatment of waste may also be important from stand point of occupation health and safety of the plant personnel as it reduces risk of occupational hazards[such as emissions of toxic gases, exothermic reactions etc.] during waste handling. The type of waste that requires the pre-treatment includes:

- Acidic/ alkali waste
- ETP sludge with excessive water
- Waste containing chromium
- Oily emulsions

2.3.2 Incineration

Incineration is a waste treatment process, in this process hazardous wastes are changed into gases and incombustible solid residue [ash] only because of high temperature thermal oxidation process. In the case if the waste shows organic behaviour, then it has a more potential to go under incineration process in view of its high calorific value.

In this process hazardous waste are combusted in the availability of excess air/oxygen at temperatures of >800º C with destruction also removal efficiency of 99.999% thereby releasing heat energy, inert gases and ash (Tang, W. Z.et al. 2016).

Criteria for organic waste for landfilling

S.No.	Criteria	Concentration
1.	Annealing loss of the dry residue at 550 º C	< 20% by weight [for non-biodegradable waste]
2.	Extractible lipophilic contents[oil and grease]	< 4% by weight [for biodegradable waste]
3.	Calorific value	< 2500 k cal/kg

Source: http://cpcb.nic.in/upload/NewItems/NewItem_149_Protocol.pdf

The waste not conforming to these limits will have to be incinerated.

The wastes which requires incineration done by the operator of hazardous waste management facility may include (Lehman, J. P.et.al., 2013) :

- Solvent waste [spent solvents]
- Phenolic waste
- Waste oils, oil emulsions and oil mixtures
- Pharmaceutical waste
- Refinery waste
- Organic waste containing halogens, Sulphur, phosphorus or nitrogen compounds
- Solid materials contaminated with oils
- Others with calorific value>2500k cal/kg

2.3.3 Stabilization

Stabilization is a process whereby the undesirable components of an inorganic material [usually heavy metals] are stabilized or neutralized by the addition of binding agents such as lime, cement or silicates, fly-ash, to produce a solid and chemically stable matrix that eliminates leaching of toxic chemicals (Pichtel, J .et al 2005). Stabilization refers to a technique that treat hazardous waste by changing it to a form that is less soluble. Stabilization refers to a process of encapsulating hazardous waste into a solid material of high structural integrity. Encapsulation either involves fine waste particles [micro-encapsulation] or a large block of waste [macro-encapsulation]. Stabilization technologies easily encapsulate most heavy metals, certain radionuclides and certain organic compounds. The selection of this technology is dependent on waste characteristics [physical and chemical] , type of waste received and process requirements. (Misra, V., & Pandey, S. D. et al., 2005). While selecting the solidification/stabilization process and designing equipments, a wide range of performance tests may be performed in conjunction with treatability studies to evaluate short and long term stability of treated material. These include waste analysis for organics, leachability, permeability and leachate end points using standard test methods.

2.3.4 Effect of various binding agents on the Hazardous Waste

The Interactions between the waste and the binding agent is an important factor regarding solidification. Batchelor B. et al. (2006) analyzed various test and evaluated environmental impacts to quantify the maximum amount of contaminant which could be released while stabilization, suggested that cement can bind a variety of waste including physical as well as chemical characteristics. LamprisC., Stegemann J.A., Cheesemann C.R. (2009) performed the chloride leaching test on the solidified products of air pollution control residues and reported that by using Portland cement as a reagent, the result exceeds the relevant UK landfill waste acceptance criteria. He also declared that addition of more than 50% Portland cement would be required in order to stabilize this residue to satisfy the current waste acceptance criteria limits. Chen Q.,Zhang L.,Ke Y., Hills C.and Kang Y.(2009) conducted tests on electroplating sludge and reported that the Portland cement has the highest acid neutralizing capacity of the hydrated paste among granulated blast-furnace slag and pulverized fuel ash. The substitution of Portland cement with the granulated blast-furnace slag or pulverized fuel ash will decrease the acid neutralizing capacity by 30-50%.

Salihoglu G. and Pinarli V.(2008) performed an experiment to treat the steel foundry electric arc furnace dust having lead and zinc in the excess amount than that required for direct landfill criteria. Three samples were tested**:** electric arc furnace dust (EAFD) with Portland cement, EAFD along with Portland cement and lime, and the last contained the EAFD and lime under the TCLP. Their results indicate that EAFD with lime and Portland cement have minimum heavy metal leaching potential. The composition used for the stabilization was 30% EAFD with 35% lime and 35% Portland cement in which the solubility of heavy metal is minimized.

Leachate handling and management

Landfill leachate should be handled and treated properly because if it is not treated it can contaminate and have adverse effect on the surface water as well as ground water .Generally the major contaminants present in the landfill leachate are heavy metals, ammonia, dissolved organic matter, sulfates, chlorides, xenobiotic organic compounds [PCBs, dioxins, etc.] (Ahmed, F. N., & Lan, C. Q. et al. 2012). The composition of the leachate depends upon the age of the landfill and the type of waste it contains.

There are various methods for Landfill leachate treatment which includes biological treatment and physical-chemical treatment. Membrane bioreactors [MBR],activated sludge process[ASP], sequencing batch reactor[SBR]and constructed wetlands are the examples of biological treatment. Physical-chemical treatment include evaporation, filteration, stripping, coagulation-flocculation, activated carbon and reverse osmosis (Kurniawan, T. A., Lo, W. H., & Chan, G. Y. et. al 2006). The Choice of the proper method of landfill leachate treatment depends upon the characteristics of the leachate, cost effectiveness, discharge limitations, site constraints and environmental impact. (Ziyang, L., Youcai, Z., Tao, Y., Yu, S., Huili, C., Nanwen, Z., & Renhua, H. et.al 2009)

For the removal of nitrogen, the basic principles involved in the biological treatment are nitrification and denitrification (Wiszniowski, J., Robert, D., Surmacz-Gorska, J., Miksch, K., & Weber, J. V. et., al 2006). In order to treat concentrated leachate, upflow anaerobic sludge blanket [UASB] and anaerobic filters are more applicable in case of anaerobic treatment (Kurniawan, T. A., Lo, W. H., & Chan, G. Y. et al.2006).

Chapter - 3

METHODOLOGY

Objectives of the study have been achieved through working on the following work elements. Approach followed for carrying out the work on each of the work elements is described in detail in this chapter.

3.1 Work elements

Following work elements were framed for achieving the proposed objectives:

1) Survey of the TSDF at site.
2) Case study of few selected hazardous waste sample.

3.2 Survey of the TSDF at site

The Purpose of the survey were to identify all the facilities available at the site and to understand the procedures followed by the TSDF site. The detailed study of Infrastructure for receiving and testing facility,waste storage facility, waste treatment facility, disposal facility, leachate collection and treatment system facility and environment monitoring facility were identified.

3.3 Materials and Methods of Case Study for Execution of Few Selected Hazardous Waste Sample.

Seven samples of hazardous waste were selected for the detailed studies including starting from the collection and transportation of the hazardous waste received from the generator at the TSDF site followed by their analysis part both comprehensive and finger print analysis for knowing the characterization of waste, treatment if they require and final disposal. Information was collected for each of the samples of hazardous waste and separate analysis work has been done.

The collected waste samples were brought to the laboratory and analyzed according to the APHA testing procedures for the analysis of water and wastewater (APHA,2012). Comprehensive analysis and fingerprint analysis were performed. These analysis helps in deciding the pathways

for disposal that whether they satisfies direct disposal criteria or else require treatment before disposing to the landfill. Table shows the analytical techniques adopted.

Parameter	Method	Reference
LOD	Loss on drying at 105 ºC	APHA (2012):2450
LOI	Loss on ignition at 550 ºC	APHA (2012):2450
Sulfates	Turbidimetric method	APHA(2012):(4500SO_4^2:E)
Nitrates	Ultraviolet Spectrophotometric Screening Method	APHA(2012):(4500NO_3:B)
Chlorides	Argentometric method	APHA(2012):(4500-Cl:B)
Water soluble substance	Oven dry method at 108 ºC	APHA(2012): 2450
heavy metals	AAS	SW-846
Volatile organic compounds	GC-MS	SW-846: (8260 B)

After analyzing the waste, reciepe development was made by the trial basis for the samples which require treatment .Stabilization has been done on that basis and then disposed of in the landfill.

3.4 MAJOR INSTRUMENTS USED :

1.) Gas Chromatography - Mass Spectrometry [GCMS]
2.) UV-Visible Spectrophotometer:
3.) Atomic Absorption Spectrophotometer [AAS]

3.4.1 Gas Chromatography - Mass Spectrometry [GCMS]

Purpose : For identification and quantification of volatile organic compounds.

Specifications :

Gas Chromatography - Mass Spectrometry

Type of column used – Capillary Column

Column length – 30 meter

Internal diameter – 0.25 mm

Figure 2.4 : Gas Chromatography - Mass Spectrometry

Operating conditions

Column oven temperature – 40^0 C

Injection temperature – 250^0C

Gas used – helium

Pressure maintained – 6 Kg/cm^2

Injection technique used – Split [used for high concentration samples and only small amounts of sample required.]

Detector – Mass Spectrometer [MS], used for identification of unknown compounds.

Principle – Gas chromatography has the tendency to separate volatile compounds from a mixture. These compounds can be detected and quantified. To get the identification of various compounds, 3 steps can be processed in a GC-MS system.

- Injection –depends on the sample [gas,liquid or solid],compounds from mixture should be volatilized or extracted from the matrix.
- Separation
- Detection

Sample preparation

5 gm of sample is taken in a 25 ml volumetric flask and 10 ml dichloromethane is added to it. Mix it and heat the sample at 60^0-70^0C for proper dissolve. Then filter this solution after adding sodium sulfate powder on filter paper. The filtered solution is the final sample prepared for GCMS.

3.4.2 UV-VISIBLE SPECTROPHOTOMETER :

Purpose : For detecting the amount of Nitrates and Sulfates.

Specifications:

Specord UV-Visible spectrophotometer

Figure 2.5 : UV-Visible spectrophotometer

Principle – UV Spectroscopy follows the Beer-Lambert law, which stated that whenever a beam of monochromatic light is moved through a solution of an absorbing substance, the rate of decrease of intensity of radiation with absorbing solution thickness is proportional to both the incident radiation and solution concentration .

Expression for Beer-Lambert Law :

$A = \log [I_0/I]$

Where, A = absorbance

I_0 = light intensity incident upon sample cell

I = light intensity leaving sample cell

Formula used for calculating nitrates:

$$Nitrates(Mg/lt) = \frac{[abs\ @220nm - 2(abs@275nm)] \times 4.43 \times dilution\ factor}{slope\ factor}$$

$$slope\ factor\ = \frac{addition\ of\ absorbance\ of\ std@(220nm - 275nm)\ before\ calibration}{addition\ of\ standards\ taken}$$

Formula used for calculating sulfates:

$$Sulfates(Mg/lt) = \frac{(abs@420nm\ with\ Bacl2 - abs@420without\ Bacl2) \times dilution\ factor}{slope\ factor}$$

$$slope\ factor = \frac{addition\ of\ absorbance\ of\ std@(with\ Bacl2 - without\ Bacl2)@420nm}{addition\ of\ standards\ taken}$$

Sample preparation for Nitrates :

10 ml of sample is taken and 2 drops of 1N HCl is added then reading is noted down from UV-Visible Spectrophotometer. If the reading of absorbance exceeds the highest value from the standard then in such case dilution is required. After dilution 2 drops of HCl is added then absorbance is measured.

Sample preparation for Sulfates:

10 ml of sample is taken in a beaker and 2ml of buffer solution is added and mixed. The solution is transferred to the cuvette and absorbance reading is noted at 420 nm then small amount of $Bacl_2$ crystals is added to sample containing buffer solution. Sample is well mixed and the absorbance is noted down.

3.4.3 ATOMIC ABSORPTION SPECTROPHOTOMETER

Principle–AAS is used mainly for the quantitative determination of metal in aqueous and solid samples from a wide range of area such as medicine, food and geology.

The basic principle can be expressed by three simple statements:

- All atoms can absorb light.
- The wavelength at which light is absorbed is specific for each element.
- The wavelength at which light is absorbed will increase the number of atoms of the choosen element in the light path increases, and is proportional to the absorbing atoms concentration.

Sample preparation : 100 ml of leachate sample in a beaker. Now 10 ml of concentrated nitric acid [HNO_3] acid is added .then total sample is digested till it becomes half of it. The solution is filtered using filter paper and then make-up to 100ml.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 BRIEF OVERVIEW OF THE TSDF

As of now there are 25 common hazardous waste treatment and disposal facilities in operation in 12 states. Many of the generators are not large enough to establish their own waste management facilities and as such no proper treatment and disposal facilities are available in state. Accordingly, in absence of such facility the State Government of Punjab has identified the six sites for the development of a Common Hazardous Waste Management Facility.

Based on an EIA study for site selection co-ordinate by the Punjab Pollution Control Board [PPCB], the site located near NimbuaVillage [20 acres] in Patiala district was selected for the development of Hazardous Waste Management Facility. This site is approx. 10 KM from Ambala-Chandigarh road [NH-22].

The Components of the Treatment, Storage and Disposal Facilities:

Infrastructure for Receiving , and Testing facility -

Receiving facility includes weighbridge and waste sampling platform. All incoming vehicles will be weighed at weighbridge and the quantity of waste is measured. The manifest sheets and weigh bills would be checked for conformity and completion. The relevant copies of the manifest system will be furnished to others as required by the Hazardous Waste Management Rules. In the Waste testing facilities waste received at the site would be undertaken in the laboratory for the analysis part. This facility would have the ability to analyze that the waste is organic or inorganic and whether they contain heavy metals or not.

Waste Storage Facility– These facilities are required for storage of waste during monsoon period and in the event of malfunctioning of any of its treatment operations. There are four sheds for the storage of waste and stabilization pit. Incineration shed for the storage of organic waste, Stabilization pit for stabilization of waste such as toxic waste, sludge etc, Shed for storage of reagents such as lime, fly-ash, cement, ferrous sulfate, sodium sulfide and e- waste storage shed.

Other facilities required at the site to support treatment and landfilling operations includes such as administration, utility, testing and analysis and equipment maintenance.

The TSDF operator must store the wastes in lined containers so as to avoid leakages and each container should be properly labelled to identify its contents as well as for safe handling, storage and disposal facility. The hazardous waste should not be stored for more than two weeks in the storage area. The waste having volatile solvents must be stored away from direct exposure to sunlight. The storage area floor level should be designed at least 150 mm above the maximum flood level.

Waste treatment facility -

The waste which is not suitable for direct disposal into the landfill requires treatment or stabilization. Stabilization process converts hazardous form of waste into non-hazardous form with the help of binding agents such as Portland cement, fly-ash, lime, clay, sodium sulfide etc.

EFFECTS OF BINDING REAGENTS ON HAZARDOUS WASTE:

Cement is frequently selected for the reagent's ability to :

a) Chemically bind free liquids.

b) Reduce the permeability of the waste form.

c) bind the waste particles surrounding them with an impermeable coating.

d) Chemically fix hazardous constituents by reducing their solubility.

e) Facilitate the reduction of the toxicity of some contaminants.

f) Keeps metal in the form of insoluble hydroxide and carbonate salts.

Lime has the property to maintain pH and to stop the chemical reactions going on the waste.

Fly-ash is used to absorb the moisture content form the waste.

Sodium sulfide is used to stabilize the toxic metals present in the waste.

Solidification stabilization treatment is used to reduce the leaching potential of the hazardous constituent from the waste. After treatment the waste no longer exhibits the hazardous characteristics and can be disposed as non-hazardous waste.

Waste disposal facility-

The secure landfill contains multiple cells where waste is deposited for final disposal. It occupies an area of 12 acres and are sufficient for the waste disposal requirement for 20 years.

The hazardous waste landfill provides for safe, long-term disposal of treated wastes. The design feature of the landfill is the liner system at bottom and sides of the landfill, which is impermeable and prevents contaminants from coming in contact with the surrounding soil and water

Leachate collection and treatment system facility-

Leachate is generally the liquid that drains or leaches out from a landfill. Leaching occurs when water percolates through any permeable material. Leachate varies widely in composition regarding the age of landfill and the type of waste that it contains. It usually contains both dissolved and suspended materials. The Leachate formed in the landfills have the potential to contaminate surrounding soil and water.

When the waste is compacted, leachate trickles down from wet waste and gets contained in this liner system which is then pumped for collection and treatment. A double liner system with perforated pipes is provided to ensure leachate does not migrate in soil or ground water. The performed piping is connected to a system of sumps, from which the leachate are pumped to treatment facilities. A leachate detection system containing perforated pipes is also provided between the first and second liner, so that any leachate escaping the first membrane is intercepted and removed for treatment.

Leachate can be treated either using Multiple-Effect Evaporator, Solar Evaporation Pond , Spray drier by incinerator flue gas.

Table 4.1: CONCENTRATION LIMIT FOR HAZARDOUS SUBSTANCES IN LEACHATE

S.N.	Parameters in leachate	Concentration
1.	pH	4-12
2.	Total Phenols	< 100 mg/l
3.	Arsenic	< 1 mg/l
4.	Lead	< 2 mg/l
5.	Cadmium	< 0.2 mg/l
6.	Chromium	< 0.5 mg/l
7.	Copper	< 10 mg/l
8.	Nikel	< 3 mg/l
9.	Mercury	< 0.1 mg/l
10.	Zinc	< 10 mg/l
11.	Fluoride	< 50 mg/l
12.	Ammonia	< 1000 mg/l
13.	Cyanide	< 2 mg/l
14.	Nitrate	< 30 mg/l
15.	Adsorbable organic bound chlorine	< 3mg/l
16.	Water soluble compounds	< 10%
17.	Calorific value	< 2500 kcal/kg

Source: http://cpcb.nic.in/upload/NewItems/NewItem_149_Protocol.pdf

Environmental monitoring and management system -

The purpose of environmental monitoring is to evaluate the effectiveness of implementation of environmental management plan and regulate monitoring of the important environmental parameters within the impact area, so that any adverse effect are detected and timely actions can be taken.

These are required for operations of a hazardous waste management site. Monitoring requires one year before the facility operations begin, continue while the facility is operational, and follow up to 30 years after closure.

In consultation with the PPCB, the operating agency will analyse the samples of air, water, ground water, leachate, soils and noise with an approved monitoring schedule.

a) Ambient Air Quality Monitoring – parameters namely SPM , RPM , NOX and SOX should be continued to be monitored as per NAAQS criteria. Major sources of air emissions at the HWMF during operating phase of the project include:

- Emissions from construction vehicles and equipment.
- Emissions from transport vehicles.
- Dust emission from cement and fly-ash silos.

Table 4.2: NATIONAL AMBIENT AIR QUALITY STANDARDS

S.NO.	POLLUTANT	TIME WEIGHTED AVERAGE	CONCENTRATION IN AMBIENT AIR		
			INDUSTRIAL, RESIDENTIAL, RURAL,AND OTHER AREA	ECOLOGICALLY SENSITIVE AREA	METHODS OF MEASUREMENT
1.	Sulphur dioxide [SO2]	Annual 24 hours	50 80	20 80	-improved west and gaeke -ultravoilet fluorescence
2.	Nitrogen dioxide	Annual 24 hours	40 80	30 80	-modified Jacob&hoccheiser -chemiluminiscene
3.	Particulate matter	Annual 24 hours	60 100	60 100	-gravimetric -TOEM -beta attenuation
4.	Particulate matter	Annual 24 hours	40 60	40 60	-gravimetric -TOEM -beta attenuation
5.	ozone	8 hours 1 hour	100 180	100 180	-UV photometric -chemiluminiscene -chemical method
6.	lead	Annual 24 hours	0.5 1.0	0.5 1.0	-AAS -ED-XRF using Teflon filter
7.	Carbon mono-oxide	8 hours 1 hour	02 04	02 04	-NDIR [non dispersive infrared spectroscopy]

8.	ammonia	Annual 24 hours	100 400	100 400	- chemiluminiscene -indophenol blue method
9.	benzene	Annual	05	05	-gas chromatography based continuousanalyser -adsorption & desorption followed by GC analysis .
10.	Benzopyrene	Annual	01	01	-solvent extraction followed by HPLC/GC analysis
11.	arsenic	Annual	06	06	-AAS
12.	Nickel	Annual	20	20	-AAS

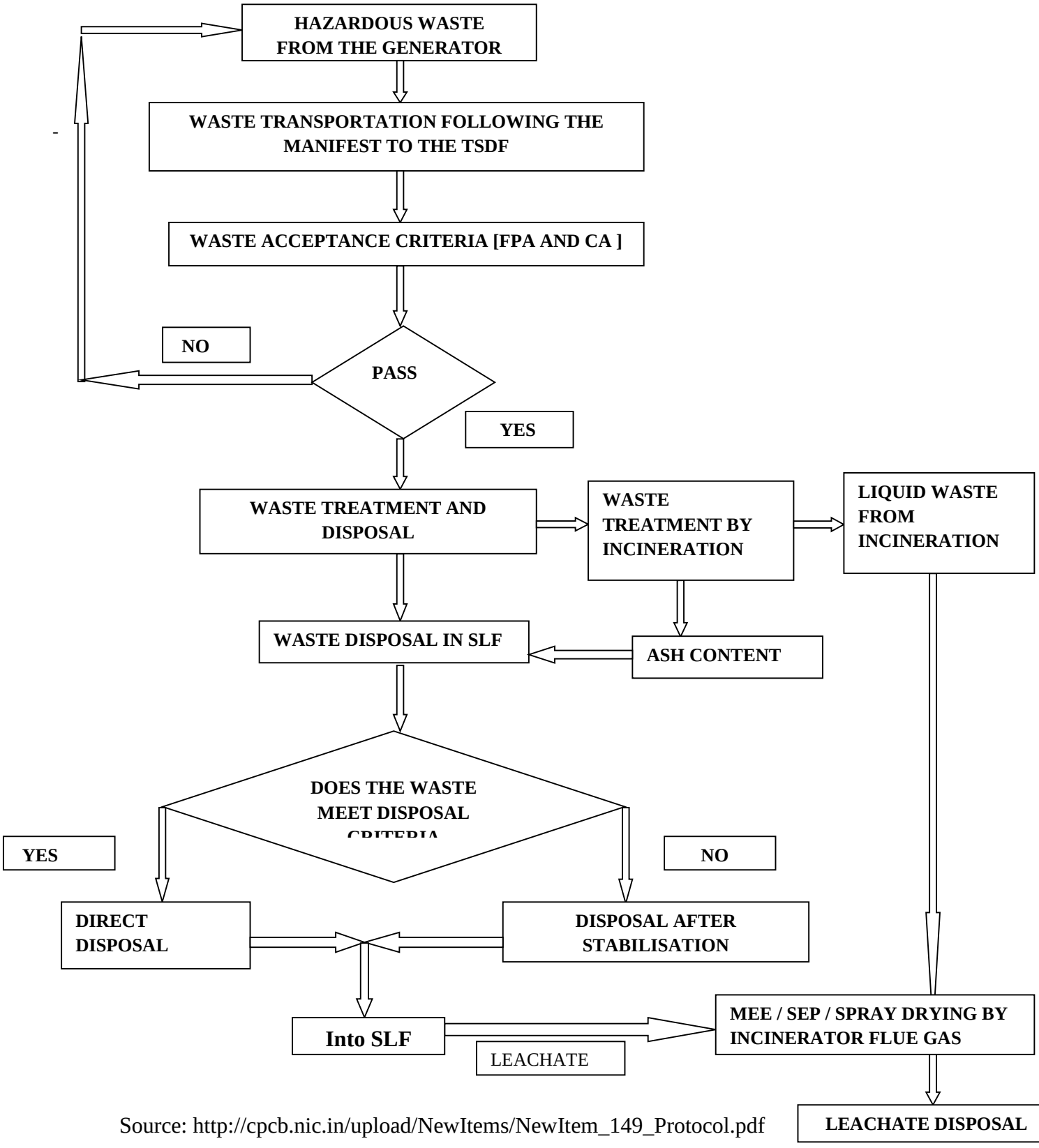
Source: http://cpcb.nic.in/National_Ambient_Air_Quality_Standards.php

b) Ground Water Monitoring – it is recommended that ground water should be analyzed for pH , color, EC ,Turbidity, SS , TDS, TOC ,COD , Heavy metals [such as Pb, Cd ,Cu , Zn ,Cr ,Hg ,Ni] , Fe and chlorides, nitrates , sulfates , TKN , Total alkalinity.

c) Soil Samples Monitoring - analyzed for pH , EC ,color , TDS ,TOC , TSS ,PAH , heavy metals [such as Pb, Cd , Cu , Zn ,Cr ,Hg ,Ni] ,CN ,F ,As.

d) Noise Monitoring – noise emissions are expected from construction equipment and vehicles, noise arising from transport vehicles during receipt of waste at landfill, operational area and near the DG sets. The standard limit provided by the CPCB for the noise is should be less than 75 dB.

4.2 TSDF Operating procedures



Source: http://cpcb.nic.in/upload/NewItems/NewItem_149_Protocol.pdf

HAZARDOUS WASTE FROM THE GENERATOR

Hazardous waste received from the generator must have proper labelling and packaging in such a manner that should it be safe for handling, storage and transport as per the guidelines issued by the Central Pollution Control Board. Labelling and packaging should be done properly so that it will be able to withstand physical and climatic conditions. After receiving, waste is transported to the TSDF following the manifest form.

WASTE TRANSPORTATION FOLLOWING THE MANIFEST TO THE TSDF

The transport of the hazardous waste shall be in accordance with the provisions of the rules made by the Central Government under the Motor Vehicles Act, 1988 and other guidelines issued time to time. The occupier should provide the transporter with the relevant information regarding the nature of hazardous waste and measures to be taken in case of an emergency.

MANIFEST SYSTEM

It refers to the system involving movement of the document to be used within the country only. The occupier i.e. the waste generator prepares six copies of the manifest comprising each of different colour code and all the six copies should be signed by the transporter.

Table 4.3: Purpose of each copy number of manifest with colour code

Copy number with colour code	Purpose
Copy 1 [white]	To be forwarded by the occupier to the state pollution control board committee.
Copy 2 [yellow]	To be carried by the occupier after taking signature on it from the transporter and rest of the four copies to be carried by the transporter.
Copy 3 [pink]	To be retained by the operator of the facility after signature.
Copy 4 [orange]	To be returned to the transporter by the operator of facility/recycler after accepting waste.
Copy 5 [green]	To be returned by the operator of the facility to SPCB after treatment and disposal of wastes.

Copy 6 [blue]	To be returned by the operator of the facility to the occupier after treatment and disposal of hazardous waste.

Source : cpcb.nic.in/upload/Publications/(26)HW-Rules-May-2003-1.doc

The generator forwards copy 1 [white] to the state pollution control board and in case if the hazardous waste is transported through any transit state ,the generator prepares an additional copy and forward the same to the concerned state pollution control board before handing the hazardous waste to the transporter.

Transporter accepts the hazardous waste for transport only when copy 3 to 6 of the manifest carried along with it. Copy 3 [pink] should be retained by the operator and upon completion of treatment and disposal operations of hazardous waste copy 5 [green] should be forwarded to the SPCB and copy 6 [blue] to the occupier i.e. generator of the facility.

WASTE ACCEPTANCE CRITERIA [FPA and CA]

After transportation of waste to TSDF, weighing of the waste is done.

WEIGH BRIDGE : Weighbridge measures the quantity of the waste by weighing the empty vehicle and the loaded vehicle and therefore record the quantity of the waste.

Figure- Weighing bridge

WASTE SAMPLING : Sampling of waste is done for Finger Print Analysis and it should be done properly. Personal protective equipment must be used while taking sample of waste.Each representative sample should be given a unique identification number.

Figure 2.5 Sample Collection Platform and how sampling of waste is done.

ANALYSIS PERFORMED IN THE LAB

- COMPREHENSIVE ANALYSIS
- FINGER PRINT ANALYSIS
- POST-STABILISATION ANALYSIS
- ENVIRONMENTAL MONITORING

COMPREHENSIVE ANALYSIS :

This is a one-time test to establish waste profile. The waste management company will take samples from all its prospective customers, analyze the waste and develop a specific waste profile for each waste. Based on it, it will draw up an agreement of price. Comprehensive analysis refers to the detailed complete analysis and gathering all informations of the hazardous waste including :

Physical Analysis : physical state of the waste [solid/semi-solid/slurry], colour and texture , specific gravity , viscosity in case of liquids , calorific value in case of organic wastes , flash point

, % moisture content [loss on drying at 105 deg C] , % organic content [loss on ignition at 550 deg C] , paint filter liquid test [PFLT].

Chemical analysis : pH

Inorganic parameters analysis : cyanide [ppm] , sulphide [ppm] , Sulphur [elemental].

Organic parameters analysis : oil & grease extractable organic , % carbon , % nitrogen , %sulphur, % hydrogen.

Compatibility tests : toxicity characteristics leaching procedure.

Table 4.4 : Parameters of Comprehensive Analysis

Comprehensive Analysis to be Submitted by the Generators of Hazardous waste	**Method of Analysis**
Physical Analysis	
Physical state of the waste[liquid/slurry/sludge/semi-solid/solid:inorganic,organic,metallic]	
Description of different phases of wastes [in cases of solid wastes slurries and sludge]contained in aqueous/non-aqueous liquids / solutions	
Colour and texture	
Specific gravity	
Viscosity in case of liquids	
Calorific value in case of organic wastes	
Flash point	USEPA, SW-846; Method 1010 and 1020
% Moisture content[loss on drying at 105degC	USEPA, SW-846; ; Method 1010 and 1020
% Organic content [loss on ignition at 550degC	USEPA, SW-846; Method 1010 and 1020
Paint filter liquid test [PFLT]	USEPA; SW-846 ; Method 9095
Chemical Analysis	
Ph	USEPA; SW-846 ; Methods 9040,9041 and 9045
Inorganic Parameters Analysis	
Cyanide [ppm]	USEPA; SW-846; Vol. 1C Part 2; test method to determine HCN released from wastes
Sulfide [ppm]	USEPA; SW-846; Vol. 1C Part 2; test method to determine H2S released from wastes

Sulphur [elemental]	USEPA ;SW-846 ; 9010,9011,9012
Concentration of relevant inorganic [as per schedule 2 of HW rules,2008 and amendments made thereof]	USEPA ;SW-846 , vol.1A, 1B,1C and vol 2
Organic Parameters Analysis	
Oil & grease extractable organic [in special cases only]	
% carbon	
% nitrogen	
% Sulphur	
% hydrogen	
Compatibility Tests	
Concentration of relevant individual organics[as per schedule 2 of HW rules,2008 and amendment made there of]	USEPA ;SW-846 ,vol.1A, 1B,1C and vol 2
Toxicity characteristics leaching procedure	USEPA ;SW-846 ; Method 1311, 1330

Source: http://cpcb.nic.in/upload/NewItems/NewItem_149_Protocol.pdf

FINGER PRINT ANALYSIS :

The objective of the fingerprint analysis is to ensure that the physical and chemical characteristics of waste received conform to the initial sample submitted by the industry for comprehensive analysis. Also it refers to the quick analysis of waste which lead to the conclusion of confirmation or deviation of the received waste for disposal to that of waste received for comprehensive analysis. It includes:

Physical analysis : physical state of the waste [liquid/slurry/sludge/semi-solid/solid] , colour & textures , specific gravity, viscosity in case of liquid waste , flash point , loss on drying at 105 deg C in case of solids, loss on ignition at 550 deg C , calorific value in case loss on ignition >= 20 % , paint filter liquid test [PFLT]

Chemical analysis : pH , reactive cyanide [ppm] , reactive sulfide [ppm].

The result of all parameters of comprehensive analysis and finger print analysis must be same and if it is not so then the concerned hazardous waste is not allowed for further treatment and disposal facility. That waste is re-analyzed and reported to the industry and waste is sent back.

Table 4.5 : Parameters of Finger print Analysis

Parameters for finger print analysis by the operators of TSD facilities	**Method of analysis**
Physical analysis	
Physical state of the waste[liquid/slurry/sludge/semi-solid/solid:inorganic,organic,metallic]	
Description of different phases of wastes [in cases of solid wastes contained in aqueous/non-aqueous liquids / solutions for slurries and sludge]	
Colour and texture	
Specific gravity	
Viscosity in case of liquids	
Flash point	USEPA, SW-846; Method 1010 and 1020
Loss on drying at 105degC in case of solids	
Loss on ignition at 550degC	
Calorific value in case loss on ignition >= 20%	
Paint filter liquid test [PFLT] for liquids	USEPA; SW-846 ; Method 9095
Liquid release test [LRT] for liquids	USEPA, SW-846 ; Method 9096
Chemical analysis	
pH	USEPA; SW-846 ; Methods 9040,9041 and 9045
Reactive cyanide [ppm]	USEPA; SW-846; Vol. 1C Part 2; test method to determine HCN released from wastes
Reactive sulfide [ppm]	USEPA; SW-846; Vol. 1C Part 2; test method to determine H2S released from wastes

Source: http://cpcb.nic.in/upload/NewItems/NewItem_149_Protocol.pdf

WASTE TREATMENT AND DISPOSAL :

After the matching of results of CA and FPA analysis, waste is send for the treatment and disposal facility. Treatment involves stabilization process in which the undesirable components of an inorganic material [usually heavy metals] are stabilized or neutralized by addition of binding agents such as lime, cement, flyash, sodium sulphide to produce a solid and chemically stable matrix that eliminates leaching of toxic chemicals.

Stabilization refers to chemical changes of hazardous constituents in a waste. The desired changes include converting the constituents into less soluble, mobile or toxic form.

Figure 2.6 : Stabilisation

EFFECTS OF BINDING REAGENTS ON WASTE :

Cement is frequently selected for the reagent's ability to :

a) chemically bind free liquids.

b) reduce the permeability of the waste form.

c) encapsulate waste particles surrounding them with an impermeable coating.

d) chemically fix hazardous constituents by reducing their solubility.

e) facilitate the reduction of the toxicity of some contaminants.

Lime has the property to maintain pH or to stop the chemical reactions going on the waste.

Flyash is used to absorb the moisture content form the waste.

Sodium sulfide is used to stabilize the toxic metals present in the waste.

Solidification stabilization treatment is used to reduce the leaching ability of the hazardous particles from the waste. After treatment the waste no longer exhibits the hazardous characteristics and can be disposed as non-hazardous waste.

WASTE DISPOSAL IN SECURED LANDFILL

A secured landfill is a facility that ensures that the final disposal of waste does not adversily affect the adjacent land uses. After stabilization waste is stored for curing and then it is ready for final disposal. Before doing so Post – stabilization analysis is done. In this process, the stabilized sample is taken and check their characteristics that whether they meet the direct disposal criteria or not. If does not meet then further treatment is done. Finally disposed off in secured landfill.

The aim of the secured landfill is to avoid any hydraulic connection between the waste and the surrounding environment, particularly with the ground water and soil

Figure 2.7: Waste disposal in secured landfill

The treatment and disposal of hazardous waste

The hazardous waste [management and handling) rules do not state the standard for the treatment of waste ,but the MoEF and CPCB have produce certain guidelines. Technical requirements about landfills for hazardous waste has been shown in “Criteria for hazardous waste landfills” and “Guidelines for setting up of operating facility-Hazardous waste management”.

The guidelines for the direct disposal of hazardous waste into landfill given by the CPCB is shown below :

Table 4.6 : Acceptance criteria for direct landfilling of hazardous waste:

S. NO.	Leachate quantity	Concentration
1	pH	4-12
2	Total phenols	< 100 mg/l
3	Arsenic	< 1 mg/l
4	Lead	< 2 mg/l
5	Cadmium	< 0.2 mg/l
6	Chromium-vi	< 0.5 mg/l
7	Copper	< 10 mg/l
8	Nickel	< 3 mg/l
9	Mercury	< 0.1 mg/l
10	Zinc	< 10 mg/l
11	Fluoride	< 50 mg/l
12	Ammonia	< 1000 mg/l
13	Cyanide	< 2 mg/l
14	Nitrate	< 30 mg/l
15	Adsorbable organic bound chlorine	< 3mg/l
16	Water soluble compounds	< 10%
17	Calorific value	< 2500 k cal/kg
	STRENGTH	
18	Transversal strength	>25KN/m^2
19	Unconfined compression test	>50KN/m^2
20	Axial deformation	<20%
	CONTENT OF ORGANIC MATERIALS	
22	Annealing loss of the dry residue at 550degC	<20% by weight [for non-biodegradable waste] <5% by weight [for biodegradable waste]
23	Extractible lipophilic contents[oil &grease]	<4% by weight

Source: http://cpcb.nic.in/upload/NewItems/NewItem_149_Protocol.pdf

LEACHATE MANAGEMENT

Leachate is generally the liquid that drains or leaches out from a landfill. Leaching occurs when water percolates through any permeable material. Leachate varies widely in composition about the age of landfill and the type of waste that it contains.it usually contains both dissolved and

suspended materials. The leachate formed in the landfills have the potential to contaminate surrounding soil and water.

Leachate can be treated either using Multiple-Effect Evaporator , Solar Evaporation Pond , Spray drier by incinerator flue gas.

Table 4.7 : CONCENTRATION LIMIT FOR HAZARDOUS SUBSTANCES IN LEACHATE

S.N.	Parameters in leachate	Concentration
1.	pH	4-12
2.	Total Phenols	< 100 mg/l
3.	Arsenic	< 1 mg/l
4.	Lead	< 2 mg/l
5.	Cadmium	< 0.2 mg/l
6.	Chromium	< 0.5 mg/l
7.	Copper	< 10 mg/l
8.	Nikel	< 3 mg/l
9.	Mercury	< 0.1 mg/l
10.	Zinc	< 10 mg/l
11.	Fluoride	< 50 mg/l
12.	Ammonia	< 1000 mg/l
13.	Cyanide	< 2 mg/l
14.	Nitrate	< 30 mg/l
15.	Adsorbable organic bound chlorine	< 3mg/l
16.	Water soluble compounds	< 10%
17.	Calorific value	< 2500 k cal/kg

Source: http://cpcb.nic.in/upload/NewItems/NewItem_149_Protocol.pdf

4.3 Case study of Hazardous Waste handling, Management and Disposal

CASE STUDY 1. SAMPLE A

1) Collection and transportation

Sample A was collected from an industry situated in Hoshiarpur and before hazardous sample A was transported to the hazardous waste site, it was packaged in such a way which is suitable for storage and transport and that the labelling was easily visible and packaging was able to withstand physical conditions and climatic factors during transportation. A manifest system was followed by the transporters carrying the waste. Waste is transported to the facility in two ways:

- Transportation of the hazardous waste from the transfer stations.
- Transportation of the waste directly from industries to the facility.

2) **Analysis- Comprehensive and Fingerprint Analysis**

Table 4.8: RESULTS OF COMPREHENSIVE ANALYSIS

S.No.	Parameter	Unit	Result	CPCB guidelines
1	Physical state	-	Solid	Solid
2	Color	-	Black	-
3	Texture	-	Powder	Solid
4	PFLT(paint filter liquid test)	-	Pass	Pass
5	Calorific value	cal/g	680	<2500cal/g
6	Bulk density	g/cm³	0.715	-
7	Flash point	ºC	>65ºC	>65ºC
8	LOD at 105ºC	%	24.57	<30
9	LOI at 550 ºC	%	19.2	<20
10	pH	-	8.2	>4 to <12
11	Water soluble substance	%	2.11	<10
12	Nitrate	Mg/l	3.807	<30
13	Sulfates	Mg/l	**2164.112**	<1000
14	Halides as Cl^-	Mg/l	43.23	<1000
	Metals			
1	Cadmium as Cd	Mg/l	0.0007	<0.2
2	Chromium as Cr	Mg/l	0.1488	<5
3	Copper as Cu	Mg/l	0.0169	<10
4	Lead as Pb	Mg/l	0.0289	<2.0
5	Mercury as Hg	Mg/l	Not analysed	<0.2
6	Nickel as Ni	Mg/l	0.0329	<3.0
7	Chromium vi	Mg/l	Not analysed	<0.5
8	Zinc as Zn	Mg/l	0.3171	<10
	Organic parameters			
1	Benzene	Mg/l	-	<0.5
2	Carbon tetrachloride	Mg/l	-	<0.5
3	Chlordane	Mg/l	-	<0.03

4	Chlorobenzene	Mg/l	-	<100
5	Chloroform	Mg/l	-	<6
6	o-cresol	Mg/l	-	<200
7	m-cresol	Mg/l	-	<200
8	p-cresol	Mg/l	-	<200
9	1,4-dichlorobenzene	Mg/l	-	<7.5
10	1,2-dichloroethylene	Mg/l	-	<0.5
11	1,1- dichloroethylene	Mg/l	-	<0.7
12	2,4-dinitrotoulene	Mg/l	-	<0.13
13	Endrin	Mg/l	-	<0.02
14	Heptachlor	Mg/l	-	<0.008
15	Hexachlorobenzene	Mg/l	-	<0.13
16	Hexachloro-1,3-butadiene	Mg/l	-	<0.5
17	Hexachloroethane	Mg/l	-	<3
18	Lindane	Mg/l	-	<0.4
19	Methoxychlor	Mg/l	-	<10
20	Methyl ethyl ketone	Mg/l	-	<200
21	Nitrobenene	Mg/l	-	<2
22	Pentachlorophenol	Mg/l	-	<100
23	Pyridine	Mg/l	-	<5
24	Tetrachloroethylene	Mg/l	-	<0.7
25	Toxaphene	Mg/l	-	<0.5
26	Trichloroethylene	Mg/l	-	<0.5
27	2,4,5-trichlorophenol	Mg/l	-	<400
28	2,4,6- trichlorophenol	Mg/l	-	<2
29	2,4,5-TP(Silvex)	Mg/l	-	<1
30	Vinyl chloride	Mg/l	-	<0.2

TABLE 4.9: RESULTS OF FINGER-PRINT ANALYSIS

s.no.	**Parameter**	**Unit**	**Result**
1	Physical state	-	Solid
2	Color	-	Black
3	Texture	-	Powder
4	Bulk density	g/cm^3	0.710
5	Viscosity in case of liquid sample	-	Not analysed
6	Liquid release test	Pass	Not analysed
7	LOD	%	22.6
8	LOI	%	17.8
9	PFLT (paint filter liquid test)	Pass	Pass
10	pH	-	8.0
11	Calorific value	Cal/g	Not analysed

12	Flash point	ºC	>65ºC
13	Reactive cyanide	Mg/l	Not analysed
14	Reactive sulphide	Mg/l	Not analysed
15	Violent chemical change(in air)	-	Not detected
16	Reacts violently with water	-	Not detected
17	Unstable and violent change without detonation	-	Not analysed
18	Generating toxic fumes with water/acid/basic	-	Not detected
19	Explosion when subjected to a strong force	-	Not analysed
20	Explosion at normal temperature and pressure	-	Not detected
\			

Discussion :

The analytical parameters of both comprehensive and fingerprint analysis shows that the physical and chemical characteristics of waste received, conform to the initial sample submitted by the industry for comprehensive analysis. The results of all parameters from CA shows that the sample A is having high concentration of sulfates and all the other parameters are lying below their standard limit. The standard limit for the sulfate concentration is below 1000 mg/l. This sample A requires treatment or stabilization (due to the excessive amount of sulfates which makes it hazardous)in order to make it non-hazardous form of waste before disposing into the landfill.

TREATMENT:

For treatment of the hazardous waste, reciepe development is made. Certain amount of reagents are added based on the requirements so as to covert the hazardous waste into non- hazardous form.

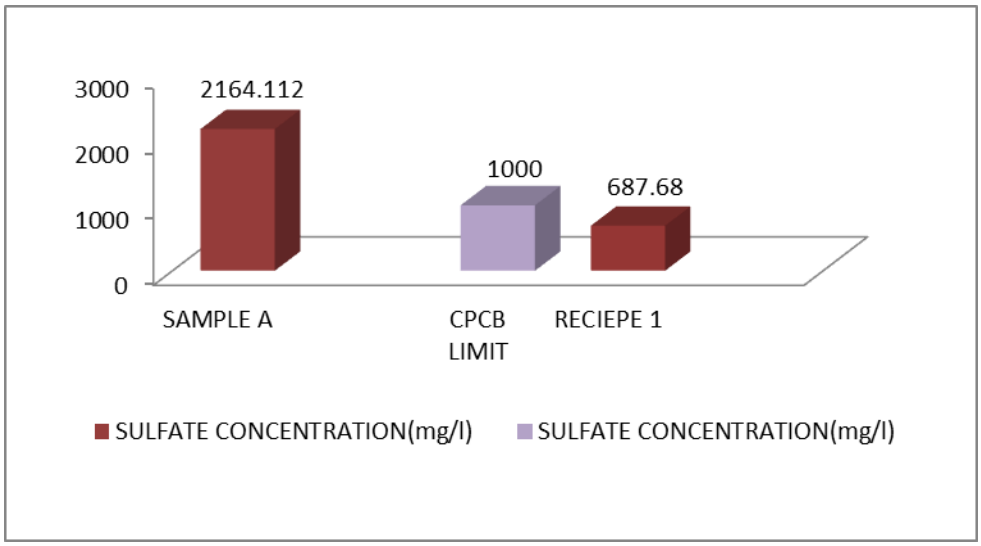
SAMPLE A : Sulfate content = 2164.112(mg/l)

Reciepe -1

sulfate in sample	Lime (%)	Flyash (%)	Cement (%)
2164.112	-	-	-
687.68	10	-	10

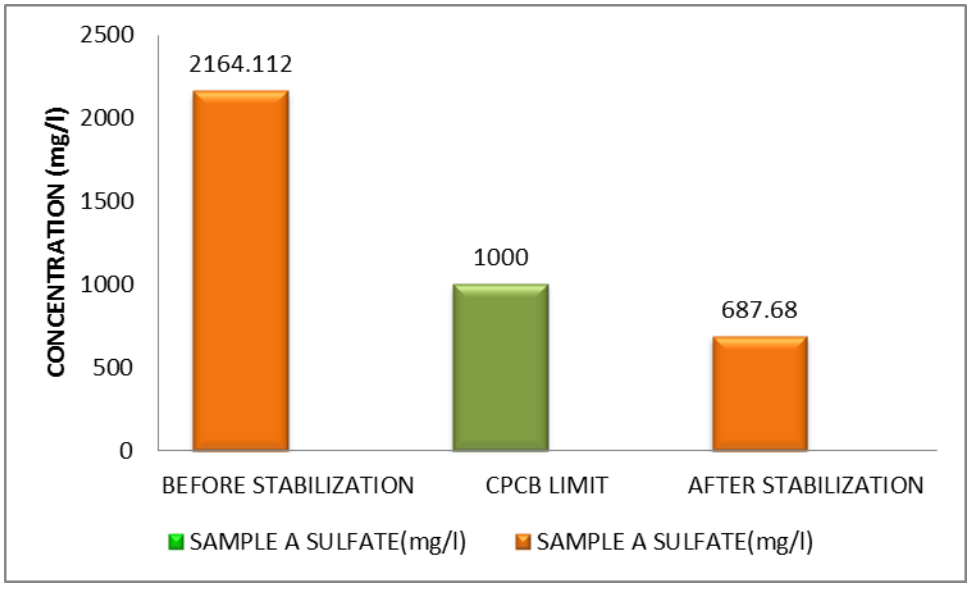
From the above tabulation it is clear that by adding cement 10% and lime 10% in sample A, the sulfate content in the sample gets reduced and lies below the CPCB limit. Cement has the ability

to chemically bind free liquids and chemically fix hazardous constituents by reducing their solubility. Therefore, sample A gets stabilized on proper mixing of the reagents.



DISPOSAL :

After Stabilization, waste is stored for curing and then it is ready for final disposal. Before doing so Post – stabilization analysis is done. In this process, the stabilized sample is taken and check their characteristics that whether they meet the direct disposal criteria or not. If does not meet then further treatment is done. Finally disposed off in secured landfill.



Above graphical representation shows that sample A now meets the direct disposal criteria and can be sent for disposal into the secured landfill.

CASE STUDY 2:`SAMPLE B

1) Collection and transportation

Sample B was collected from an industry situated in Saidpura and before hazardous sample B was transported to the hazardous waste site, it was packaged in such a way that it is good for storage and transport and that the labelling was easily visible and packaging was able to withstand physical conditions and climatic factors during transportation. A manifest system was followed by the transporters carrying the waste.Waste is transported to the facility in two ways:

- Transportation of the hazardous waste from the transfer stations.
- Transportation of the waste directly from industries to the facility.

2) Analysis- Comprehensive and Fingerprint Analysis

Table 4.10: Results of comprehensive analysis :

S.No.	Parameter	Unit	Result	CPCB guidelines
1	Physical state	-	Semi-solid	Solid
2	Color	-	Brown	-
3	Texture	-	Wet cake	Solid
4	PFLT(paint filter liquid test)	-	Pass	Pass
5	Calorific value	cal/g		<2500cal/g
6	Bulk density	g/cm³	1.19	-
7	Flash point	ºC	>65ºC	>65ºC
8	LOD at 105ºC	%	**51.97**	<30
9	LOI at 550 ºC	%	10.16	<20
10	pH	-	9.1	>4 to <12
11	Water soluble substance	%	0.7	<10
12	Nitrate	Mg/l	**82.325**	<30
13	Sulfates	Mg/l	**1087.74**	<1000
14	Halides as Cl^-	Mg/l	148.907	<1000
	Metals			
1	Cadmium as Cd	Mg/l	0.0006	<0.2
2	Chromium as Cr	Mg/l	0.0296	<5
3	Copper as Cu	Mg/l	BDL	<10
4	Lead as Pb	Mg/l	0.7618	<2.0

5	Mercury as Hg	Mg/l	-	<0.2
6	Nickel as Ni	Mg/l	BDL	<3.0
7	Chromium vi	Mg/l	-	<0.5
8	Zinc as Zn	Mg/l	0.4509	<10
	Organic parameters			
1	Benzene	Mg/l	-	<0.5
2	Carbon tetrachloride	Mg/l	-	<0.5
3	Chlordane	Mg/l	-	<0.03
4	Chlorobenzene	Mg/l	-	<100
5	Chloroform	Mg/l	-	<6
6	o-cresol	Mg/l	-	<200
7	m-cresol	Mg/l	-	<200
8	p-cresol	Mg/l	-	<200
9	1,4-dichlorobenzene	Mg/l	-	<7.5
10	1,2-dichloroethylene	Mg/l	-	<0.5
11	1,1- dichloroethylene	Mg/l	-	<0.7
12	2,4-dinitrotoulene	Mg/l	-	<0.13
13	Endrin	Mg/l	-	<0.02
14	Heptachlor	Mg/l	-	<0.008
15	Hexachlorobenzene	Mg/l	-	<0.13
16	Hexachloro-1,3-butadiene	Mg/l	-	<0.5
17	Hexachloroethane	Mg/l	-	<3
18	Lindane	Mg/l	-	<0.4
19	Methoxychlor	Mg/l	-	<10
20	Methyl ethyl ketone	Mg/l	-	<200
21	Nitrobenene	Mg/l	-	<2
22	Pentachlorophenol	Mg/l	-	<100
23	Pyridine	Mg/l	-	<5
24	Tetrachloroethylene	Mg/l	-	<0.7
25	Toxaphene	Mg/l	-	<0.5
26	Trichloroethylene	Mg/l	-	<0.5
27	2,4,5-trichlorophenol	Mg/l	-	<400
28	2,4,6- trichlorophenol	Mg/l	-	<2
29	2,4,5-TP(Silvex)	Mg/l	-	<1
30	Vinyl chloride	Mg/l	-	<0.2

Table 4.11 : FINGER-PRINT ANALYSIS

s.no.	**parameter**	**Unit**	**Result**
1	Physical state	-	Semi-solid
2	Color	-	Brown
3	Texture	-	Wet cake
4	Bulk density	g/cm^3	1.1
5	Viscosity in case of liquid sample	-	Not analysed

6	Liquid release test	Pass	Not analysed
7	LOD	%	50.06
8	LOI	%	10.95
9	PFLT	Pass	Pass
10	pH	-	9.4
11	Calorific value	Cal/g	Not analysed
12	Flash point	ºC	>65ºC
13	Reactive cyanide	Mg/l	Not analysed
14	Reactive sulphide	Mg/l	Not analysed
15	Violent chemical change(in air)	-	Not detected
16	Reacts violently with water	-	Not detected
17	Unstable and violent change without detonation	-	Not analysed
18	Generating toxic fumes with water/acid/basic	-	Not detected
19	Explosion when subjected to a strong force	-	Not analysed
20	Explosion at normal temperature and pressure	-	Not detected

Discussion:

The results obtained from the comprehensive and fingerprint analysis of sample B reveals that the physical and chemical characteristics of waste received, conform to the initial sample submitted by the industry for comprehensive analysis. From the CA analysis it is depicted that the sample Bis having high moisture content. In addition to this, high concentration of nitrates and sulfates were also present.The LOD content in the sample B is 51.97% , nitrate 82.325 mg/l and sulfate 1087.74 mg/l. All the other parameters are lying with in the standard of CPCB limit. This sample requires treatment for minimizing the moisture content, concentration of sulfates and nitrates present in the waste.

TREATMENT:

Reciepe development is required for the treatment of sample B as it contains high concentrations of parameters which makes the waste sample B hazardous and does not fit for direct disposal into the landfill.

SAMPLE B : Nitrate = 82.325(mg/l) ;Sulfate = 1087.74(mg/l) ; L.O.D =51.97 (%)

Parameters	Nitrate	sulfate	LOD
in sample	82.325	1087.74	51.97

Reciepe -1

Lime (%)	Flyash (%)	Cement (%)	Nitrate	Sulfate	LOD
-	40	-	88.546	835.58	11.36

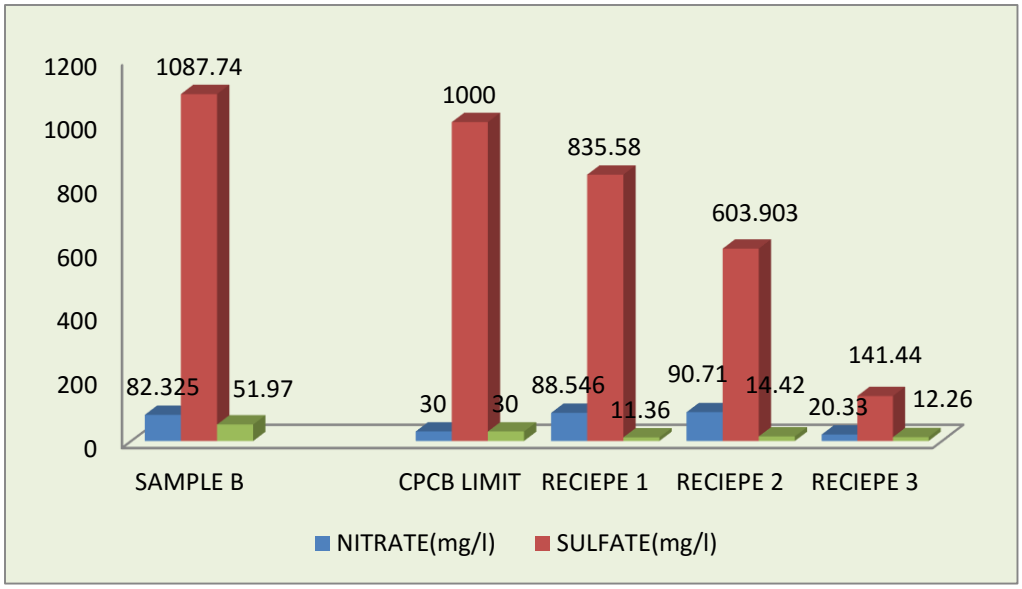
Reciepe -2

Lime (%)	Flyash (%)	Cement (%)	Nitrate	Sulfate	LOD
-	30	-	95.77	603.903	14.42

Reciepe -3

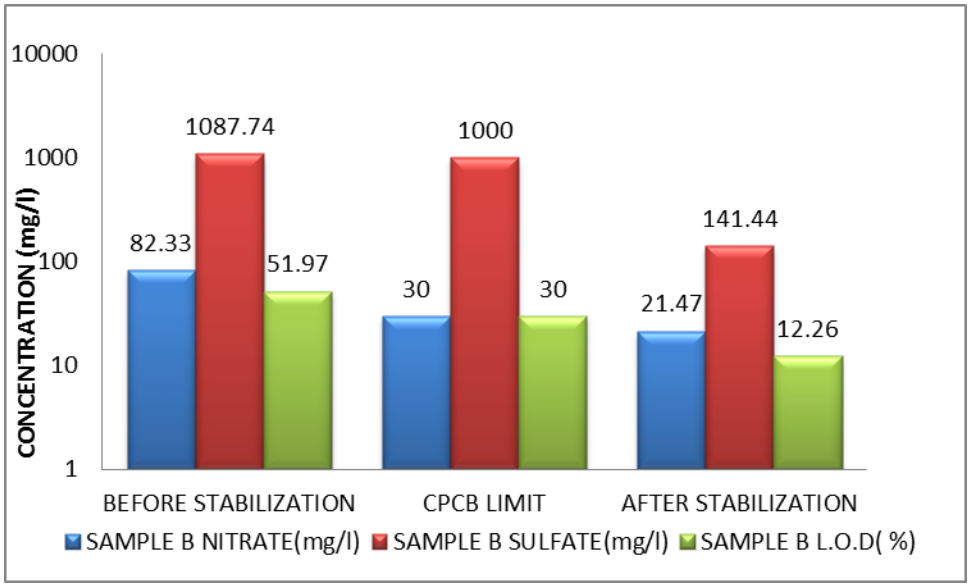
Lime (%)	Flyash (%)	Cement (%)	Nitrate	sulfate	LOD
-	30	10	21.47	141.44	12.26

Reciepe was made by the hit and trial method. The above three trials describes that on addition of 30% fly-ash ,the concentration of nitrates , sulfates and LOD content gets reduced but not below the CPCB limit. Further addition of 40% flyash in second trial of reciepe also does not show more effect. Lastly in the third trial, the proportion of 10% addition of cement with 30% flyash binds the nitrate and sulfate concentration and reduces the moisture content below the CPCB limit. The graphical representation of the same is shown below.



DISPOSAL :

After the treatment of waste sample B, the treated sample was checked that whether those parameters now actually lies within the CPCB limit or not. It was observed that after stabilization LOD, sulfate and nitrate all lies within limit and satisfies the direct disposal criteria. Finally the waste sample B was transferred from the stabilization pit to the landfill disposal site.



CASE STUDY 3 :SAMPLE C

1) Collection and transportation

Sample C was collected from an industry situated in ludhiana and before hazardous sample C was transported to the hazardous waste site, it was packaged in such a way that it is good for storage and transport and that the labelling was easily visible and packaging was able to withstand physical conditions and climatic factors while transportation. A manifest system was followed by the transporters carrying the waste .Waste is transported to the facility in two ways:

- Transportation of the hazardous waste from the transfer stations.
- Transportation of the waste directly from industries to the facility.

2) **Analysis- Comprehensive and Fingerprint Analysis**

Table 4.12: Results of Comprehensive analysis

S.No.	Parameter	Unit	Result	CPCB guidelines
1	Physical state	-	Solid	Solid
2	Color	-	Light brown	-
3	Texture	-	Powder, lumps	Solid
4	PFLT(paint filter liquid test)	-	Pass	Pass
5	Calorific value	cal/g		<2500cal/g
6	Bulk density	g/cm³	1.03	-
7	Flash point	ºC	>65ºC	>65ºC
8	LOD at 105ºC	%	25.58	<30
9	LOI at 550 ºC	%	11.92	<20
10	pH	-	8.7	>4 to <12
11	Water soluble substance	%	7.07	<10
12	Nitrate	Mg/l	**353.64**	<30
13	Sulfates	Mg/l	487	<1000
14	Halides as Cl^-	Mg/l	**5523.99**	<1000
	Metals			
1	Cadmium as Cd	Mg/l	0.0103	<0.2
2	Chromium as Cr	Mg/l	0.0483	<5
3	Copper as Cu	Mg/l	0.1028	<10
4	Lead as Pb	Mg/l	0.2191	<2.0
5	Mercury as Hg	Mg/l	-	<0.2
6	Nickel as Ni	Mg/l	0.0019	<3.0
7	Chromium vi	Mg/l	-	<0.5
8	Zinc as Zn	Mg/l	0.3398	<10
	Organic parameters			
1	Benzene	Mg/l	-	<0.5
2	Carbon tetrachloride	Mg/l	-	<0.5

3	Chlordane	Mg/l	-	<0.03
4	Chlorobenzene	Mg/l	-	<100
5	Chloroform	Mg/l	-	<6
6	o-cresol	Mg/l	-	<200
7	m-cresol	Mg/l	-	<200
8	p-cresol	Mg/l	-	<200
9	1,4-dichlorobenzene	Mg/l	-	<7.5
10	1,2-dichloroethylene	Mg/l	-	<0.5
11	1,1- dichloroethylene	Mg/l	-	<0.7
12	2,4-dinitrotoulene	Mg/l	-	<0.13
13	Endrin	Mg/l	-	<0.02
14	Heptachlor	Mg/l	-	<0.008
15	Hexachlorobenzene	Mg/l	-	<0.13
16	Hexachloro-1,3-butadiene	Mg/l	-	<0.5
17	Hexachloroethane	Mg/l	-	<3
18	Lindane	Mg/l	-	<0.4
19	Methoxychlor	Mg/l	-	<10
20	Methyl ethyl ketone	Mg/l	-	<200
21	Nitrobenene	Mg/l	-	<2
22	Pentachlorophenol	Mg/l	-	<100
23	Pyridine	Mg/l	-	<5
24	Tetrachloroethylene	Mg/l	-	<0.7
25	Toxaphene	Mg/l	-	<0.5
26	Trichloroethylene	Mg/l	-	<0.5
27	2,4,5-trichlorophenol	Mg/l	-	<400
28	2,4,6- trichlorophenol	Mg/l	-	<2
29	2,4,5-TP(Silvex)	Mg/l	-	<1
30	Vinyl chloride	Mg/l	-	<0.2

Table 4.13 : FINGER-PRINT ANALYSIS

s.no.	parameter	Unit	Result
1	Physical state	-	Solid
2	Color	-	Light brown
3	Texture	-	Powder, lumps
4	Bulk density	g/cm³	1.0
5	Viscosity in case of liquid sample	-	Not analysed
6	Liquid release test	Pass	Not analysed
7	LOD	%	26.7
8	LOI	%	12.6
9	PFLT	Pass	Pass
10	pH	-	8.5
11	Calorific value	Cal/g	Not analysed
-12	Flash point	ºC	>65ºC

13	Reactive cyanide	Mg/l	Not analysed
14	Reactive sulphide	Mg/l	Not analysed
15	Violent chemical change(in air)	-	Not detected
16	Reacts violently with water	-	Not detected
17	Unstable and violent change without detonation	-	Not analysed
18	Generating toxic fumes with water/acid/basic	-	Not detected
19	Explosion when subjected to a strong force	-	Not analysed
20	Explosion at normal temperature and pressure	-	Not detected

Discussion:

The results obtained from the comprehensive and fingerprint analysis of sample C reveals that the physical and chemical characteristics of waste received, conform to the initial sample submitted by the industry for comprehensive analysis. From the result of comprehensive analysis of waste sample C it is observed that the sample is having a very high concentration of nitrates and chlorides as compared to the CPCB limit.The nitrate content in the sample is 353.64 mg/l and chloride is 5523.99 mg/l. All the other parameters are lying with in the standard of CPCB limit.This sample C requires treatment or stabilization (due to the excessive amount of nitrates and chlorides which makes it hazardous)in order to make it non-hazardous form of waste before disposing into the landfill.

TREATMENT:

The waste sample C requires treatment for minimizing the concentration of nitrates and chlorides, present in the waste. Prior to the treatment, reciepe development is required for the treatment as it contains high concentrations of parameters which makes the waste sample Chazardous and does not fit for direct disposal into the landfill.

Sample C: Nitrate = 353.64(mg/l) ; Chloride =5523.99(mg/l)

Parameters	Nitrate	Chloride
in sample	353.64	5523.99

Reciepe -1

Lime (%)	Flyash (%)	Cement (%)	Nitrate	Chloride

-	30	-	140.161	2449.77

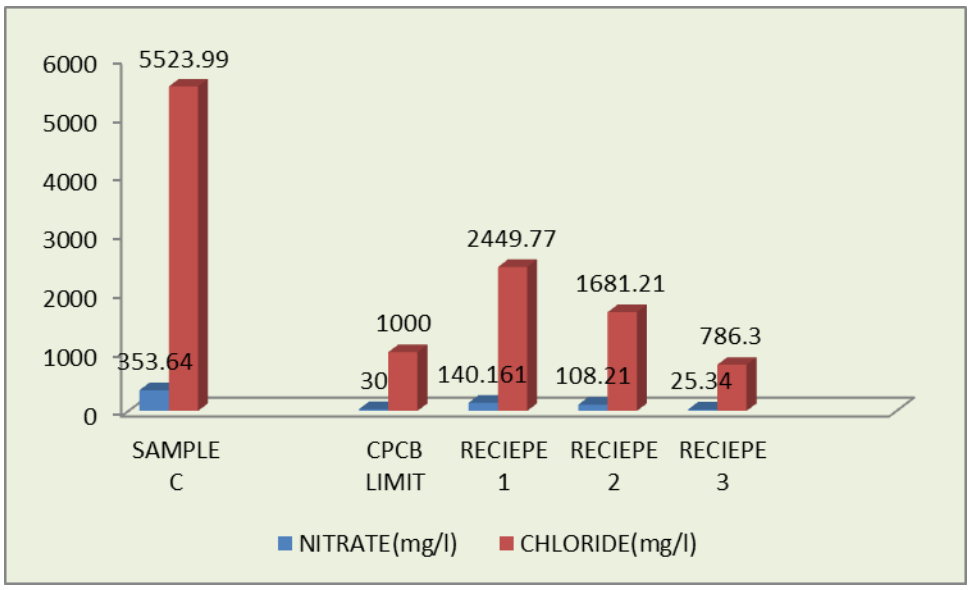
Reciepe -2

Lime (%)	Flyash (%)	Cement (%)	Nitrate	Chloride
-	30	10	108.21	1681.21

Reciepe -3

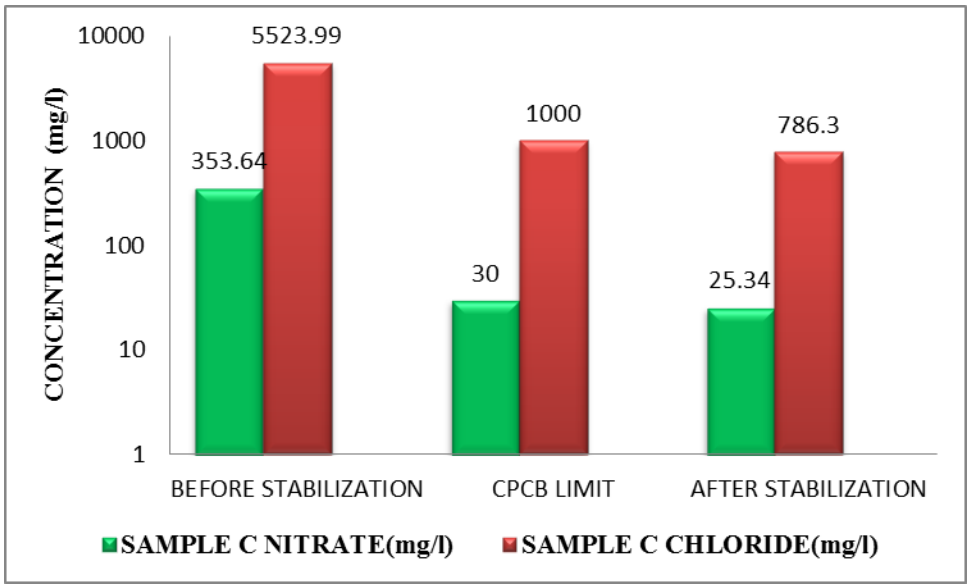
Lime (%)	Flyash (%)	Cement(%)	Nitrate	Chloride
-	30	20	25.34	786.3

Reciepe Development was made by the hit and trial method. The above three trials describes that on addition of 30% fly-ash, the concentration of nitrates and chlorides gets reduced but not below the CPCB limit. Furthermore addition of 10% cement and 30% fly-ash in the sample C in second trial of reciepe also does not show more effect. Lastly in the third trial, the proportion of 30% addition of flyash and 20% cement binds the nitrate and chloride concentration and reduces below the CPCB limit. The graphical representation of the same is shown below.



DISPOSAL :

After the treatment of waste sample C, the treated sample was checked that whether those parameters now actually lies within the CPCB limit or not. It was observed that after stabilization nitrate and chloride concentration all lies within limit and satisfies the direct disposal criteria. The graphical representation of the same is shown below. Finally the waste sample C was transferred from the stabilization pit to the landfill disposal site.



CASE STUDY 4 : SAMPLE D

1) Collection and transportation

Sample D was collected from an industry situated in Jalandhar and before hazardous sample D was transported to the hazardous waste site, it was packaged in such a way that is good for storage and transport and that the labelling was easily visible and packaging was able to withstand physical conditions and climatic factors during transportation. A manifest system was followed by the transporters carrying the waste .Waste is transported to the facility in two ways:

- Transportation of the hazardous waste from the transfer stations.
- Transportation of the waste directly from industries to the facility.

2) **Analysis- Comprehensive and Fingerprint Analysis**

Table 4.14 : Results of comprehensive analysis

S.No.	Parameter	Unit	Result	CPCB guidelines
1	Physical state	-	Solid	Solid
2	Color	-	Grey	-
3	Texture	-	Lumps, Powder	Solid
4	PFLT(paint filter liquid test)	-	Pass	Pass
5	Calorific value	cal/g	850	<2500cal/g
6	Bulk density	g/cm³	0.739	-
7	Flash point	ºC	>65ºC	>65ºC
8	LOD at 105ºC	%	23.16	<30
9	LOI at 550 ºC	%	**23.01**	<20
10	pH	-	8.7	>4 to <12
11	Water soluble substance	%	6.26	<10
12	Nitrate	Mg/l	**81.04**	<30
13	Sulfates	Mg/l	956.42	<1000
14	Halides as Cl^-	Mg/l	**2497.80**	<1000
	Metals			
1	Cadmium as Cd	Mg/l	BDL	<0.2
2	Chromium as Cr	Mg/l	0.0646	<5
3	Copper as Cu	Mg/l	0.0226	<10
4	Lead as Pb	Mg/l	0.0098	<2.0
5	Mercury as Hg	Mg/l	-	<0.2
6	Nickel as Ni	Mg/l	BDL	<3.0
7	Chromium vi	Mg/l	-	<0.5
8	Zinc as Zn	Mg/l	0.1956	<10
	Organic parameters			
1	Benzene	Mg/l	-	<0.5
2	Carbon tetrachloride	Mg/l	-	<0.5
3	Chlordane	Mg/l	-	<0.03
4	Chlorobenzene	Mg/l	-	<100
5	Chloroform	Mg/l	-	<6
6	o-cresol	Mg/l	-	<200
7	m-cresol	Mg/l	-	<200
8	p-cresol	Mg/l	-	<200
9	1,4-dichlorobenzene	Mg/l	-	<7.5

10	1,2-dichloroethylene	Mg/l	-	<0.5
11	1,1- dichloroethylene	Mg/l	-	<0.7
12	2,4-dinitrotoulene	Mg/l	-	<0.13
13	Endrin	Mg/l	-	<0.02
14	Heptachlor	Mg/l	-	<0.008
15	Hexachlorobenzene	Mg/l	-	<0.13
16	Hexachloro-1,3-butadiene	Mg/l	-	<0.5
17	Hexachloroethane	Mg/l	-	<3
18	Lindane	Mg/l	-	<0.4
19	Methoxychlor	Mg/l	-	<10
20	Methyl ethyl ketone	Mg/l	-	<200
21	Nitrobenene	Mg/l	-	<2
22	Pentachlorophenol	Mg/l	-	<100
23	Pyridine	Mg/l	-	<5
24	Tetrachloroethylene	Mg/l	-	<0.7
25	Toxaphene	Mg/l	-	<0.5
26	Trichloroethylene	Mg/l	-	<0.5
27	2,4,5-trichlorophenol	Mg/l	-	<400
28	2,4,6- trichlorophenol	Mg/l	-	<2
29	2,4,5-TP(Silvex)	Mg/l	-	<1
30	Vinyl chloride	Mg/l	-	<0.2

Table 4.15 : FINGER-PRINT ANALYSIS

s.no.	parameter	Unit	Result
1	Physical state	-	Solid
2	Color	-	Grey
3	Texture	-	Lumps, Powder
4	Bulk density	g/cm^3	0.745
5	Viscosity in case of liquid sample	-	Not analysed
6	Liquid release test	Pass	Not analysed
7	LOD	%	24.50
8	LOI	%	22.68
9	PFLT	Pass	Pass
10	pH	-	8.8
11	Calorific value	Cal/g	826
12	Flash point	^oC	$>65^oC$
13	Reactive cyanide	Mg/l	Not analysed
14	Reactive sulphide	Mg/l	Not analysed
15	Violent chemical change(in air)	-	Detected
16	Reacts violently with water	-	Not detected
17	Unstable and violent change without detonation	-	Not analysed
18	Generating toxic fumes with water/acid/basic	-	Not detected
19	Explosion when subjected to a strong force	-	Not analysed
20	Explosion at normal temperature and pressure	-	Not detected

Discussion:

The results obtained from the comprehensive and fingerprint analysis of sample D reveals that the physical and chemical characteristics of waste received, conform to the initial sample submitted by the industry for comprehensive analysis. From the result of comprehensive analysis of waste sample D it is observed that the sample is having a very high concentration of nitrates and chlorides as compared to the CPCB limit. In addition to that, loss on ignition is also more than the standard CPCB limit. The nitrate content in the sample is 81.04 mg/l and chloride is 2497.80 mg/l and loss on ignition is 23.01%

All the other parameters are lying with in the standard of CPCB limit. This sample D requires treatment or stabilization (due to the excessive amount of nitrates and chlorides which makes it hazardous)in order to make it non-hazardous form of waste before disposing into the landfill.

TREATMENT :

Sample D : Nitrate =81.0(mg/l) ;Chloride =2497.80(mg/l) ; LOI = 23%

Parameters in sample	Nitrate	Chloride	LOI (%)
	353.64	5523.99	23

Reciepe -1

Lime (%)	Flyash (%)	Cement(%)	Nitrate	Chloride	LOI
5	30	-	31.12	1729.5	19.36

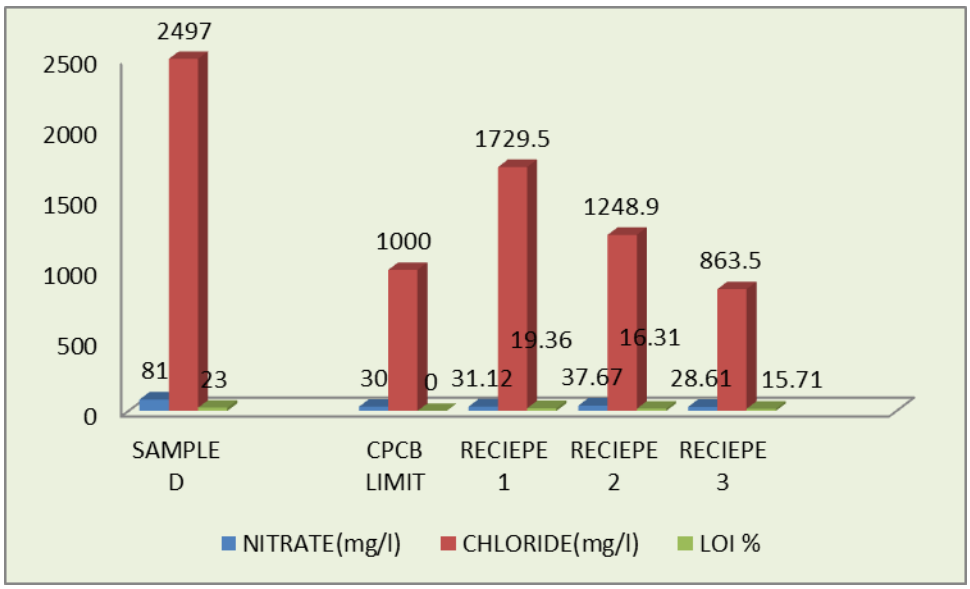
Reciepe -2

Lime (%)	Flyash (%)	Cement(%)	Nitrate	Chloride	LOI
10	20	10	37.67	1248.90	16.31

Reciepe -3

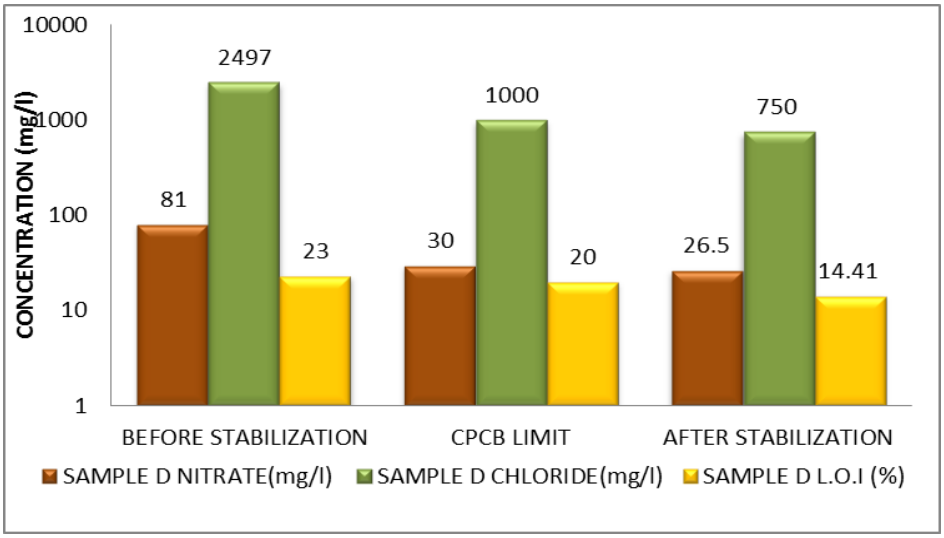
Lime (%)	Flyash (%)	Cement(%)	Nitrate	Chloride	LOI
10	25	15	28.61	863.50	15.71

Reciepe Development was made by the hit and trial method. The above three trials describes that on addition of 30% fly-ash and 5% lime , the concentration of nitrates and chlorides and loss on ignition gets reduced but not below the CPCB limit except loss on ignition. Furthermore addition of 10% cement , 20% fly-ash and 10% lime in the sample E in second trial of reciepe also does not show more effect. Lastly in the third trial, the proportion of 25% addition of flyash ,10% lime and 15% cement binds the nitrate and chloride concentration and reduces below the CPCB limit. The graphical representation of the same is shown below.



DISPOSAL :

After the treatment of waste sample D, the treated sample was checked that whether those parameters now actually lies within the CPCB limit or not. It was observed that after stabilization nitrate and chloride concentration and Loss on ignition all lies within limit and satisfies the direct disposal criteria. The graphical representation of the same is shown below. Finally the waste sample D was transferred from the stabilization pit to the landfill disposal site.



CASE STUDY 5 : SAMPLE E

1) Collection and transportation

Sample E was collected from an industry situated in Mohali and before hazardous sample E was transported to the hazardous waste site, it was packaged in a way that is good for storage and transport and that the labelling was easily visible and packaging was able to withstand physical conditions and climatic factors during transportation. A manifest system was followed by the transporters carrying the waste .Waste is transported to the facility in two ways:

- Transportation of the hazardous waste from the transfer stations.
- Transportation of the waste directly from industries to the facility.

2) Analysis- Comprehensive and Fingerprint Analysis

Table 4.16 : Results of Comprehensive analyis

S.No.	Parameter	Unit	Result	CPCB guidelines
1	Physical state	-	Solid	Solid
2	Color	-	Black	-
3	Texture	-	Lumps, powder	Solid
4	PFLT(paint filter liquid test)	-	Pass	Pass
5	Calorific value	cal/g	**2892**	<2500cal/g
6	Bulk density	g/cm³	0.74	-

7	Flash point	ºC	>65ºC	>65ºC
8	LOD at 105ºC	%	**41.06**	<30
9	LOI at 550 ºC	%	**53.35**	<20
10	pH	-	6.9	>4 to <12
11	Water soluble substance	%	1.72	<10
12	Nitrate	Mg/l	**534.8**	<30
13	Sulfates	Mg/l	297.7	<1000
14	Halides as Cl^-	Mg/l	216	<1000
	Metals			
1	Cadmium as Cd	Mg/l	BDL	<0.2
2	Chromium as Cr	Mg/l	0.0515	<5
3	Copper as Cu	Mg/l	0.0521	<10
4	Lead as Pb	Mg/l	0.021	<2.0
5	Mercury as Hg	Mg/l	-	<0.2
6	Nickel as Ni	Mg/l	BDL	<3.0
7	Chromium vi	Mg/l	-	<0.5
8	Zinc as Zn	Mg/l	0.2543	<10
	Organic parameters			
1	Benzene	Mg/l	-	<0.5
2	Carbon tetrachloride	Mg/l	-	<0.5
3	Chlordane	Mg/l	-	<0.03
4	Chlorobenzene	Mg/l	-	<100
5	Chloroform	Mg/l	-	<6
6	o-cresol	Mg/l	-	<200
7	m-cresol	Mg/l	-	<200
8	p-cresol	Mg/l	-	<200
9	1,4-dichlorobenzene	Mg/l	-	<7.5
10	1,2-dichloroethylene	Mg/l	-	<0.5
11	1,1- dichloroethylene	Mg/l	-	<0.7
12	2,4-dinitrotoulene	Mg/l	-	<0.13
13	Endrin	Mg/l	-	<0.02
14	Heptachlor	Mg/l	-	<0.008
15	Hexachlorobenzene	Mg/l	-	<0.13
16	Hexachloro-1,3-butadiene	Mg/l	-	<0.5
17	Hexachloroethane	Mg/l	-	<3
18	Lindane	Mg/l	-	<0.4
19	Methoxychlor	Mg/l	-	<10
20	Methyl ethyl ketone	Mg/l	-	<200
21	Nitrobenene	Mg/l	-	<2
22	Pentachlorophenol	Mg/l	-	<100
23	Pyridine	Mg/l	-	<5
24	Tetrachloroethylene	Mg/l	-	<0.7
25	Toxaphene	Mg/l	-	<0.5
26	Trichloroethylene	Mg/l	-	<0.5
27	2,4,5-trichlorophenol	Mg/l	-	<400
28	2,4,6- trichlorophenol	Mg/l	-	<2

29	2,4,5-TP(Silvex)	Mg/l	-	<1
30	Vinyl chloride	Mg/l	-	<0.2

Table 4.17 : FINGER-PRINT ANALYSIS

S.No.	Parameter	Unit	Result
1	Physical state	-	Solid
2	Color	-	Black
3	Texture	-	Lumps, Powder
4	Bulk density	g/cm^3	0.76
5	Viscosity in case of liquid sample	-	Not analysed
6	Liquid release test	Pass	Not analysed
7	LOD	%	38.91
8	LOI	%	50.82
9	PFLT	Pass	Pass
10	pH	-	7.0
11	Calorific value	Cal/g	2750
12	Flash point	^oC	>65^oC
13	Reactive cyanide	Mg/l	Not analysed
14	Reactive sulphide	Mg/l	Not analysed
15	Violent chemical change(in air)	-	Detected
16	Reacts violently with water	-	Not detected
17	Unstable and violent change without detonation	-	Not analysed
18	Generating toxic fumes with water/acid/basic	-	Not detected
19	Explosion when subjected to a strong force	-	Not analysed
20	Explosion at normal temperature and pressure	-	Not detected

Discussion:

The results obtained from the Comprehensive and fingerprint analysis of sample E reveals that the physical and chemical characteristics of waste received, conform to the initial sample submitted by the industry for comprehensive analysis. From the result of comprehensive analysis of waste sample E it is observed that the sample is having a very high percentage of loss on ignition as compared to the CPCB limit.

TREATMENT :

This sample E meets the criteria for incineration as it has very high calorific value due to some voltaic organic compounds observed from gas chromatography-mass spectrophotometer. The sample E is sent to incinerator for burning.

CASE STUDY 6 : SAMPLE F

1) Collection and transportation

Sample F was collected from an industry situated in Saidpura and before hazardous sample F was transported to the hazardous waste site, it was packaged in such a way that it is good for storage and transport and that the labelling was easily visible and packaging was able to withstand physical conditions and climatic factors during transportation. A manifest system was followed by the transporters carrying the waste .Waste is transported to the facility in two ways:

- Transportation of the hazardous waste from the transfer stations.
- Transportation of the waste directly from industries to the facility.

2) Analysis- Comprehensive and Fingerprint Analysis

Table 4.18 : Results of comprehensive analysis

S.No.	Parameter	Unit	Result	CPCB guidelines
1	Physical state		Solid	Solid
2	Color		Black	-
3	Texture		Lumps, powder	Solid
4	PFLT(paint filter liquid test)		Pass	Pass
5	Calorific value			<2500cal/g
6	Bulk density		1.19	-
7	Flash point		>65ºC	>65ºC
8	LOD at 105ºC		21.09	<30
9	LOI at 550 ºC		10.43	<20
10	pH		8.6	>4 to <12
11	Water soluble substance		0.315	<10
12	Nitrate		22.19	<30
13	Sulfates		23.22	<1000
14	Halides as Cl^-		48.03	<1000
	Metals			
1	Cadmium as Cd		0.0006	<0.2
2	Chromium as Cr		0.1853	<5
3	Copper as Cu		0.0521	<10
4	Lead as Pb		0.0509	<2.0
5	Mercury as Hg		-	<0.2
6	Nickel as Ni		0.4335	<3.0

7	Chromium vi		-	<0.5
8	Zinc as Zn		0.2543	<10
	Organic parameters			
1	Benzene		-	<0.5
2	Carbon tetrachloride		-	<0.5
3	Chlordane		-	<0.03
4	Chlorobenzene		-	<100
5	Chloroform		-	<6
6	o-cresol		-	<200
7	m-cresol		-	<200
8	p-cresol		-	<200
9	1,4-dichlorobenzene		-	<7.5
10	1,2-dichloroethylene		-	<0.5
11	1,1- dichloroethylene		-	<0.7
12	2,4-dinitrotoulene		-	<0.13
13	Endrin		-	<0.02
14	Heptachlor		-	<0.008
15	Hexachlorobenzene		-	<0.13
16	Hexachloro-1,3-butadiene		-	<0.5
17	Hexachloroethane		-	<3
18	Lindane		-	<0.4
19	Methoxychlor		-	<10
20	Methyl ethyl ketone		-	<200
21	Nitrobenene		-	<2
22	Pentachlorophenol		-	<100
23	Pyridine		-	<5
24	Tetrachloroethylene		-	<0.7
25	Toxaphene		-	<0.5
26	Trichloroethylene		-	<0.5
27	2,4,5-trichlorophenol		-	<400
28	2,4,6- trichlorophenol		-	<2
29	2,4,5-TP(Silvex)		-	<1
30	Vinyl chloride		-	<0.2

Table 4.19 : Finger print analysis

s.no.	Parameter	Unit	Result
1	Physical state	-	Solid
2	Color	-	Black
3	Texture	-	Lumps, Powder
4	Bulk density	g/cm^3	
5	Viscosity in case of liquid sample	-	Not analysed
6	Liquid release test	Pass	Not analysed
7	LOD	%	20.12

8	LOI	%	10.09
9	PFLT	Pass	Pass
10	pH	-	8.5
11	Calorific value	Cal/g	
12	Flash point	^{o}C	>65°C
13	Reactive cyanide	Mg/l	Not analysed
14	Reactive sulphide	Mg/l	Not analysed
15	Violent chemical change(in air)	-	Not detected
16	Reacts violently with water	-	Not detected
17	Unstable and violent change without detonation	-	Not analysed
18	Generating toxic fumes with water/acid/basic	-	Not detected
19	Explosion when subjected to a strong force	-	Not analysed
20	Explosion at normal temperature and pressure	-	Not detected

Discussion:

The results obtained from the comprehensive and fingerprint analysis of sample F reveals that the physical and chemical characteristics of waste received, conform to the initial sample submitted by the industry for comprehensive analysis. On viewing the comprehensive analysis of sample F it is clear that this sample lies under the criteria for direct landfilling as it has no toxic metals , no organic substances and LOD, LOI, pH, calorific value, nitrates, sulfates ,chlorides all lies within the standard CPCB limit for hazardous waste handling and management rules.

Treatment:

This sample does not require treatment or stabilization before disposing to the landfill.

Disposal :

The sample F is directly disposed into the landfill as it meets the direct disposal criteria.

CHAPTER 5

CONCLUSION

The detailed study of facilities such as Infrastructure for receiving and testing facility, waste storage facility, waste treatment facility, disposal facility, leachate collection and treatment system facility and environment monitoring facility were discussed. From the analysis part including both comprehensive and fingerprint analysis, the characterization of waste was determined which shows sample E undergoes treatment method of incineration, sample F does not require any treatment and undergoes direct landfill, sample A, B, C, D undergoes 'landfill after treatment' method. Multiple trials of Reciepe development concludes that sample having high moisture content is well absorbed by adding fly-ash, and cement have tendency to encapsulate and bind the contaminant such as sulfate, chloride, nitrate.

Use of the Personnel protective equipments such as nose mask, hand gloves, covered shoes should be recommended while the analysis work and at the operational area.

In this project work, leachate handling and management is not carried out.

There is a need to work on the design, construction and proper functioning of the multiple effective evaporator for the treatment of leachate so that the treated water can used for other purpose such as irrigation.

Also, one can work on stabilization of one kind of waste with the other kind of waste. For example the waste which requires stabilization and having high moisture content could be treated with waste which require direct landfill.

REFERENCES

Ahmed, F. N., & Lan, C. Q. (2012). Treatment of landfill leachate using membrane bioreactors: A review. *Desalination*, *287*, 41-54.

Batchelor, B. (2006). Overview of waste stabilization with cement. *Waste Management*, *26*(7), 689-698.

Chen, Q., Zhang, L., Ke, Y., Hills, C., & Kang, Y. (2009). Influence of carbonation on the acid neutralization capacity of cements and cement-solidified/stabilized electroplating sludge. *Chemosphere*, *74*(6), 758-764.

CPCB document on 'National Inventory of Hazardous Waste Generating Industries and Hazardous Waste Management in India' as on February 2009.

CPCB Protocol for Performance Evaluation and Monitoring of the Common Hazardous Waste Treatment Storage and Disposal Facilities including Common Hazardous Waste Incinerators, 2010.

Daniel, D. E. (Ed.). (2012). *Geotechnical practice for waste disposal*. Springer Science & Business Media.

Dutta, S. K., Upadhyay, V. P., & Sridharan, U. (2006). Environmental management of industrial hazardous wastes in India. *Journal of Environmental Science and Engineering*, *48*(2), 143.

Kurniawan, T. A., Lo, W. H., & Chan, G. Y. (2006). Physico-chemical treatments for removal of recalcitrant contaminants from landfill leachate.*Journal of hazardous materials*, *129*(1), 80-100.

Khopkar, S. M. (2007). *Environmental pollution monitoring and control*. New Age International.

Lampris, C., Stegemann, J. A., & Cheeseman, C. R. (2009). Solidification/stabilisation of air pollution control residues using Portland cement: Physical properties and chloride leaching. *Waste management*,*29*(3), 1067-1075.

Lehman, J. P. (Ed.). (2013). *Hazardous waste disposal* (Vol. 4). Springer Science & Business Media.

Malviya, R., & Chaudhary, R. (2006). Factors affecting hazardous waste solidification/stabilization: a review. *Journal of Hazardous Materials*, *137*(1), 267-276.

Misra, V., & Pandey, S. D. (2005). Hazardous waste, impact on health and environment for development of better waste management strategies in future in India. *Environment international*, *31*(3), 417-431.

Pichtel, J. (2005). *Waste management practices: municipal, hazardous, and industrial*. CRC Press.

Salihoglu, G., & Pinarli, V. (2008). Steel foundry electric arc furnace dust management: Stabilization by using lime and Portland cement. *Journal of hazardous materials*, *153*(3), 1110-1116.

Shi, C., & Fernandez-Jimenez, A. (2006). Stabilization/solidification of hazardous and radioactive wastes with alkali-activated cements. *Journal of hazardous materials*, *137*(3), 1656-1663.

Sonkamble, S., Sethurama, S., Krishnakumar, K., Dhunde, P., Amarender, B., & Kumar, V. S. (2013). Role of geophysical and hydrogeological techniques in EIA studies to identify TSDF site for industrial waste management. *Journal of the Geological Society of India*, *81*(4), 472-480.

Steven M. Becker, (2008).Environmental health, public safety, and social impacts associated with transportation accidents involving hazardous substances.

Technical EIA Guidance manual for Common Hazardous Waste TSDF , August 2010.

Tang, W. Z. (2016). *Physicochemical treatment of hazardous wastes*. CRC Press.

Wiszniowski, J., Robert, D., Surmacz-Gorska, J., Miksch, K., & Weber, J. V. (2006). Landfill leachate treatment methods: A review. *Environmental Chemistry Letters*, *4*(1), 51-61.

Ziyang, L., Youcai, Z., Tao, Y., Yu, S., Huili, C., Nanwen, Z., & Renhua, H. (2009). Natural attenuation and characterization of contaminants composition in landfill leachate under different disposing ages. *Science of the Total Environment*, *407*(10), 3385-3391.