# Report On
# Co-incineration of Hazardous Waste in Cement Kilns in Central Zone

2010-11

CPCB

Central Zonal Office
Central Pollution Control Board
Bhopal

CPCB

# Report On
# Co-incineration of Hazardous Waste in Cement Kilns in central Zone

| | | |
|---|---|---|
| Principal Coordinator | : | Sh.S. Suresh, Zonal Officer |
| Coordinator | : | Sh. P. Jagan, Scientist 'C' |
| Monitoring Team | : | Sh. P. Jagan, Scientist 'C'<br>Dr.Anoop Chaturvedi, JSA<br>Sh. Sunil Kolhatkar, JLA |
| Type Set By | : | Smt. Farzana Khan, DEO<br>Sh. P. Baghel, Attendant |

# Contents

Central Pollution Control Board
Zonal Office – Bhopal

# Co-incineration of Hazardous Waste in Cement Kilns in central Zone

## Introduction:

Cement manufacturing is energy intensive process with thermal energy contributing to around 30-40% of the cost of cement production. Co-processing of waste materials in properly controlled cement kilns provides energy and materials recovery while cement is being produced and offers an environmentally sound recovery option for many wastes. Co-processing in the cement industry is a sustainable development concept based on the principles of making one industry's waste another's raw material.

The use of alternative materials to replace the traditional raw materials also reduces the exploitation of natural resources and the environmental footprint of such activities. On the other hand there is mounting problem of disposal of hazardous wastes from various industries, many of which have heat value and is presently incinerated in the stand alone incinerator.

The hazardous wastes with heat content can substitute coal which is a major fossil fuel and in turn reducing fuel consumption with added benefit of

environment sustainability through overall reduction of $CO_2$ due to avoidance of incineration. Properly designed and operated cement kilns can provide a practical, cost-effective and environmentally preferred option (in line with the Waste Management Hierarchy) to landfill and incineration, through the co-processing of waste materials.

Keeping all in mind CPCB has taken a initiative for preparation of guidelines and directing industries for co-processing of waste in their kilns. To verify the status of implementation in the jurisdiction, Zonal Office, Bhopal has taken a project in the year 2010-11. In this connection visited the cement plants which are practicing the co-processing in their kiln. The general description of the waste management including, collection, storage, feeding and monitoring details along with the specific unit wise observations are given below.

## Waste Management Hierarchy

1. Wastes can be managed in a number of ways, depending on their physical and chemical nature, and on the economic, social, and environmental context in which they are produced.

2. Specific decisions on waste management will always be influenced by local circumstances such as the availability of waste treatment facilities, alternative markets for materials, and the infrastructure available to safely collect, manage and transport waste materials.

3. The essential process characteristics for the use of waste can be summarised as follows:
    - Maximum temperatures of approximately 2000°C (main firing system, flame temperature) in rotary kilns.
    - Gas retention times of about 8 seconds at temperatures above 1200°C in rotary kilns and more than 2 seconds at temperatures above 850°C in the secondary firing system.
    - Uniform burnout conditions due to the high temperatures at sufficiently long retention times and Oxidizing gas atmosphere in rotary kilns.
    - Complete utilization of fuel ashes and wastes as clinker components and hence, simultaneous material recycling and energy recovery.

4. Sorption of gaseous components like HF, HCl, and SO2 on alkaline reactants.
5. Short retention times of exhaust gases in the temperature range known to lead to formation of PCDDs/PCDFs.
6. Chemical-mineralogical incorporation of non-volatile heavy metals into the clinker matrix.

**Waste materials to be used** : The following waste materials shall be used as alternative fuels :

- Used tires,
- Meat and bone meal, animal fat,
- Plastics,
- Packaging waste,
- Waste wood, impregnated saw dust,

- Paper, cardboard,
- Sludge (paper fiber, sewage)
- Agricultural and organic waste,
- Shale, oil shales,
- Coal slurries, distillation residues,
- Fine/ anodes / chemical cokes,
- Waste oils, oiled water,
- Spent solvents.

**Waste materials not to be used**: The following waste materials shall not be used as alternate fuel or raw material source under any circumstances:

- Nuclear waste,
- Asbestos-containing waste,
- Wastes containing heavy metals including mercury, lead or cadmium
- Electronic scrap
- Explosives,
- Wood treated with copper, chrome, arsenic etc.
- Mineral acids, Infectious medical waste,
- Chemical or biological weapons destined for destruction,
- Entire batteries,
- Unknown or non-specified waste.

## Requirements for co-processing of waste

1. An approved national/local licenses, permits, authorizations and permissions.
2. Suitable location, technical infrastructure, storage and processing equipment.

3. Adequate air pollution control devices and emission monitoring of identified parameters ensuring compliance with regulation and permits.
4. Exit gas conditioning/cooling and low temperatures (< 200°C) in the air pollution control device to prevent dioxin formation.
5. Clear management and organizational structure with unambiguous responsibilities, reporting lines and feedback mechanism.
6. Qualified and skilled employees to manage wastes and health, safety and environmental issues with effective error reporting system.
7. Adequate emergency and safety equipment and procedures, and regular training.
8. Adequate facilities for hazardous waste acceptance and feeding control.
9. Adequate record keeping of wastes and emissions.
10. An environmental management and continuous improvement system certified according to ISO 14001, EMAS or similar internationally accepted standard.
11. Independent audits, emission monitoring and reporting.
12. Stakeholder dialogues with local community and authorities, and mechanisms for responding to comments and complaints.
13. Open disclosure of performance and compliance verification reports on a regular basis.

## Waste Characterization

1. A Waste Analysis Plan (WAP) should be prepared and maintained that should be used to obtain a representative sample of a waste and to conduct a detailed chemical and physical analysis of this representative sample.
2. A WAP should address measures to identify potentially reactive and incompatible wastes.
3. The WAP should comprise testing of a representative sample of waste to verify its constituents for acceptance as alternative fuels and testing of samples taken during or after waste pre-processing or blending to verify the quality of the resultant stream.
4. Failure to adequately screen waste samples prior to acceptance and to confirm its composition on arrival at the installation may lead to subsequent problems, including an inappropriate storage and mixing of incompatible substances, and accumulation of wastes.

## Waste storage and handling

The issues to be focused while storing the waste:

a. Location of storage areas.
b. Storage area infrastructure
c. Condition of tanks, drums, vessels and other containers
d. Stock control.
e. Segregated storage.
f. Site security and
g. Fire risk.

## Design Considerations:

Transfer and storage areas should be designed to control accidental spills. This may require that:

a. Adequately bunded and sealed storage areas, which are impermeable and resistant to the stored materials.
b. All spills should be collected, placed in a suitable container, and stored for disposal in the kiln.
c. All connections between tanks should be capable of being closed via valves, and overflow pipes should be directed to a contained drainage system.
d. Measures to detect leaks and take appropriate corrective action should be provided.
e. Contaminated runoff should be prevented from entering storm drains and water courses.
f. Adequate alarms for abnormal conditions should be provided**.**

## Different Feed point

Different feed points that are used to introduce waste materials into the cement production process are:

- Via the main burner at the rotary kiln outlet end.
- Via a feed chute at the transition chamber at the rotary kiln inlet end (for lump fuel).

- Via secondary burners to the riser duct.
- Via precalciner burners to the precalciner and
- Via a feed chute to the precalciner (for lump fuel).

## Kiln Operation Control

1. The impact of waste materials on the total input of circulating volatile elements such as chlorine, sulphur, or alkalis should be assessed very carefully prior to acceptance, as they may cause operational troubles in a kiln. Specific acceptance criteria for these components should be set by each facility based on the process type and on the specific kiln conditions.
2. The general principles of good operational control of the kiln system using conventional fuels and raw materials should be applied.
3. Waste should never be fed during start-up and shut-down of the kiln, except nonhazardous waste used as alternative fuel and with combustion characteristics comparable to fossil fuel.
4. The mineral content of the waste may change the characteristics of the clinker. The raw mix composition should be adjusted accordingly to stick to the given chemical set points.

## End Product Control

1. As a principle, co-processing should not alter the quality of the cement being produced. Clinker or cement quality should meet specifications of applicable quality standards.

2. Use of wastes in the clinker burning process may change the metal concentrations in cement products.

3. Leaching studies conducted to asses the environmental impacts of heavy metals embedded in concrete revealed that

    a. The leached amounts of all trace elements from monolithic concrete (service life and recycling) are below or close the detection limits of the most sensitive analytical methods

    b. No significant differences in leaching behavior of trace elements have been observed between different types of cements produced with or without alternative fuels and raw materials

## Protocol for Emission Monitoring

1. Periodical monitoring (minimum once per quarter) is appropriate for the following substances:

    - Metals (Hg, Cd, Tl, As, Sb, Pb, Cr, Co, Cu, Mn, Ni, V) and their compounds
    - HCl
    - HF

- $NH_3$
- PCDDs/PCDFs

2. Performance tests should be conducted to demonstrate compliance with the emission limits and performance specifications for continuous monitoring systems, when the kiln operates under normal operating conditions.

3. Measurements of the following may be required under special operating conditions:

- Benzene, toluene and xylene (BTX)
- Polycyclic aromatic hydrocarbons (PAHs) and
- Other organic pollutants (for example, chlorobenzenes, PCBs including coplanar congeners, chloronaphthalenes, etc.)
- In case of disposal of wastes consisting of, containing or contaminated with persistent organic pollutants, the DRE should be determined.

## Status of Cement Plants in Central Zone

| State | Cement Plants | Number of Kilns | Cement Capacity, MTA |
|---|---|---|---|
| Chhattisgarh | 09 | 12 | 11.774 |
| Madhya Pradesh | 10 | 17 | 15.85 |
| Rajasthan | 18 | 23 | 15.49 |
| Central Zone | 37 | 52 | 43.114 |

## Cement Plants in Madhya Pradesh

| Industry | No of Kiln | Cement Capacity, MTA | Clinker Capacity, MTA | Energy Consumed KWH |
|---|---|---|---|---|
| ACC Kymore | 2 | 1.7 | 2.2 | 77 |
| C.C.I.-Nayagaon | 1 | 0.4 | 0.38 | Closed |
| Diamond Cement | 2 | 1.2 | 1.025 | 73 |
| Jaypee Bela | 1 | 1.5 | 1.35 | NA |
| Jaypee Rewa | 2 | 2.5 | 2.25 | NA |
| Maihar Cement | 3 | 2.0 | 1.9 | 32 |
| Prism Cement | 1 | 2.0 | 2.0 | 58 |
| Satna Cement | 1 | 0.75 | 0.72 | 66 |
| Birla Vikas | 1 | 0.8 | 0.8 | 73 |
| Vikram Cement | 3 | 3.0 | 2.95 | 92 |

## Cement Plants in Chhattisgarh

| Industry | No of Kiln | Cement Capacity, MTA | Clinker Capacity, MTA | Energy Consumed KWH |
|---|---|---|---|---|
| ACC Jamual | 3 | 1.584 | 0.761 | 83 |
| Ambuja Eastern | 1 | 1.2 | 1.08 | 87 |
| C.C.I.-Akaltar | 1 | 0.4 | 0.38 | Closed |
| C.C.I.-Mandhar | 1 | 0.4 | 0.38 | Closed |
| Century Cement | 2 | 1.2 | 1.122 | 102 |
| Grasim Cement | 1 | 1.7 | 1.0 | 72 |
| L & T Cement | 1 | 2.75 | 2.23 | 65 |
| Lafarge - Arasmeta | 1 | 2.24 | 1.2 | 63 |
| Lafarge - Sonadih | 1 | 0.3 | 1.0 | 65 |

# Cement Plants in Rajasthan

| Industry | No of Kiln | Cement Capacity, MTA | Clinker Capacity, MTA | Energy Consumed KWH |
|---|---|---|---|---|
| ACC - Lakheri | 1 | 0.4 | 0.36 | 64 |
| Aditya Cement | 1 | 1.5 | 0.95 | 83 |
| Ambuja Rajasthan | 1 | 1.4 | 1.33 | 101 |
| Binani Cement | 1 | 1.65 | 1.485 | NA |
| Birla White Cement | 2 | 0.36 | 0.314 | NA |
| Birla Cements | 2 | 0.6 | 0.6 | 69 |
| Chittor Cements | 1 | 0.5 | 0.5 | 72 |
| JK Cement – NIMB. | 3 | 2.4 | 2.1 | 101 |
| JK Cement – MANG. | 1 | 0.23 | 0.207 | NA |
| JK Udaipur | 2 | 0.8 | 0.8 | 112 |
| JK White Cement | 1 | 0.25 | 0.22 | 71 |
| Jaipur Udyog Ltd. | 1 | NA | NA | NA |
| Lakshmi Cement | 3 | 2.0 | 1.8 | 90 |
| Mangalam Cement | 1 | 0.4 | 0.38 | 95 |
| Neer Cement | 1 | 0.6 | 0.57 | 81 |
| Raj Cement | 1 | 1.2 | 1.2 | 49 |
| Shree Cement | 1 | 1.0 | 0.722 | 54 |
| Shriram Cement | 1 | 0.2 | 0.2 | 58 |

**General Observations:**

1. Most of the units are instructed to co-incinerate the hazardous waste but they are not given permission by SPCBs in spite of repeated meetings/ clarifications and even after obtaining the trial run permission by CPCB.

2. Storage, handling and feeding systems for using the hazardous waste in cement kiln need improvement. Manual handling of hazardous waste was observed in almost all the plants which may cause health problems to workers in future.

3. Taking interstate transportation permission from SPCBs for transporting the hazardous waste from one state to other state is a big challenge for the industry, because there is lack of co-ordination between different SPCBs as a results industry is suffering and finally permission delayed.

4. Non-availability, irregular supply and insufficient quantity of hazardous waste is creating problem for the cement plants for smooth co-incineration of hazardous waste.

5. The industries are not equipped for regular monitoring of environmental parameters as per the protocol given by CPCB, especially for micro pollutants in most of the cement units who were using hazardous waste on regular basis.

6. It was informed that the hazardous waste Treatment, Storage and Disposal Facility operators (TSDFs) operators are not co-operating to the industries for collecting the waste for incineration of hazardous waste in cement kilns. It was informed that they are not allowing lifting and transporting the wastes from the industries.

7. Most of the hazardous wastes are being transported by road only which is highly risk.

8. The hazardous wastes are being transported by unauthorized vehicles due to non-availability of authorized transporters. Moreover the transporters will not agree for transporting small quantity of waste.

9. It was observed that in most of the industries awareness about the safe handling & disposal of hazardous waste to the operator was not founded & found less in most of the industry and some places helpers were not wearing proper protective gadgets during the handling of the waste.

10. Huge quantity of marble slurry has been generated at Makhrana, Rajsamund, kishangarh and Chittorgarh in Rajasthan. Lot of problem is being faced in disposal of waste. M/s ACC Lakheri has been using Makrana Marble slurry in their cement plant. It was informed that due to high magnesia other areas slurry could not be used by them.

11. There are 11 CETPs in Rajasthan facing lot of sludge disposal problems especially Balotra, Bithuja, Jasol, Jodhpur, Bhiwadi and Pali CETPs. Earlier it was proposed that the waste from Pali will be used in M/s Shree cement. Due to transportation, cost feasibility and other technical problems could not be completed. Now study is under progress for using of Acidic waste from CETP Jodhpur with alkaline waste from CETP Bithuja. All the CETPs are provided temporary storage shed for disposal to TSDF Udaipur. The CETPs at Balotra region are connected to newly commissioned TSDF at Pachpadra in Badmer district.

12. Heaps of Jerosite waste has been generated from the Hindustan zinc plants at Chanderia and Debari which was dumped in the premises after converting as Jerofix. As per the officials from HZL, Chanderia (Rajasthan) R&D work is under progress for using as a road filler for national highway project. The industry has also send some quantity of Jerosite slag to M/s Aditya Cement and chittorgarh cement works for exploring the possibility of using in cement kilns. It was informed that due to presence of high silica, cement plants are not coming forward to use the waste in cement kilns.

13. The individual ETP sludges from the textile units at Bhilwara have been using in M/s Aditya Cement, Nimbahera (Rajasthan). The other areas at Pali, Jodhpur and Balotra are

disposing in the low-lying areas and in some units burnt in boilers for steam generation along with lignite.

14. There are four Chlor Alkali units in central zone. All are provided captive SLFs for disposing the mercury bearing Brine Sludge. Except M/s Hukum Chand Jute Mill, Amlai all the units have converted mercury cell to membrane cell technology for manufacturing caustic soda. Now only non-mercury brine sludge is being generated in the plants. The plants have provided separate SLFs for mercury and non-mercury wastes. The officials from the units in the opinion that it is better to dispose the waste to cement plants than maintain of SLFs.

15. It is observed that majority of the cement plants are trying to collect and use the paint sludge only because of its high calorific value. As a result getting paint sludge is very difficult. They are not focusing concentration on the other wastes.

16. Huge quantity of red mud is being generated daily by BALCO, Korba in the aluminum plant. Many R&D works are also conducted for utilizing in other industries. Heaps of waste was stored and frequent breeching of dyke occurred in the past. Moreover it is not covered in the hazardous waste category. The major constituent in it is iron.

17. Spent Pot Lining (SPL) is a waste material of Aluminum smelting industry which is generated from pot room and having a CV in the range of 4000 to 5000 which can be used in cement plant along with coal as a alternative fuel. SPL generated from M/s BALCO, Korba and trail run of co-incineration is concocted by M/s Ultra tech cement Ltd. Raipur. But due to very high bond index it can't be crushed and pulverized easily that is a big problem for using this material as AFR. The plants are not coming forward to use because of its transportation cost and initial capital investment.

18. M/s Satpura thermal power plant is proposing to co incinerate the DM water resins in their power plant boiler for which application submitted.

19. M/s Vikram Cement, Neemuch has already conducted the trial runs for using of tyre chips in their cement kilns. This plant is continuously using the RDF (Reduce derived fuel) in the kilns. The Reduce derived fuel is being brought from Jaipur.

20. M/s Suratgarh super thermal power plant is proposing to co-incinerate the use used oil/waste oil and tank bottom sludge in the power plant boiler for which industry approached to CPCB and RSPCB.

21. CPCB should encourage industries & CETPs for exploring the possibility for using the sludge from CETPs at Balotra,

Bithuja, Jasol, Pali, Jodhpur and Bhiwadi in Rajasthan facing lot of sludge disposal problems especially, and Pali CETPs. Earlier it was proposed that the waste from Pali will be used in M/s Shree cement. Due to transportation, cost feasibility and other technical problems could not be completed. Now study is under progress for using of Acidic waste from CETP Jodhpur with alkaline waste from CETP Bithuja. All the CETPs are provided temporary storage shed for disposal to TSDF Udaipur. The CETPs at Balotra region are connected to newly commissioned TSDF at Pachpadra in Badmer district.

**Recommendations:**

1. SPCBs should give permission to industries as soon as trial run completes without any delay at least for the large & corporate companies for co-incineration of hazardous waste.

**2.** All the units should provide proper Storage facilities and feeding systems for the hazardous waste in the plant and avoid manual handling of hazardous waste.

**3.** Taking interstate transportation permission from SPCBs for transporting the hazardous waste from one state to other state may be made further simpler.

**4.** Awareness should be created among the users for using the different types of wastes to fill up the gap of insufficient

quantity of hazardous wastes where adequate quantity of wastes are not available for smooth co-incineration of hazardous waste.

5. The industries should be equipped for monitoring of environmental parameters as per the protocol during co incineration of hazardous waste.
6. The monitoring results shown in tables were provided by different privet monitoring agencies . However it may be cross check by statutory agency / CPCB.

7. The TSDF operators may be directed for not making any hurdles for collection of the waste by the industries for co-incineration in cement kilns.

8. The hazardous wastes should be transported by the authorized transporters by using closed containers to avoid spillages and the transporters may be directed to transport the waste as and when required by the industries for co-incineration.

9. Awareness should be developed among the workers and operators about the safe handling & disposal of hazardous waste to the operator was not founded & found less in most of the industry and some places helpers were not wearing proper protective gadgets during the handling of the waste.

10. CPCB should encourage industries & CETPs for exploring the possibility for using the CETPs at Balotra, Bithuja, Jasol, Pali, Jodhpur and Bhiwadi in Rajasthan.

11. R&D may be done in Rajasthan in co-ordination with cement plant to explore the possibility for using of Rajsamund, Kishangarh and Chittorgarh marble slurry in cement kilns.

12. The cement plants located at Chittorgarh and Udaipur may be directed to use the jarosite waste in cement kilns and HZL may be asked to dispose the waste as a road filler material for national highway project.

13. Permission for trial run may be granted to thermal power plants for co-incineration in of used oil/ waste oil and tank bottom sludge in boilers.

14. CPCB should develop guidelines for disposing of red mud, jerosite, ISF slag, ferroalloys slag etc.

15. Cement plants should explore the possibility for using the non-mercury bearing brine sludge in cement kilns.

## Results and Discussion:

**M/s ACC Ltd, Jamul:** The Acid Tar Sludge (ATS) is being generated from the coke oven plant of M/s Bhilai Steel Plant (BSP), Bhilai (CG).The ATS waste comes under hazardous waste and classified as categories of 13.3 & 13.4 of schedule I. The waste is having the calorific value of 800-1000 K/cal with moisture content of 25-35% and used as AFR in the cement kiln for co-processing as well as safe disposal of waste. The co-processing trail run was conducted by M/s ACC Ltd. Jamul in July 2010 through M/s SGS, Delhi. The monitoring results submitted by the consultant are summarized and given below at Table-1.

It may be seen from the results that the incremental variation in the emission during co-processing and post co-processing when compared with the pre- co-processing monitoring values. The values are also compared with the CPCB notified norms for incineration of Hazardous waste. The analysis result of the stack emissions revealed that most of the values are well within the standards prescribed by CPCB, but concentration of PM and $NO_x$ were exceeding marginally from standards and there is no change was observed in the concentration of HCl, HF, VOC, PAH, CN and heavy metals. The graphical

representation of concentrations of the PM, NOx, HC and Dioxin & furans are also depicted.

**M/s Lafarge Cement, Sonadhi**: The liquid and solid hazardous waste is generated by the various industrial units in Gujarat has been collected by the TSDF i.e. M/s GEPIL, Surat and transported to M/s Lafarge Cement, Sonadiah for co-incineration as a AFR upto 10% of total coal consumption. The liquid and solid hazardous waste is a mixture of various flammable organic compounds and blended as per the specification of cement plant. Presently the liquid waste used by the industry having the CV of 3000-3500 K/cal with a moisture content of 5-9% and solid waste having the CV of 2800 to 3200 $J/m^3$ with moisture content of 10-15%. The values of the monitored parameters are given below in Table no. 2 (Liquid hazardous waste) and Table no.3 (Solid hazardous waste). The graphical representation of concentrations of the PM, NOx, HC and Dioxin & furans for the both the waste are also depicted.

It may be seen from the monitoring results given at table no. 2 & 3, that there are no significant changes in the emission values epically in metal concentration during the waste incineration. The concentration of PM, $NO_{x,}$ and Dioxin & Furen are found as 51 $Mg/Nm^3$, 260 $Mg/Nm^3$, and 0.005 Ng $TEQ/Nm^3$ against the prescribed limit of 50 $Mg/Nm^3$,400 $Mg/Nm^3$ and 0.01 Ng $TEQ/Nm^3$ respectively.

**M/s Aditya Cement, Shambhupura**: Co-processing in cement kiln perforce provides high temperature and long residence condition during the operation and is an effective technology for the management of hazardous waste in an environmentally safe manner. In the continuation of this M/s Aditya cement, Shambhupura (Raj.) conducted trail of co-processing of ETP sludge receiving from various textile industries located in Bhilwara. During the study it was observed various pollutants such as $SO_2$, $NO_x$, HCI, HF, Hydrocarbons CO, TOC, PAH, VOC etc. when using only traditional fuels such as coal and when using hazardous waste as well are measured.

On the basis of the monitoring report it is clearly indicated that there is no regular trends in the level of the pollutant with 100% coal and is burnt along with the ETP sludge (max.5%.) However the concentration and emission level during the trail run are below the CPCB standard for incineration of hazardous waste in the incinerator.

The values of the monitored parameters are given below in Table no. 4. The graphical representation of concentrations of the PM, NOx, HC and Dioxin & furans were also depicted. It may be seen from the monitoring results given at table no. 4, that there are no significant changes in the emission values epically in metal concentration during the waste incineration. The concentration of PM, $NO_x$, and Dioxin & Furen are found as 46 $Mg/Nm^3$, 198 $Mg/Nm^3$, and 0.002 Ng $TEQ/Nm^3$ against the prescribed limit of 50 $Mg/Nm^3$, 400 $Mg/Nm^3$ and 0.01 Ng $TEQ/Nm^3$ respectively.

# Unit wise Specific Observations

## 1. M/s Lafarge Cement, Bhatapara (CG)

1. M/s Lafarge Cement located at Bhatapara in Chhattisgarh with the capacity of 1.5 MTPA clinker production. This unit is engaged in co-incineration of hazardous waste as AFR.

2. Lafarge India has taken initiative to co incinerate the hazardous waste along with coal in its cement kilns. Accordingly solid and liquid hazardous waste mix from the GEPIL's TSDF at Surat in Gujarat State were prepared according to the pre studied quality specification and a plant scale trial run co-incineration was proposed as per guidelines from CPCB, New Delhi. Trial co-incineration was prepared to be conducted at Sonadih Cement Plant.

3. Liquid as well as solid hazardous waste incineration facility was available in the unit. Hazardous waste received from Gujarat with the contract of GAPIL who is TSDF at Surat where the hazardous waste blended as per the requirement of the unit provide at cement plant. At the time of visit liquid

waste incinerator was not working due to shortage of liquid waste. Only solid hazardous waste was incinerated through feeding side of the kiln.

4. Arrangement required storage of liquid waste storage, transportation and incineration was found very good.

5. Proper safety arrangement regarding fire, accident, spillage and workers safety was done very well. Separate storage facility with CC TV was provided.

6. While approving the trial run co-incineration at Sonadih Cement Plant, CPCB has identified various parameters to be monitored during the co-incineration of the hazardous solid and liquid waste mix. The trial run for co-incineration of the hazardous waste mix has been carried out. Details of the production, process parameters, amount of coal and waste mix co-incinerated during the trial run have been recorded as per the format suggested by CPCB.

7. Apart from the source emission parameters, measurement of ambient air in the up-wind and down wind directions has been carried out. Samples of clinker, coal raw meal and cement were also collected to check the quality.

8. The solid and liquid waste mix were fed separately in pyro-process – liquid waste mix through firing gun in the Kiln

burner while solid waste mix into kiln inlet. Required infrastructure has been created for feeding the liquid and solid waste mix.

9. A feed rate of 1.0 tonne/hour of mixed solid waste and 3.0 kl/hour of mixed liquid waste was targeted. However, the exact feed rate has been monitored on hourly basis and was recorded.

10. Various Plant and process related data have been collected as per the recommendations of CPCB.

**11.** CPCB has set the standards for emissions during the incineration of hazardous waste. The standards are applicable for the emissions from the incinerators where the hazardous waste is incinerated.

12. The particulate emissions were always less than 50 mg/$Nm^3$, Sulphur Dioxide emissions were observed to be less than below detectable limit i.e. 3.2 mg/$Nm^3$, Oxides of Nitrogen emissions, which are much depended on the temperature, were found to be equal or less during the co-incineration period than when coal is used.

13. There is an increase in HF emission during co-incineration period whereas the HCL emissions do not show any particular trend, No volatile organics were generated during the entire trial period, Poly aromatic hydrocarbons showed a decreasing

trend whereas Total Organics have slightly increased during the co-incineration period and Dioxins & Furans were less than 0.094 ng TEQ /$Nm^3$ all the times; and Mercury was not detected during the entire trial run period whereas Cadmium and Thallium were found to be less than 0.04 mg/$Nm^3$. All other heavy metals were found to be are found to be less than 0.38 mg/Nm3

14. As the Mass balance was found to be between 0.7-1.3 as per procedure, the range of closure was in agreement with the inflow and outflow of the metals concerned.

15. In view of the above percepts and studies, it can be concluded that the impacts of using hazardous waste mix along with coal, to the extent of quantity mentioned above, are negligible. The overall impact of the hazardous waste on the environment is beneficial in terms of the disposal, air impacts and conservation of fossil fuels.

**Table 2: Kiln stack emission monitoring results of M/s Lafarge Cement Ltd. (CG)**

| S.No | Parameter as per Protocol | Unit of result | Pre co incineration | During co incineration | Post co incineration | |
|---|---|---|---|---|---|---|
| 01 | PM | Mg/$Nm^3$ | 35 | 51 | 44 | |
| 02 | $SO_2$ | Mg/$Nm^3$ | ND | ND | ND | |
| 03 | HCl | Mg/$Nm^3$ | ND | ND | ND | |
| 04 | CO | Mg/$Nm^3$ | 2400 | 3690 | 1890 | |
| 05 | $NO_x$ | Mg/$Nm^3$ | 268 | 260 | 187 | |
| 06 | TOC | Mg/$Nm^3$ | -- | -- | -- | |
| 07 | HF | Mg/$Nm^3$ | ND | ND | ND | |
| 08 | Hydrocarbon | Mg/$Nm^3$ | 7.32 | 9.19 | 6.81 | |
| 09 | VOC | Ug//$Nm^3$ | 2.93 | 2.68 | 2.57 | |
| 10 | PAH | Mg/$Nm^3$ | ND | ND | ND | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 11 | Dioxin and Furen | Ng TEQ/$Nm^3$ | 0.004 | 0.005 | 0.003 | |
| 12 | CN | $Mg/Nm^3$ | ND | ND | ND | |
| 13 | Hg | $Mg/Nm^3$ | ND | ND | ND | |
| 14 | Cd | $Mg/Nm^3$ | - | - | - | |
| 15 | Pb | $Mg/Nm^3$ | ND | ND | ND | |

**Table 3 : Kiln stack emission monitoring results of M/s Lafarge Cement Ltd. (CG)**

| S.No | Parameter as per Protocol | Unit of result | Pre co incineration | During co incineration | Post co incineration |
|---|---|---|---|---|---|
| 01 | PM | $Mg/Nm^3$ | 50 | 31 | 36 |
| 02 | $SO_2$ | $Mg/Nm^3$ | ND | ND | ND |
| 03 | HCl | $Mg/Nm^3$ | ND | ND | ND |
| 04 | CO | $Mg/Nm^3$ | 3700 | 4680 | 2650 |
| 05 | $NO_x$ | $Mg/Nm^3$ | 330 | 328 | 326 |
| 06 | TOC | $Mg/Nm^3$ | -- | -- | -- |
| 07 | HF | $Mg/Nm^3$ | ND | ND | ND |
| 08 | Hydrocarbon | $Mg/Nm^3$ | -- | -- | -- |
| 09 | VOC | $Ug//Nm^3$ | 3.19 | 2.76 | 2.39 |
| 10 | PAH | $Mg/Nm^3$ | ND | ND | ND |
| 11 | Dioxin and Furen | Ng TEQ/$Nm^3$ | 0.003 | 0.003 | ND |
| 12 | CN | $Mg/Nm^3$ | ND | ND | ND |
| 13 | Hg | $Mg/Nm^3$ | ND | ND | ND |
| 14 | Cd | $Mg/Nm^3$ | - | - | - |
| 15 | Pb | $Mg/Nm^3$ | ND | ND | ND |

## 16. M/s Ambuja Cement, Rawan (CG)

1. M/s Ambuja Cements Limited is located at Bhatapara village, Baloda Bazar, Tehsil in Chhattisgarh state. The industry was commissioned in 1987 and the present capacity is 1.8 MTPA cement and 15 MW Power. After taking over by M/s Holcim, a lot of improvement was seen in the plant.

2. The industry has valid consents under Air and Water Acts. In the consent, Particulate Matter emission limit has been given

as 50 mg/$Nm^3$ by CECB for all stacks, except crusher stack 100 mg/$Nm^3$. As per the consent, the capacity of the plant is 1.8Million TPA cement and 15MW power. Industry has already obtained environmental clearance for expansion for 2.72 TPA cement and 25 MW power from MoEF. During visit, construction work of new plants was under progress.

3. M/s Ambuja Cement was recently started the co-incineration of hazardous waste with solid waste procured from M/s PTA, Haldia (West Bengal). During the trial run M/s Vimta Lab monitored the required Air pollutant parameter. SPCB permitted co-incineration of hazardous waste in kiln no. 2.

4. Industry is procuring hazardous waste (PT sludge) from Haldia (West Bengal). The CV of sludge was 800Kcal/J. Presently unit got permission to use sludge approximately 20T/day after successful complication of trial run it may increase up to 5 % of coal consumption.

5. Solid hazardous waste was stored properly at isolated location and covered with plastic sheet. Manifest maintained properly.

6. At the time of co-incineration of hazardous waste M/s Vimta Lab, Haldia monitored the required parameters as given in guidelines of hazardous waste incineration. Continue monitoring of Dioxin & Furan, primary pollutant of Air and other relevant parameter were also monitored.

7. Material was incinerated in the kiln from feed side and arrangement of waste feeding in semiautomatic type and manual handling was also observed during loading and unloading of hazardous waste.

8. As informed, industry has written a letter to CECB for burning the used oil in kiln. Also used oil from the vehicles in the mines after mixing with ammonium nitrate for using in the mine blasting. Industry has submitted the Form 4 to CECB. It has also maintained hazardous waste manifest records.

| **Category** | **Quantity of waste** | | **Disposal** |
|---|---|---|---|
| | **As per the authorization** | **Actual in 2007** | |
| 5.1 | 18.4KLA | 0.210 KL | Sold to registered recyclers |
| 5.2 | 198 TPA | 94.08 MT | |
| 26.2 | 9174MTA | 2249MTA | Chemical gypsum is used for making cement. |

9. Provided hazardous waste display board at main gate and at storage site. The waste oil and furnace oil sludge has been stored in filled drums and kept under shed and pucca platform at the storage site. During visit, no waste was found stored. About 7.4MT sold to M/s Supreme Petro Synthesis, Bhilai, who was a valid hazardous waste recycler.

10. The fly ash from the 15MW CPP was being transferred pneumatically to two 180T capacity silos for captive use in cement plants. In addition to this, fly ash was also being brought from Korba for using in cement plant. As informed, industry is proposing to use SPL from M/s BALCO, Korba in cement kiln. In this connection, a letter has already been written to CECB for permission.

11. Gypsum was stored under the covered shed and lime stone stacking was being done openly. Coal has been stored in the dome and shed. Open storage of coal was not observed. As informed, the industry has reduced the use of chemical gypsum by replacing it with mineral gypsum. As per the records, the industry consumed 2249 MT of chemical gypsum in 2010.

12. Industry has installed meteorological station for measuring the wind speed, wind direction and temperature. Ambient Air Quality monitored at four locations during the monitoring.

13. Opacity meters (Baltech Ltd and BHA Ltd) were installed at kiln & raw mill, cooler, coal mill and captive thermal power plant. Records are being maintained related to opacity meter readings. As informed, the calibrations of opacity meters are being done by the industry once in a month.

14. The industry has set-up separate environmental cell consisting of full time environmental engineer and monitoring team. Also laboratory facilities for monitoring of routine noise levels, air and water quality parameters developed. Ground water quality is monitored through M/s Bhagawati Anna Lab, Raipur in the villages around the plant once in six months, ambient air quality monitored at five locations weekly twice for 24 hours by the industry in and outside the plant and soil quality has been monitored once in a year through Shri Ravi Shankar university, Raipur around the industry. Ambient noise levels monitored at seven locations in the plant, Source emissions, wastewater from STP & mine discharge and fugitive emissions were being monitored once in a month. The monthly monitoring reports are being submitted to CECB and quarterly report to CPCB.

15. No effluent has been discharged from the plant premises. The treated effluent from Sewage Treatment Plant is fully used for gardening purpose in the colony. No industrial effluent is generated from the process. The industry has provided a sewage treatment plant of 500$m^3$/day capacity for treating the domestic waste from the colony.

16. The industry has two-coal crushers of 100 TPD capacities each (primary and secondary) for crushing the coal to use in the kilns as well as captive thermal power plant. Both the crushers

were connected to de-dusting system, in addition to the water spray to control the fugitive emission.

17. The industry has 420 ha area for mining of lime stone and 600TPD crusher at mines. De-dusting system and water spray system has been provided to control dust at crusher. The industry has 6 lakh $m^3$ capacity mine reservoir to cater water requirement. Grass developed on the coir bed provided on overburden of mines for maintaining the slope & stability and to prevent soil erosion.

**M/s ACC Cement, Jamul (CG)**

1. M/s ACC, Jamul cement works (JCW) plant has been taken over by Holcim in 2005. The plant has three kilns in which kiln I and II are semi dry process technology and kiln III is dry process. All the three kilns are being used for making of Portland slag cement only. The details of the units and its capacities with the pollution control devices installed are given in table1. As informed, semi dry process will be phased out by 2010 and also proposed to construct clinker silo, cement silo and coal dome along with the new kilns for which EIA presentation has already been done on 20.03.2009 at MoEF, Delhi for expansion of the plant.

2. The consents under Air and Water Acts are valid. In that consents, Particulate Matter emission limit was given as 50 mg/$Nm^3$ by CECB for all stacks. As per the consent, the capacity of the plant is 15.8 LTPA Portland slag cement and 25MW power. During visit, dismantling work of the raw mill silos was under progress.

3. M/s ACC Cement, Jamul has been completed the trail run of hazardous waste with different hazardous waste and submitted the report to CPCB through SPCB. As the report submitted by the unit for co-incineration there is no abnormal value was observed during the trial run.

4. Hazardous waste was procured from M/s Bhilai Steel Plant which is generated in the coke oven plant and the Calorific value of hazardous waste is very less and moisture content was also very high.

5. Storage arrangement of liquid hazardous waste was made by the unit near the kiln from where liquid hazardous waste feed in the kiln through pumping. Separate storage tank with the capacity of 20 MT was available with spillage collection system.

| Waste type | Category | Quantity in TPA | Disposal method |
|---|---|---|---|
| Used oil/grease | 5.1 | 400 | Used oil/grease and transformer oil is generated in the plant and being sold to authorized recyclers |
| Transformer oil | 5.2 | 600 | |
| Acid tar sludge | 13.3 | 2000 | The acid tar sludge and decanter sludge will be used in the kilns. |
| Decanter sludge | 13.4 | 3500 | |

6. Used oil is being sold to an authorized recycler registered with CPCB. Used oil is stored in MS drums and drums are kept in closed room under lock and key. As per the authorization the following waste generated in the plant.

7. 50% of the granulated slag is being used for cement manufacturing which is a waste material generated from BSP. As informed about

25 million tonnes of waste slag from BSP has been utilized till now. Granulated slag drier APCDs appears insufficient as a result lot of emission was observed during visit. Monitoring could not be done due to improper location of porthole and no monitoring platform was provided.

8. The industry has 25 MW coal based captive power plant for power generation. Fly-ash was not being used in cement plants because in PPC 50 % slag is being used. Therefore, all the 205 MTD of fly-ash has been given to brick manufacturing units.

9. As informed, ACC has constituted a separate department named AFR "Alternate Fuels & Raw Material" at HO as well as at unit level also. This section is working for generating the possibilities of use of Hazardous waste disposed by other industries in their Cement units. These wastes are co- incinerated in cement Kiln as fuel or raw material. At JCW initiatives has already been taken towards co processing of hazardous waste like Acid Tar sludge generated form BSP and Spent pot liner from BALCO, Korba in the Kiln. Contract for co-processing of Acid Tar Sludge with BSP is at the final stage. Authorization under HWMH Rule 2003 amended in 2008 from CECB regarding use of Hazardous waste has been obtained. JCW is also in discussion with CECB to provide a disposal option for plastic waste through co-incineration in the Kilns.

10. Hazardous waste display board has been provided at the main gate. As per the records the industry is maintaining the Hazardous waste manifest and submitting the annual report to CECB. About 5 KL of

waste oil/used oil was stored in drums and kept openly without any proper display. As informed, the authorization and storage was common for mines and the plant.

11. Water spray system was not provided at raw material storage and handling areas as a result lot of fugitive emissions were observed at Slag lumps separation area near drier stack, kiln no.2 feeding point gland leakage, near slag drier duct exit, coal mill solenoid valve leakage, clinker cooler mechanical transfer point, spillages from the cement mill in the ground floor.

12. The limestone, slag and gypsum were filled in hoppers by using crane in the raw material gantry yard, which was generating lot of fugitive emission. The industry has not provided silos for clinker and slag storage purpose, however six nos.of old RCC silos for storing the raw mill feed were under dismantling during visit. Coal and gypsum were stored partly open and partly under the shed.

13. Two nos. of Durag and Mipoy Finland make opacity meters were installed at Kiln 3, Captive Power Plant (boiler-I and II) ESPs. The industry has no laboratory and manpower for routine monitoring and analysis of consent parameters. Only one stack monitoring kit and two HVS are available with the industry.

14. Safety goggle, helmet, safety shoes, earplugs and gloves were provided to the employees. During visit, lot of noise was observed at the cement mill. The House keeping is poor in cement mill, raw material gantry and flyash silo areas.

15. The industry is storing the rainwater in two no of inactive mine pits at Jamul limestone mines with the capacity of 12 lakh $M^3$ each. Ground water is not being used. Only harvested water is used for Cement plant, CPP and domestic purpose for the whole year. No wastewater has been generated in the process, 100% recycled in the plant process. Only evaporation losses occur. Treated domestic wastewater is being used for the green belt development. Cooling towers and R.O. plant has been provided for treating the process and captive power plant wastewater. Facultative stabilization pond for treatment of domestic wastewater.

16. The unit has conducted the trail run during co-processing of the TAR waste during July 2010 and the results are given below:

**Table 1: Kiln stack emission monitoring results of M/s ACC, Jamul (Chhattisgarh)**

| S.No | Parameter as per Protocol | Unit of result | Pre co incineration | During co incineration | Post co incineration |
|---|---|---|---|---|---|
| 01 | PM | $Mg/Nm^3$ | 68 | 71 | 57 |
| 02 | $SO_2$ | $Mg/Nm^3$ | 55 | 190 | 16 |
| 03 | HCl | $Mg/Nm^3$ | ND | ND | ND |
| 04 | CO | $Mg/Nm^3$ | 1400 | 1350 | 1276 |
| 05 | $NO_x$ | $Mg/Nm^3$ | 261 | 496 | 417 |
| 06 | TOC | $Mg/Nm^3$ | 4.38 | 3.92 | 4.90 |
| 07 | HF | $Mg/Nm^3$ | ND | ND | ND |
| 08 | Hydrocarbon | $Mg/Nm^3$ | 8.44 | 2.85 | 21.78 |
| 09 | VOC | $Ug//Nm^3$ | ND | ND | ND |
| 10 | PAH | $Mg/Nm^3$ | ND | ND | ND |
| 11 | Dioxin & Furan | Ng $TEQ/Nm^3$ | 0.002 | 0.005 | 0.003 |
| 12 | CN | $Mg/Nm^3$ | ND | ND | ND |
| 13 | Hg | $Mg/Nm^3$ | ND | ND | ND |
| 14 | Cd | $Mg/Nm^3$ | - | - | - |
| 15 | Pb | $Mg/Nm^3$ | ND | ND | ND |

## M/s Ultratech, Hirmi (CG)

1. This plant using SPL as hazardous waste in cement kiln.

2. Due to very hard material, the crushing of SPL is a very big problem. The bond index of lime stone is 13-15 and bond index of SPL is around 40-45 due to this lime crusher also not able to crush the material for further processing.

3. Continue availability of raw material is also an issue.

4. Ultratech Cement procured 50MT SPL from M/s BALCO for trial run and trial run of co-processing is still not completed.

5. Calorific value of this SPL is around 8000 kcal/J and main Hazardous substance in SPL is Cyanide and Fluoride.

6. SPL is waste material of Al-smelting industry and generated dery changing of cathode.

7. Presently SPL was stored in the coal yard and covered with HDPE sheet and area was also earmarked with caution ribbon.

**M/s Aditya Cement, Chittorgarh (Rajasthan)**

1. The industry has two kilns with Line-I: 5500TPD and Line-II: 8000TPD clinker production capacities. During the inspection, Line II was under shutdown since 06.08.2009 due to annual maintenance and was expected to restart from the second week of September 2009. The newly constructed cement mill-III, raw mill-III was under commissioning stage.

2. The industry is transporting the raw materials though rail and road from various places i.e. Red ochor from Sawa village, lime stone from own captive mine, which is located 2.5 km away from the plant, laterite from Sadhabi village near Nimbahera, coal from SECL, Korba and pet coke from Reliance Refinery at Hazira, mineral gypsum from Nagaur and chemical gypsum from own group plants.

3. All the raw materials are stored in respective sheds constructed for the purpose. Part quantity of coal, lime stone, additives etc. are stored openly with a tarpaulin cover. It was informed, that in rainy season the unit maintains at least one month inventory.

4. The conveyor belts were covered, the transfer points are connected with suction & bag filters, water spray system provided in all the material handling areas and at transfer points for controlling the fugitive emissions. The industry has three road sweeping machines, whereas two machines were found in operation at the time of

inspection. The house keeping at the raw material handling area, fly ash and gypsum storage areas was poor.

5. The industry has 73MW (2x25 MW & 1x23 MW) AFBC captive power plants with five field ESPs for controlling the air pollution. During the visit, TPP-I was being operated at 19MW load and the opacity meter reading was 42 mg/$Nm^3$. About 200 tonnes per day fly ash has been generating in TPP-I. 2x140 tonnes capacity silos were constructed for storing the ash for use in the cement mills.

6. The industry has provided the hazardous waste display board at the main gate and at the storage site. The waste oil and used oil from the plant and mines was stored commonly. At the time of inspection about 18 KL used oil was stored in drums and was kept under shed. It was informed that used oil was sold to M/s Bharat Oil, Jaipur, an authorized hazardous waste recycler. Hazardous waste manifest has been maintained. The used batteries are taken back by the dealer, while supplying the fresh batteries.

7. The ambient air quality was being monitored at four locations once in a week along the plant boundary and stack emissions from ten major stacks are monitored once in a month by the industry. The new laboratory was under commissioning stage. The unit has three HVSs, seven RDSs, four SMKs, one gas analyser and other related instruments for monitoring of air quality. Wastewater monitoring and analysis instruments were not available. The industry has full time environmental chemist and other supporting staff for

monitoring. Ambient air quality is also monitored at five locations in the limestone mines area.

8. All the major roads were paved in the plant, except some roads at the raw material storage area. Industry has provided two tankers for the plant and two for mines for water spray on the roads to suppress the dust due to vehicular movement. It has purchased one TPS vehicle, which can suck and clean the spillages under the tunnels, inside silos, below the conveyor belts etc.

9. As informed, the industry was consuming 7 KLD water from mines and 8 KLD from ground water source in the plant for cooling purpose and other uses. About 15 lakh KLD water has been stored in mine reservoir for using in the plant. Rain water harvesting system was adopted at the mines area and in the plant premises.

10. 500 KLD STP consisting of equalization, aeration & settling tank and sludge drying beds was in operation for treating the wastewater from the residential colony. The treated effluent was being reused 100% for gardening purpose.

11. The industry has captive lime stone mines spread over 74 hectare area with an annual production of 6.6 million tonnes. The industry has provided two lime stone crushers of 800 TPH and 1600 TPH capacity. Both were provided separate bag filters and 30m high stack and interlocked the crushers with bag filter.

12. The industry has installed online $NO_2$ and $SO_2$ analyzer in kilns and installed opacity meters in all the main stacks, except in cement mill-II. The opacity meters are supplied by Baltec system, Pune. Calibration has been done by instrumentation department on monthly basis.

| Cat. | Quantity of waste | | Disposal |
|---|---|---|---|
| | Type of waste | As per authorization | |
| 5.1 | Used oil /spent oil | 1,200 KLA | Sold to registered recyclers |
| 24.2 | ETP Sludge from textile units | 18,000 MTA | Reused as raw material in cement kiln |
| 34.4 | Chemical sludge from breweries | 3,600 MTA | |

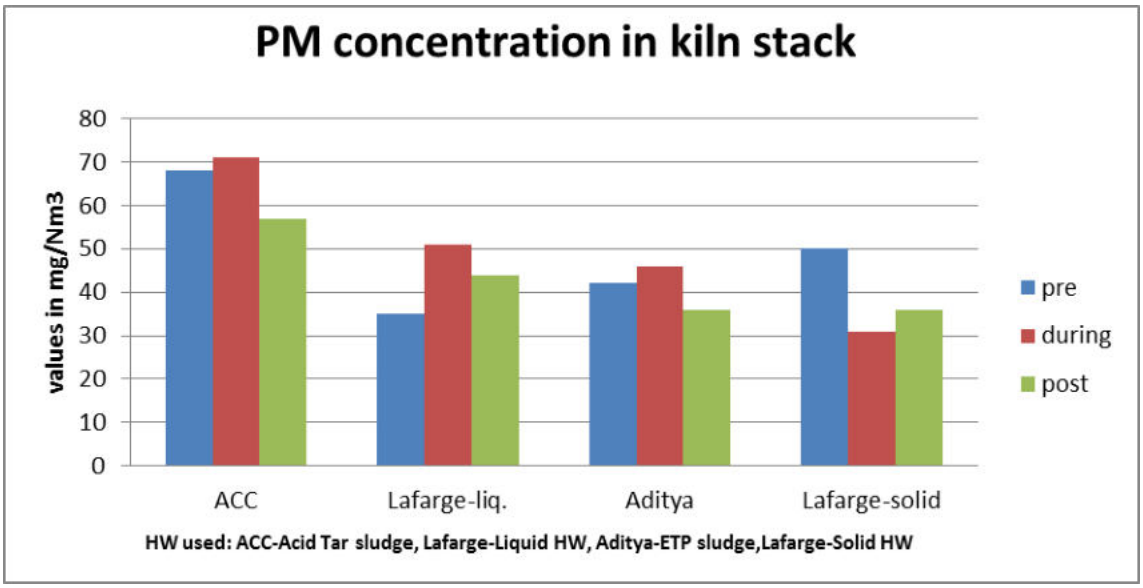
13. No treatment facility exists. A temporary storage facility is provided in covered shed with concrete floor & pit for oil spillages collection. Partly sold to authorized recyclers and reused in process equipment for lubrication etc. Last time sold to M/s Bharat oil, Jaipur on 3.3.2009.as per the authorization the following wastes are generated by the industry

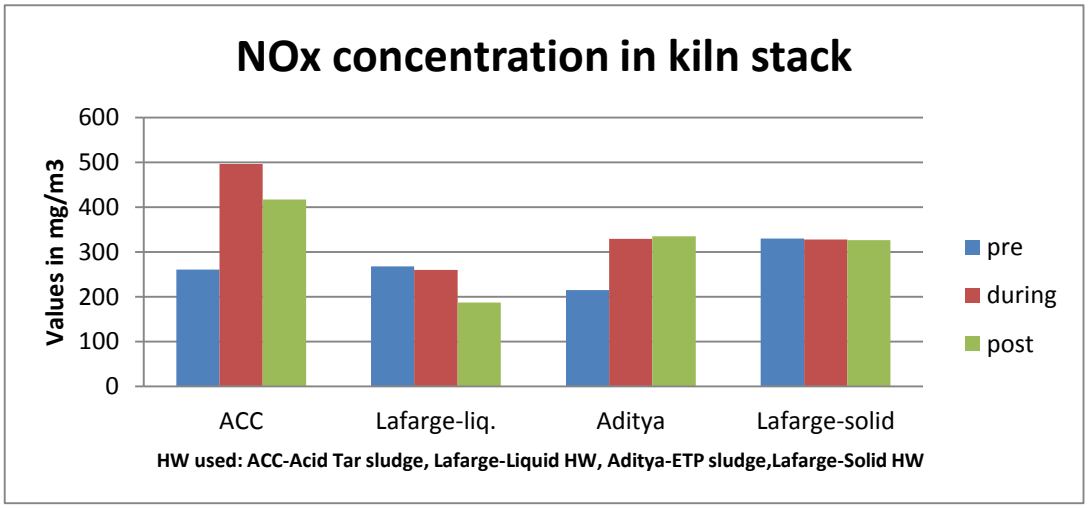
14. The unit has been co-incinerating ETP sludge of about 1000 tonnes per month from textile mills from Bhilwara Industrial Area in the cement kilns. At the time of inspection 8,000 tonnes of waste was stored in the shed constructed for the purpose. Agro waste i.e.

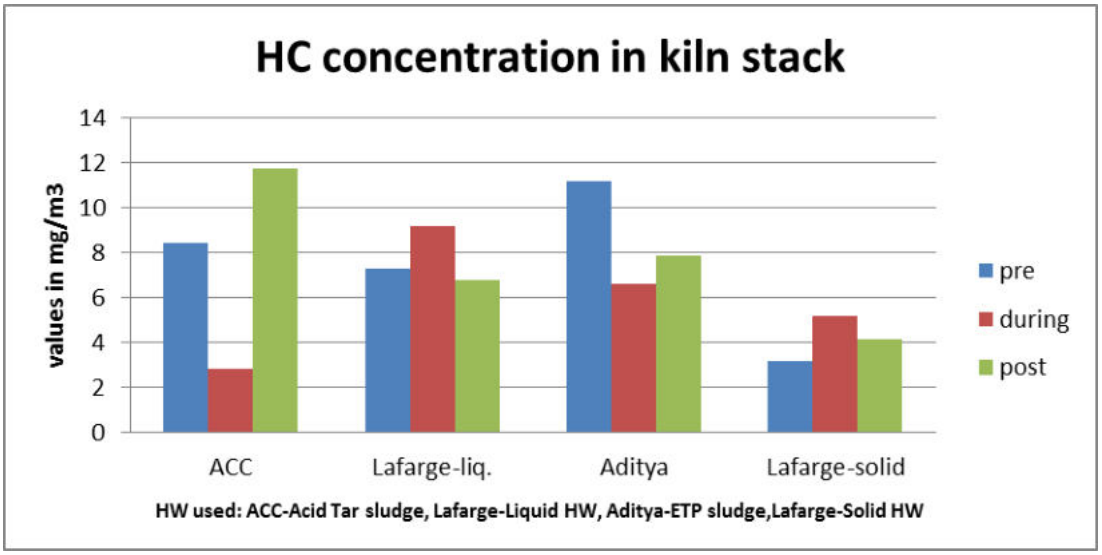
Soya husk, ground nut sells etc. was also found stored for use in kilns. As informed by Shri D.G. Maheswari, the unit had proposing to co-incinerate Jarosite waste from M/s HZL, Chanderia in the kilns.

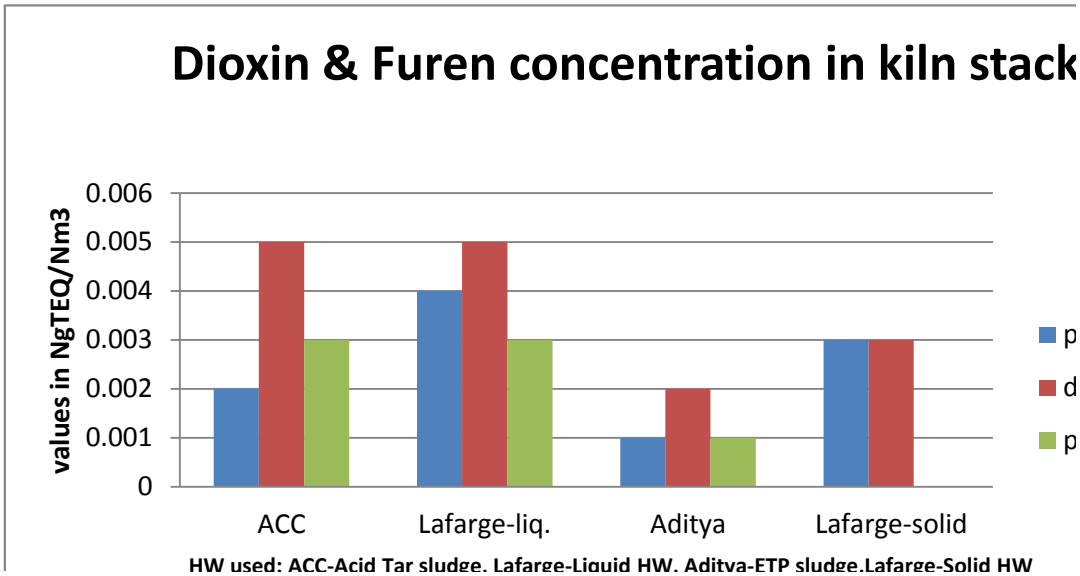
**Table 4 : Kiln stack emission monitoring results of M/s Aditya cement Ltd. (Raj.)**

| S.No | Parameter as per Protocol | Unit of result | Pre co incineration | During co incineration | Post co incineration |
|---|---|---|---|---|---|
| 01 | PM | $Mg/Nm^3$ | 42 | 46 | 36 |
| 02 | $SO_2$ | $Mg/Nm^3$ | <3 | <3 | <3 |
| 03 | HCl | $Mg/Nm^3$ | 12 | 15 | 12 |
| 04 | CO | $Mg/Nm^3$ | 198 | 190 | 183 |
| 05 | $NO_x$ | $Mg/Nm^3$ | 215 | 329 | 335 |
| 06 | TOC | $Mg/Nm^3$ | ND | ND | ND |
| 07 | HF | $Mg/Nm^3$ | 1.47 | 1.07 | 0.92 |
| 08 | Hydrocarbon | $Mg/Nm^3$ | 11.2 | 6.6 | 7.9 |
| 09 | VOC | $Ug//Nm^3$ | ND | ND | ND |
| 10 | PAH | $Mg/Nm^3$ | ND | ND | ND |
| 11 | Dioxin and Furen | Ng $TEQ/Nm^3$ | 0.001 | 0.002 | 0.001 |
| 12 | CN | $Mg/Nm^3$ | ND | ND | ND |
| 13 | Hg | $Mg/Nm^3$ | ND | ND | ND |
| 14 | Cd | $Mg/Nm^3$ | ND | ND | ND |
| 15 | Pb | $Mg/Nm^3$ | ND | ND | ND |


PM concentration in kiln stack
values in mg/Nm3
80
70
60
50
40
30
20
10
0
ACC
Lafarge-liq.
Aditya
Lafarge-solid
pre
during
post
HW used: ACC-Acid Tar sludge, Lafarge-Liquid HW, Aditya-ETP sludge,Lafarge-Solid HW


NOx concentration in kiln stack
Values in mg/m3
600
500
400
300
200
100
0
ACC
Lafarge-liq.
Aditya
Lafarge-solid
pre
during
post
HW used: ACC-Acid Tar sludge, Lafarge-Liquid HW, Aditya-ETP sludge,Lafarge-Solid HW


HC concentration in kiln stack
values in mg/m3
14
12
10
8
6
4
2
0
ACC
Lafarge-liq.
Aditya
Lafarge-solid
pre
during
post
HW used: ACC-Acid Tar sludge, Lafarge-Liquid HW, Aditya-ETP sludge,Lafarge-Solid HW

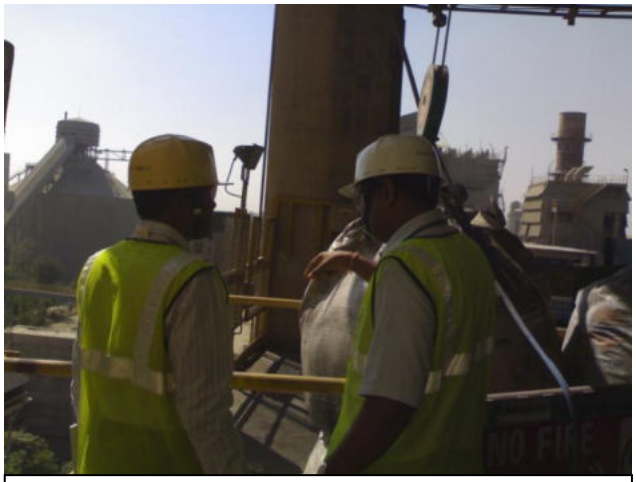

Dioxin & Furen concentration in kiln stack
values in NgTEQ/Nm3
0.006
0.005
0.004
0.003
0.002
0.001
0
ACC
Lafarge-liq.
Aditya
Lafarge-solid
p
d
p
HW used: ACC-Acid Tar sludge, Lafarge-Liquid HW, Aditya-ETP sludge,Lafarge-Solid HW

# HW co-incineration at M/s Lafarge cement

Stack emission monitoring

Stack emission monitoring

HW stored in the HDPE bags



Chain & pulley system for lifting the waste

Waste feeding point

Waste belt conveyor

## HW co-incineration at M/s Lafarge cement

Measuring of temperature & velocity of the

HW display Board at main gate

HW stored openly in HDPE bags

Waste ready for lifting for co-incineration

HW stored openly in HDPE bags

Stack monitoring during co-incineration

# HW Co-incineration at M/s Ambuja Cement, Bhatapara

Stack emission monitoring during co-incineration

Stack emission monitoring during co-incineration

AAQ monitoring during co-incineration


CAAQMS at Ambuja Cement


SPL storage shed

HW stored unscientifically


SPL and coal stored in one shed

Tarpaulin sheet covered on the SPL

## HW Co-incineration at M/s ACC, Jamul

HW pumping system


HW storage before co-incineration


HW co-incineration