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Environmental Impact Assessment of ICI Glycol Waste Incineration in Gharibwal Cement Limited

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1. Introduction

Environment Assessment Services (EAS) of IUCN - Pakistan carried out an Environmental Impact Assessment (EIA) of ICI's glycol waste incineration in Gharibwal Cement Limited (GCL). This EIA was carried out in April 1997. An EIA report was required by the Punjab Environment Protection Department (PEPD) to assess any potential damage to human health and the environment, and the mitigation options for minimizing or avoiding the damage. This paper will cover: the EIA background i.e why the EIA was required? why did ICI opt for this option? what makes this EIA so unique? what are the advantages and disadvantages of using this process? what are the possible impacts of this activity on human health and the environment; key findings of the EIA; the mitigation options for minimizing or avoiding the damage; and its importance to the environmental movement in Pakistan.

2. Background

ICI Polyester plant in Sheikhupura, Punjab, produces glycol waste which because of it's high concentrations of antimony qualifies for a hazardous waste. After the Sindh Environmental Protection Agency (SEPA) imposed a ban on deep sea dumping of glycol waste in 1994, ICI explored other options and opted for incineration in a cement kiln. At the height of controversy, IUCN played the role of a conflict resolver between SEPA and ICI. On IUCN's suggestion ICI used Fuller's Earth in each of it's Glycol waste storage drums as a temporary solution instead of dumping in the deep sea. ICI approached IUCN and asked it to conduct the EIA because of it's previous involvement and it's competency in carrying out EIAs of such issues.

3. Why the EIA was required?

The EIA was required by the PEPD for two main reasons:

1. The Pakistan Environmental Protection Act (PEPA) of 1997 and Pakistan Environmental Protection Ordinance of 1983, makes it mandatory for all the public sector and private sector projects (includes activity, plan, scheme, proposal or undertaking involving any change in the environment ...) that may have adverse environmental impacts to have an EIA carried out; and

2. Glycol waste is hazardous in nature because of high concentrations of Antimony Cadmium, and it's burning may emit pollutants which may be hazardous to the surrounding population, vegetation and livestock, and may be in violation of the National Environment Quality Standards (NEQS).

Based on the above two reasons PEPD directed ICI to have an EIA carried out of the activity.

4. What makes this EIA unique?

EIA's in Pakistan have generally been carried out of developmental and industrial projects that require construction/erection of physical structures. However, this is the first time in Pakistan that an EIA has been carried out of an activity. This is the beginning of a very healthy trend that the EPA's have started to exercise their discretion of asking proponents to pay attention to the environmental details.

An EIA is carried out after the designing stages and before any activity has begun. In this case that was not observed. Although an EIA was commissioned but ICI continued to incinerate it's waste in the kiln in gross violation of the EIA professional and legal ethics and procedures. It is a frequent occurrence that an EIA is commissioned after the site and other parameters have already been decided and EIA is carried out only to fulfil a legal requirement.

5. What is a Glycol Waste?

5.1 Process

The polyester polymer (polyethylene terephthalate) is manufactured from monoethylene glycol (MEG) and pure terephthalic acid (PTA) in a two stage reaction. In the first stage of reaction i.e. esterification is carried out in a vessel in which excess monoethylene glycol and pure terephthalic acid is added. Vessel pressure is increased and heating started. The reaction starts at high temperature with liberation of water. In order to keep the reaction in forward direction the water generated is removed through a distillation column. In about two hours when the required batch temperature is achieved and predetermined quantity of water is collected, the reaction is terminated by cutting off heat.

Once esterification is complete, a specific quantity of analytical grade phosphoric acid is added and the batch is transferred to another vessel i.e. polymerizer. During the transfer, titanium dioxide slurry is injected. After transfer of the batch, a measured quantity of 20% antimony trioxide slurry in glycol is added. Heat and vacuum are applied to the vessel to achieve the required temperature. The vacuum keeps the reaction in the forward direction. During the course of reaction when monomer molecules react, polymer is formed with elimination of glycol. The glycol so produced is evaporated to the reaction in forward direction. The glycol carries part of monomer/polymer into glycol vapor condenser. The glycol removed from polymerization is termed as crude glycol which contains water, glycol, monomer/polymer. This polymer/monomer along with glycol contains traces of additives i.e. antimony trioxide, titanium dioxide and phosphorous. Approximately 20 kg of this material is collected for each batch of 3.2 tons for distillation in a separate recovery system.

The recovery system comprises of a vessel, distillation column, cooler and condenser. The pure glycol is recovered from the crude and reused. The residue left in the vessel is hydrolyzed with Caustic Soda for removal of chemically bonded glycol with monomer/polymer. The residue is further made alkaline for easy discharge from vessel. The alkalized residue is collected in drums. The residue pH is around 11 at the time it is filled into drums. The drums are filled at 80-100^{o}C. Approximately 230 tons of this residue is generated annually. The glycol waste composition and a comparison with NEQS is given in Tables 1 & 2.

5.2 Glycol Waste Composition and NEQS Compliance

To help understand what makes glycol hazardous, following is the composition of the glycol waste (Table 1) as provided by the ICI. To be able to decide if a waste could be discharged in the open drains that flows into a water body, the effluent has to comply with the NEQS. An comparison of the waste with the NEQS is given in Table 2.

Table 1: Analysis of Glycol Waste (Average Composition)

Constituents	Composition (%)
Water	15-20
Sodium terephthalate	70-75
Diethylene glycol & Triethylene glycol terephthalate	3-5
Trace metals	0.2-0.5

Source: ICI

Table 2: Comparison of the Glycol Waste with the NEQS

Parameters	NEQS	Concentration in glycol waste

pH	6-9	11
Nickel	1.0	0.0140
Zinc	5.0	0.0156
Cadmium	0.1	Nil
Copper	1.0	0.0200
Chromium	1.0	0.2300
Lead	0.5	0.005
Silver	1.0	Nil
Barium	1.5	Nil
Iron	2.0	0.1040
Manganese	1.5	0.2320
Cobalt	-	0.0170
Antimony	-	17.4000

Except for pH all values are in mg/l

Source: PCSIR Analysis. 1996

5.3 Health effects

Glycol waste contents are reported to irritate skin and eyes. Inhalation of small quantities is not hazardous. Ingestion can cause stupor or coma. Fatal kidney injury can also occur. Bio-accumulation and food chain entry of organic components are not known.

6. EIA Findings

The IUCN team conducted the field study in the first half of April, 1997. This included examining the ambient air quality in and around GCL on sites selected through the use of an air dispersion model. Public consultations were held with various concerned groups and a health survey was conducted. The incineration process was studied in detail and technical data were collected from GCL. Laboratory analysis of samples, technical data analysis, satellite imagery interpretation and report compilation were done in Karachi.

Air dispersion model, cross-checked with local residents, revealed that the wind largely carried the GCL smoke and dust to north western and eastern areas in winter, and south-eastern areas in summer. The maximum predicted touch down concentration of the particulate matter were found at a downward distance of 4 to 5 km in nine months of the year; in April it was 6 km and in July, 4 km. The major part of particulate emission did not fall on any of the populated areas around GCL.

Ambient air quality monitoring stations were set up at the potential emission receptor sites. The information obtained showed air quality conforming to WHO, USEPA and World Bank guidelines, except for the dust. The dust emission was nonetheless expected to reduce considerably with the installation of the electrostatic precipitators by July 1997.

In its present form, the glycol waste composition does not exceed the NEQS limits for liquid industrial effluent, except for its high pH. In other countries, ICI has at times disposed the glycol waste in municipal sewer, sea, landfill, or through cement kiln incineration. ICI Pakistan has chosen the cement kiln incineration process to demonstrate the company's commitment to environment as a good corporate citizen, for a better public image. Tests conducted by PCSIR indicate that air emission from glycol waste incineration does not exceed the NEQS limit for industrial air emission.

7. Alternatives

Two alternatives for the activity were suggested by the EIA team: (A) incineration with glycol waste feeding from the cold end of the cement kiln, and (B) incineration with glycol waste feeding from the hot end of the cement kiln.

Option A was tested by ICI, using 0.01% glycol waste concentration. Problems encountered included complaints from factory workers on unpleasant smell after glycol waste mixing with slurry, which caused headache and vomiting in some of the workers. Chocking of slurry intake channels was also reported in some of the early trials. About one ton of glycol waste was added to a 9,400 ton slurry tank daily. With two out of three kilns in operation, the daily slurry consumption was about 2,000 ton. This meant that the following day addition of another ton to the remaining slurry almost doubled its glycol waste concentration.

Each kiln is fed with about 1000 ton slurry daily. Assuming a homogeneous slurry-waste mixing, this amount will carry about 100 kg glycol waste. While moving down the kiln towards the burning zone, out of the 100 kg waste, about 15 kg water gets evaporated in the chaining zone. At the same time, about 30 kg organic matter also gets vaporized by the time the slurry attains a temperature of 200^{o}C. Much of the evaporating organic matter should get attached to the clinker dust on the way to the electrostatic precipitator (EP). These particles will be trapped by EP. Any remaining organic matter traces, not attached to clinker dust, will also be attracted by the EP's charged surfaces. This can form a coating on the charged surfaces. This coating has the potential of very slowly reducing the EP's efficiency in the long run. Any left-over traces escaping the system should be inconsequential for the environment.

Traveling down into the hotter zone, almost 90% (90 kg) of the waste gets burned partially, producing sodium terephthalate fumes, as the temperature approaches 800^{o}C. On their way to the smoke stack, these fumes will hit the incoming slurry, get mixed with it and then evaporate again after sliding down to hotter zone in the kiln. This continuous cycle will increase the concentration of partly burnt glycol waste in the slurry. This concentrated material will burst out to smoke stack whenever there is a break in slurry feed. The remaining about 10 kg material (presumably the stable inorganic component of the glycol waste), or the residue, will get mixed with the 600 ton clinker and eventually become a part of the cement produced. Its small quantity (0.0017%) will not affect cement quality. On the way to the smoke stack, much of the gaseous and particulate matter will get trapped by the incoming fresh slurry. This provides the escaping material another chance to get mixed with the clinker. In essence, the slurry feeding system acts as a scrubber for the escaping material. At the final stage of flue gas emission, the electrostatic precipitator will trap any left-over traces.

Option B proposed direct introduction of glycol waste in the burning zone. This will avoid waste mixing with the slurry, hence eliminating the foul smell problem. Compared to 1200^{o}C temperature and a 2 second resident time in a custom designed hazardous waste incinerator, the cement kiln provides temperatures exceeding 1500^{o}C and a resident time of over 10 seconds which is more than adequate for complete glycol waste decomposition including the destruction of dioxins and furans. Any material escaping along with the flue gases should get trapped by the incoming fresh slurry, which will act as a scrubber. At the final stage of flue gas emission, the electrostatic precipitator will trap any left-over traces.

For both the incineration options, conversion of the glycol waste (largely 1,4 benzene disodium carboxylate) to dioxin (2,3,7,8-tetrachloro dibenzo-p-dioxin) or polychlorinated furans is not likely due to chemical non-compatibility of the precursor. Besides, the hot gases at temperatures far exceeding 1000^{o}C do not cool down gradually to allow chemical recombination. Moving towards the smoke stack, the hot gases hit the cool surface of incoming fresh slurry. This sudden temperature drop should not allow dioxins or furans production. And even if any such molecule does get formed, it will be retained by the incoming slurry and will get carried down the kiln to high temperature zone (1500^{o}C) where it will get decomposed. The flue gas emission will not carry any detectable dioxins or furans. Similarly, there is no possibility of dioxins or furans presence in the clinker by the time it reaches the high temperature zone. The cement produced will be dioxins and furans free.

8. Mitigation Options

The following mitigation measures were proposed by the EIA team:

- Mitigation measures for Option A included pH adjustment of glycol waste without increasing its viscosity. This adjustment aimed to minimize or eliminate the foul smell produced during glycol waste mixing with the slurry. Glycol waste concentration built-up in the mixing tank could be controlled by adding waste to the slurry according to slurry consumption rate. Built-up in the kiln could be avoided by feeding the slurry-waste mix every alternate day. This can best be achieved by using a separate tank for slurry-waste mixing.

- For Option B, use of non-reacting and robust glycol waste homogenizing tank and piping was recommended. The waste viscosity needed to be adjusted to avoid feed pipe chocking.

- Mitigation measures common to Option A and Option B included workers' training in occupational health and safety, provision of personal protective equipment, and routine health checkup of workers. For packing, transporting and storage of glycol waste, the mitigation measures included use of drums in good condition, proper selection of trucks and truck drivers, verbal and written safety instructions for truck drivers, loading and unloading procedures for minimum damage to drums, construction of a proper storage area at GCL, and arrangements for crushing the damaged empty drums before their sale to steel industry for recycling.

- The glycol waste has a small calorific value of 5820 J/g, and hence a limited role as a supplementary fuel in the cement making process. Nonetheless, during the glycol waste incineration, air fuel ratio in the kiln must be adjusted to avoid excess carbon monoxide emission. Otherwise, the electrostatic precipitator will trip.

- Although the EIA gave a go-ahead to the incineration, however, it suggested that this is not a permanent solution. A permanent technical and environment friendly solution should be explored and adopted.

9. International/national contest

Glycol waste is bound to be generated in the manufacturing of polyester fiber. Meaning that it will have to be disposed off as well because the quantities are large and cannot be stored for a long period of time due to space constraints. Until recently the most common practice had been to dump it in the high seas and it was done regularly by most of the companies world wide. However, with the growing concerns about marine pollution and the entry of toxic metals in the food chain through sea food consumption, better ways are being explored to dispose of wastes like glycol. United Nations conventions on safe disposal of hazardous wastes and protection of the marine environment have also signified the importance of this activity.

The activity has not only opened new avenues for the industries facing problems in disposing their waste, it will also bring in additional business to the cement industry which can use the waste as fuel and also get some monetary benefit by charging for the incineration. However, the main benefit is that the industry will be able to dispose waste in an environment friendly manner.

10. Current Status

Despite a positive EIA report GCL management refused to continue with the incineration. No reason was given. Current status is not known.

11. Conclusions

The study is a landmark in the environmental history of Pakistan. It is a good example of cooperation between the industrial sector and the government. ICI being a good corporate citizen tried to meet it's obligations as per the law. Although deep sea dumping is considered an acceptable option, but ICI realizing government's, public's and environmental action groups reactions, decided to explore other options which is a welcome sign.

It is heartening to see that the EPAs are maturing and have started to perform according to their mandate. Although EPAs are severely under-staffed and lack in technical capabilities. However, such actions will help in convincing the public that they are doing a job which is for their good should be funded adequately to be able to properly undertake their duties.