ADDITIONAL REPORT OF COMMITTEE ON ENVIRONMENT DAMAGE ASSESSMENT DUE TO AIR POLLUTION CAUSED ON ACCOUNT OF EXPLOSION & FIR AT M/S YASHASHVI RASAYAN PVT. LTD. DAHEJ, DISTRICT, BHARUCH, GUJARAT. IN COMPLIANCE OF AN ORDER MADE BY PRINCIPAL BENCH OF HON'BLE NATIONAL GREEN TRIBUNAL, ON 08.06.2020, AT NEW DELHI. IN THE MATTER OF OA NO. 22 Of 2020 (ARYAVART FOUNDATION V/s YASHASHVI RASAYAN PVT. LTD. & ANR)

UNDER THE CHAIRMANSHIP OF JUSTICE B.C. PATEL, FORMER CHIEF JUSTICE, DELHI HIGH COURT.

Prepared By

Ministry of Environment, Forest & Climate Change

FOR SUBMISSION TO

HON'BLE NATIONAL GREEN TRIBUNAL, PRINCIPAL BENCH, NEW DELHI

SEPTEMBER 2020

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COMMITTEE MEMBERS

Name	Institute	Signature
Hon'ble Justice Shri B.C. Patel	Former Chief Justice, Delhi High Court and former Judge of the Gujarat High Court, Ahmedabad	BCPatel
Shri Vishwa Bandhu Meena	Scientist 'C' Ministry of Environment, Forest & Climate Change, Regional Office, Bhopal	[signature]
Shri Pratik D. Bharne	Scientist 'E' Central Pollution Control Board (CPCB), Regional Directorate (West), Vadodara	[signature]
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Shri Ashish K Panda	Consultant, National Institute of Disaster Management (NIDM), New Delhi	Ashish Panda

CONTENT

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1.0 BACKGROUND:

The committee constituted as per order 08.06.2020 in the matter of OA NO. 22 Of 2020 (ARYAVART FOUNDATION V/s YASHASHVI RASAYAN PVT. LTD. & ANR) has submitted its report- **"REPORT OF COMMITTEE IN COMPLIANCE OF ORDER OF HON'BLE NGT, PRINCIPAL BENCH NEW DELHI IN THE MATTER OF OA NO. 22 Of 2020 (ARYAVART FOUNDATION V/s YASHYASHVI RASAYAN PVT. LTD. & ANR) WRT FATAL ACCIDENT AT M/S YASHYASHVI RASAYAN PVT. LTD. DAHEJ, GUJARAT (AUGUST 2020)**" on 07.08.2020 to Hon'ble NGT, Principal bench, New Delhi through e-mail – judicial-ngt@gov.in.

A request was made in the report that study on environmental damage assessment due to air pollution would require at least three weeks' time and therefore, request was made to grant additional time. Now the report is submitted by NEERI on environmental damage assessment due to air pollution and the same was deliberated amongst the members of the committee through video conferences, placed in subsequent sections.

2.0 ENVIRONMENT DAMAGE COST ASSESSMENT DUE TO AIR POLLUTION ON ACCOUNT OF EXPLOSION AND FIRE AT M/S. YASHASHVI RASAYAN PVT LTD., DAHEJ, DIST BHARUCH GUJARAT

2.1 Introduction

M/s. Yashashvi Rasayan Pvt Ltd, situated at, Plot No. Z/96/E, SEZ-II, Dahej, Taluka Vagra, District Bharuch, is engaged in manufacturing of varieties of chemicals /acids (Herbicides & intermediates) since 2017.

The unit is manufacturing (1) 3,6 Di Chloro 2 Methoxy Benzoic Acid 500 MT or (2) Di Potassium Salt of 3,6 Di Chloro Salicylic Acid 701.5 MT or (3) 2,5 Di Chloro Phenol 510.92 MT or (4) 2,5 Di Chloro Aniline 664.75 MT, (5) Nitrosyl Sulfuric Acid and other by-products.

The unit has 11 underground tanks for storage of Methanol, Xylene and Diesel. The unit has 14 tanks on ground to store Sulphuric acid, Sodium hydroxide, Potassium hydroxide, Nitric Acid, O.D.C.B., D.C.N.B., Di-chloro Aniline, Dimethyl Sulphate, Sulphur dioxide, Carbon Dioxide (Gas). A truck trailer full of Hydrogen cylinders was parked at the time of accident close to the tank farm area.

Due to mishandling of chemicals, explosion followed by fire that took place on June 3, 2020 at tank farm area resulting into emissions of combustion products spreading in prevailing wind direction (SE to NW) towards M/S LNG Patronet Ltd, Hindalco industries and Adani Petronet Port Ltd, as reported. Damage happened to storage tanks above ground only. There was no damage to underground storage tank. There was tyre burning of the trailer, however, no impact on the hydrogen cylinders due to timely control of fire.

In the explosion following ground level tanks exploded releasing various air pollutants into the atmosphere:

Table 1: Quantity of different raw materials in the above-ground Storage tanks (MT)

Tag No. of Tanks	Tank No.	Material	Capacity (Liters)	Density	MOC	Storage (MT)
ST-5101A	2	2,5-Dichloro Aniline (2,5- DCA)	150000	1.31	SS 304L	77.9
ST-5101B	3	2,5-Dichloro Nitrobenzene (2,5-DCNB)	150000	1.423	SS 304L	99.6
ST-5102A	6	98% Sulphuric Acid	50000	1.83	CS	30.4
ST-5102B	7	98% Sulphuric Acid	50000	1.83	CS	37.1
ST-5103A	8	98% Nitric Acid (Conc. Nitric Acid)	20000	1.50	CS GL (Glass lined)	0.9 Dead volume
ST-5103B	9	98% Nitric Acid (Conc. Nitric Acid)	20000	1.50	CS GL (Glass lined)	0.9 Dead volume +18.8 =19.7
ST-5104A	10	Ortho Dichloro Benzene (ODCB)	30000	1.3	CS	24.8
ST-5104B	11	Ortho Dichloro Benzene (ODCB)	30000	1.3	CS	10.6
ST-5105A	12	Caustic Potash Lye (KOH Lye)	60000	1.48	CS	43.4
ST-5105B	13	Caustic Potash Lye (KOH Lye)	60000	1.48	CS	28.9
ST-5106A	14	Caustic Soda Lye (NaOH Lye)	50000	1.48	CS	12.8
ST-5106B	15	Caustic Soda Lye (NaOH Lye)	50000	1.48	CS	11.8
ST-5107A	4	Dimethyl Sulphate (DMS)	60000	1.32	CS	*Dead volume*
ST-5107B	5	Dimethyl Sulphate (DMS)	60000	1.32	CS	*7.5 +22.9 =30.4*

As the information provided by the company, the tank-9 (Nitric Acid) had 0.9 MT Dead volume & tank No 5 had 7.5 MT volume of DMS (Dimethyl Sulphate). Accidently, 18.8 MT HNO_3 unloaded from tanker in to tank No.5 of DMS and then shifted to tank No. 9 along with 7.5 MT DMS (Mixture of DMS & HNO_3) = 0.9+7.5+18.8=27.2 MT mixed chemicals. Similarly, accidently 22.9 MT of DMS filled in HNO_3 tank (Tank No. 8). As to resolve this complex chemistry for linear calculation we have segregated & considered combustion of an individual chemical storage from mixtures.

2.2 Methodology

Table 1 shows the quantity of chemicals available in the industry premises. Emission is estimated by stoichiometric balancing of different chemicals. **Table 2** shows the emitted major pollutants along with authentic reference.

Table 2: Pollutants emitted after explosion & fire.

Chemical Name	Formula	Density	Most Emitted Gases After An Independent Combustion	Reference
2,5-Dichloro Aniline (2,5-DCA)	$C_6H_5Cl_2N$	1.31	Nitrogen oxides (NOx), Carbon dioxide (CO2), Hydrogen chloride gas	https://www.fishersci.com/store/msds?partNumber=AC113091000&productDescription=2%2C3-DICHLOROANILINE%2C+99%25+100GR&vendorId=VN00032119&countryCode=US&language=en-Structure

Chemical Name	Formula	Density	Most Emitted Gases After An Independent Combustion	Reference
2,5-Dichloro Nitrobenzene (2,5-DCNB)	$C_6H_3Cl_2NO$	1.423	Nitrogen Oxides (NOx), Carbon dioxide (CO_2), Hydrogen chloride (HCL)	https://www.fishersci.com/store/msds?partNumber=AC209212500&productDescription=2%2C5-DICHLORONITROBENZENE+250GR&vendorId=VN00032119&countryCode=US&language=en
98% Sulphuric Acid	H_2SO_4	1.83	Mainly SO_2	https://www.sciencedirect.com/topics/earth-and-planetary-sciences/nitric-acid
98% Sulphuric Acid	H_2SO_4	1.83		
98% Nitric Acid (Conc. Nitric Acid)	HNO_3	1.50	Mainly NO_2	https://www.ch.ic.ac.uk/rzepa/mim/environmental/html/nitric.htm
98% Nitric Acid (Conc. Nitric Acid)	HNO_3	1.50		
Ortho Di-chloro Benzene (ODCB)	$C_6H_4Cl_2$	1.3	Carbon dioxide (CO2), Hydrogen chloride(HCL)	https://www.sciencedirect.com/science/article/abs/pii/S2468823119301452
Ortho Di-chloro Benzene (ODCB)	$C_6H_4Cl_2$	1.3		
Caustic Potash Lye (KOH Lye)	KOH	1.48	Emissions to air are also not a concern because the substance is rapidly neutralized in air due the presence of carbon dioxide in air Like NaOH, KOH exhibits high thermal stability.	https://www.helpe.gr/userfiles/8a53b155-76e9-4d45-9773-a27000e44a36/Caustic-Soda-Summary-GPS.pdf
Caustic Potash Lye (KOH Lye)	KOH	1.48		
Caustic Soda Lye (NaOH Lye)	NaOH	1.48		
Caustic Soda Lye (NaOH Lye)	NaOH	1.48		
Dimethyl Sulphate (DMS)	$C_2H_6SO_4$	1.32	Carbon dioxide (CO_2), Sulphur di oxide(SO_2)	https://pubchem.ncbi.nlm.nih.gov/compound/Dimethyl-sulfate
Dimethyl Sulphate (DMS)	$C_2H_6SO_4$	1.32		

- **2, 5-Dichloro Aniline (2, 5- DCA)**

  After decomposition of 2,5 DCA in an instant explosion in storage produces mainly, Nitrogen oxides (NOx), Carbon monoxide (CO), Carbon dioxide (CO_2), Hydrogen chloride gas according to Thermo Fisher Scientific Safety Data Sheet.

  According to the calculation and reaction balancing, 77.9 MT of stored 2,5 DCA produces approximately 184.2 MT of pollutants (Nitrogen oxides (NOx) = 22.1 MT, Carbon dioxide (CO_2) = 127 MT, Hydrogen chloride gas = 35.1 MT). Formation of CO is neglected because in the atmosphere, it is spatially variable and short-lived, CO_2 is considered in place after balancing the reactions.

  $$2C_6H_5CL_2N + 31/2O_2 \rightarrow 4HCL + 2NO_2 + 12CO_2 + 3H_20$$
  $$4C_6H_5CL_2N + 31O_2 \rightarrow 8HCL + 4NO_2 + 24CO_2 + 6H_20$$

- **2, 5 – Di-chloro-nitrobenzene (2, 5 DCNB)**

  Combustion of 2, 5-Dichloronitrobenzene leads to Nitrogen oxides (NOx), Carbon monoxide (CO), Carbon dioxide (CO_2), Hydrogen chloride gas (Thermo Fisher Scientific Safety Data Sheet)

  According to calculation and reaction balancing 99.6 MT of stored 2, 5 DNB produces approximately 198.7 MT of pollutants (Nitrogen oxides (NOx) = 23.9 MT, Carbon dioxide (CO_2) = 137 MT, Hydrogen chloride gas = 37.8)

  $$2C_6H_3Cl_2NO_2 + 25/2O_2 \rightarrow 4HCL + 2NO_2 + 12CO_2 + H_20$$
  $$4C_6H_3Cl_2NO_2 + 25O_2 \rightarrow 8HCL + 4NO_2 + 24CO_2 + 2H_20$$

- **Sulphuric Acid**

  At higher temperatures, SO_2 is the major component generated from decomposition of H_2SO_4 in the tank.

  According to stoichiometric calculation S1-30.4 MT, S2-37.1 MT of stored Sulphuric acid produces approximately S1-sulphur di oxide (SOx))= (19.856 MT), S2-sulphur di oxide (SOx)) = 24.232 MT of pollutants.

$$H_2SO_4 \rightarrow SO_{3+} H_20$$

$$SO_3 \rightarrow SO_{2+} O_2$$

- **Nitric acid**

  Nitric acid decomposes slowly to nitrogen dioxide. The nitric oxide produced may react with atmospheric oxygen to give nitrogen dioxide. With more concentrated nitric acid, nitrogen dioxide is produced directly in a reaction with 1:4 stoichiometry.

  One mole of Nitric acid break down into 4 moles Nitrogen di oxide and 2 moles of water & a oxygen through molecular weight ratio calculation we found that 1 part of Nitric acid emits around 0.7 parts of pollutants that include mainly Nitrogen di oxide (NOx)

  According to above calculation N1-0.9 MT Dead volume, N2-19.7 MT of stored Nitric acid produces approximately N1- Nitrogen di oxide (NOX)= 0.63 MT, N2- Nitrogen di oxide (NOx) = 13.79 MT, of pollutants.

$$4\ HNO_3 \rightarrow 4\ NO_2 + 2\ H_2O + O_2$$

- **Ortho Di-chloro Benzene (ODCB)**

  Combustion by-products include hydrogen chloride, and chloro-carbons. It is combustible above 66 °C. It forms the explosive vapour /air mixtures.

According to reaction calculation ODCB1-24.8 MT, ODCB 2-10.6 MT of stored Ortho Di-chloro Benzene (ODCB) produces approximately from storage1- HCL= 12.3 MT, CO_2 = 44.5 MT, storage2- HCL= 5.3 MT, CO_2 = 19.03 MT of pollutants

$$2C_6H_4Cl_2 + 13O_2 \rightarrow 4HCL + 12CO_2 + 2H_20$$

- **Caustic Potash Lye (KOH Lye) & Caustic Soda Lye (NaOH Lye)**

  According to global product strategy and safety summary, emissions to air are also not a concern because the substance is rapidly neutralized in air due the presence of carbon dioxide in air and have high thermal stability as well.

- **Di methyl Sulphate (DMS**)

  Above 83 °C explosive vapour is formed if released to air, a vapour pressure of 0.677 mm Hg at 25 °C indicates dimethyl sulphate will exist solely as a vapour in the atmosphere. Vapour-phase dimethyl sulphate will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 82 days. Vapour-phase dimethyl sulphate will be degraded in the atmosphere by reaction with water (estimated atmospheric lifetime of >2 days).

  Decomposes on heating and on burning. This produces toxic fumes including sulphur oxides. One mole of DMS break down into 2 moles CO2 and 1 moles of SO2 & water through molecular weight ratio calculation we found that 1 part of Di methyl Sulphate DMS emits around 1.2 parts of pollutants, i.e. 0.507 parts of SOx & 0.697 parts of CO_2.

  According to above calculation DMS of dead volume 7.5 MT+ New batch of 22.9MT of DMS i.e. in total 7.5+22.9=30.4MT would produce SOx=15.41 MT, CO2=21.18 MT of pollution

$$2C_2H_6SO_4 + 5O_2 \rightarrow 2SO_2 + 4CO_2 + 6H_20$$

The consolidated results are given in the following table:

Table 3: Quantity (MT) of pollutants formed due to explosion & fire

Stored Material	Storage (MT)	SO_2 (MT) (a)	NOx (MT) (b)	HCl (MT) (c)	CO_2 (MT) (d)	CO (MT) (e)	Total Pollutant in air (MT) (a+b+c+d+e)
2,5-Dichloro Aniline (2,5-	77.9	-	22.1	35.1	127	-	184.2
2,5-Dichloro Nitrobenzene (2,5-DCNB)	99.6	-	23.9	37.8	137	-	198.7
98% Sulphuric Acid	30.4	19.856	-	-	-	-	19.856
98% Sulphuric Acid	37.1	24.232	-	-	-	-	24.232
98% Nitric Acid (Conc. Nitric Acid)	0.9	-	0.63	-	-	-	0.63
98% Nitric Acid (Conc. Nitric Acid)	19.7	-	13.79	-	-	-	13.79
Ortho Dichloro Benzene (ODCB)	24.8	-	-	12.3	44.5	-	56.8
Ortho Dichloro Benzene (ODCB)	10.6	-	-	5.3	19	-	24.38
Caustic Potash Lye (KOH Lye)	43.4	-	-	-	-	-	0
Caustic Potash Lye (KOH Lye)	28.9	-	-	-	-	-	0
Caustic Soda Lye (NaOH Lye)	12.8	-	-	-	-	-	0
Caustic Soda Lye (NaOH Lye)	11.8	-	-	-	-	-	0
Dimethyl Sulphate (DMS)	*Dead volume*	-	-	-	-	-	-
Dimethyl Sulphate (DMS)	*30.4*	15.41	-	-	21.18	-	36.59
Total in MT (Rounded off to 1 decimal)		59.4	60.4	90.5	348.6	0.0	559.17

2.3 Valuation of Environmental Damages

Business activities in most of the sectors result in harmful emission of particulates and gases pollutants into air leading to air pollution. Pollutants are either emitted directly (primary pollutants) or are formed in atmosphere due to reaction of two or more pollutants. Due to uncertainty, secondary gaseous pollutants are not considered here. Most of the primary and secondary air pollutants create negative impact on human health, visibility, agriculture, tourism etc. There is a need to understand the level of impact the pollutants generate and monetizing these impacts /damages is one of the ways by which the scale of impact can be communicated.

In order to quantify the impacts in monetary terms, it is essential to understand the mechanism by which the impact happens. The impact pathway reveals, how emitted pollutants lead to different adverse outcomes on human wellbeing and other natural environment.

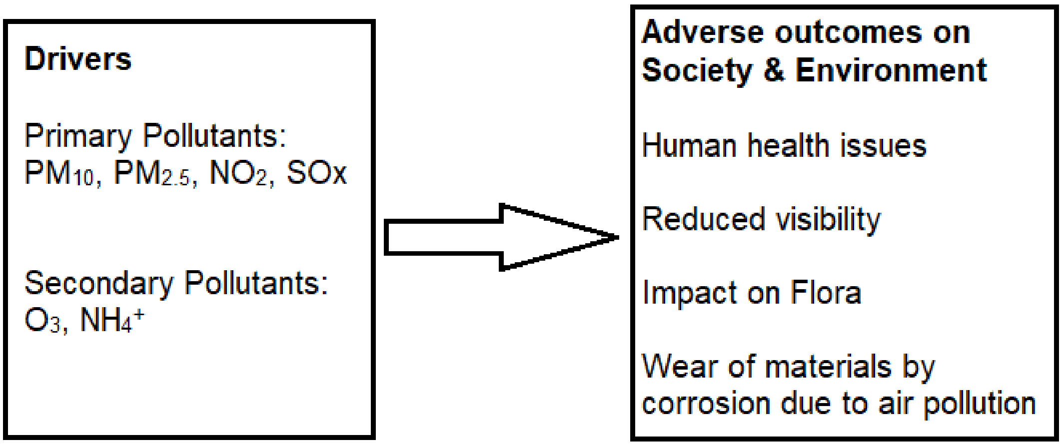

Figure: Impact Pathway.

Emission of primary pollutants and formation of secondary pollutants results in poor air quality ultimately leading to some adverse impacts on human and environment as follows

1. **Health effects on human**: Emission of pollutants lead to respiratory diseases such as bronchitis, asthma, allergy, lung disorder, pulmonary diseases, Lung cancer etc.

2. **Visibility**: Navigation during the time of transportation is largely affected due to the formation of smog. PM and O_3 are the major contributors to reduced visibility.

3. **Impacts on flora**: Reduced air quality within the atmosphere can retard the growth of trees affecting metabolism at the cellular level. Acid rain can also damage trees and acidifies soil reducing the yield.

4. **Wear and tear of materials**: Acidic components formed due to the reaction of pollutants in the atmosphere result in acid rain that has a tendency to corrode the building materials. PM has discoloring properties reducing aesthetic beauty and quality.

Given the above impacts, it is necessary to properly quantify the concentration of pollutants released into the atmosphere, track their dispersion, study the impacts and use various econometric tools to conduct valuation. While the ideal scenario in the current case would be monitor the emissions on site from the instance of the accident to understand the pollutant load released into the atmosphere. In the event of non-availability of monitored data, the stoichiometric results are used for valuation purposes.

For economic valuation, Value Transfer Method (VTM) has been used. In VTM, the valuation of extent of damages produced by same pollutants at one geographic place, can be transferred to another place using economic checks and balances. The base methodology, using the VTM, used for the current valuation has been taken from CSIR-NEERI's framework and publications[1,2]. The framework defines the use of VTM and the approach in detail. The base formula used in the analysis includes

$$Damage\ Cost\ in\ India\ (I)(₹) = Damage\ Cost\ at\ Location\ x * PPP\ Adustment\ Factor\ (I\ vs\ x) * IR$$

For valuation of SOx and NOx, UK-Defra values have been taken for calculating the monetary value of damages. Suitable econometric conversions including purchasing power parity (PPP) and inflation rate (IR) have been used to convert UK defra values to Indian values. The Indian values per tonne of emission hence arrived are used for valuation of damages

For Carbon dioxide, since it is GHG and can have a long term impact on environment, the social cost of carbon median values have been used as estimated by USEPA. Similar econometric factors including PPP and IR have been used to get the Indian values. For HCl, externalities estimates done for utility sector calculated by Fraunhofer Institute, Germany and Pace University, USA is referred due to limited availability of literature with suitable econometric adjustments as stated above. Using the above equation and given literature, the damage value per tonne for all the pollutants have been calculated in Indian Rupees for the base year of

[1] https://www.neeri.res.in/file_homes/41441989_EDCA_Final_Soft.pdf
[2] https://link.springer.com/article/10.1007/s11869-020-00845-3

2019 and is given in **Table 4.** The consolidated table for environmental damages is given below:

Table 4: Calculated damage cost (₹ Lakhs) for air pollution due to explosion & fire

Pollutant	**SO_2**	**NO_X**	**HCl**	**CO_2**	**Total**
Pollutant Load (MT) (a)	59.4	60.4	90.5	348.6	558.9
Damage Value per tonne in ₹ Lakhs (b)	2.1989	2.1729	0.2189	0.0225	-
Damage Value in ₹ Lakhs (c=a*b)	130.6	131.2	19.8	7.8	**289.5**

From above table, the estimates, suggest a **total environmental damage of ₹ 2.895 Crores due to air pollution** caused by explosion and fire at M/s. Yashashvi Rasyan Pvt Ltd, Dahej.

References

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