TOXIC TRAITS

An Overview of the Adverse Health Impacts of Chemicals Associated with Petrochemical Industries and Across the Life Span of Plastics

April 2024

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*Acknowledgment: The section 'Ground Reality' is based on the findings from the fieldwork conducted by Benisha B.M., Fouziya Tehzeeb, and Karthik Gunasekaran in and around Panipat (Haryana) Petrochemical Hub.

PREFACE

The Centre for Financial Accountability presents a study that documents petrochemical production's health impacts to underscore their gravity. The report focuses on the key polymers and chemicals used in plastic production and their documented health impacts. It also includes a case study of the health impacts on communities living around the IOCL refinery in Panipat. Based on the evidence in Panipat and several other petrochemical-producing regions in India, it is not difficult to conclude that plastics fuel all forms of infertility – of people, animals, and the soil.

In April 2024, 175 countries will meet for the 4th round of negotiations for an international legally binding instrument on plastic pollution, including in the marine environment. It is heartening to note that the Revised Zero Draft of the proposed Instrument centres human health in the objectives, scope and some of the obligations. We hope the health impacts of plastics across the full lifecycle including feedstocks, precursors, and polymers which are the building blocks of plastics, continue to be a key concern and is not lost in the din of a lopsided development discourse which prioritised private profit over public well being.

According to the Centre for Disease Dynamics, Economics and Policy, over 60% of all healthcare facilities in the country are privately owned, of which 33% are located in rural areas. In terms of budget allocations to the Ministry of Health and Family Welfare, its share has seen an overall decrease in expenditure from 2.16% in 2019-20 to 1.9% in 2024-25. The health budget for 2024-25, including the Department of Health Research, constitutes 0.27% of the projected GDP for the same fiscal year. This is less than the 2023-24 budget share (0.3%) of the total GDP. There is a clear declining trend of public expenditure in the health sector and an increased presence of the private sector in health delivery systems. As is evident in this report, petrochemical and plastic production results in complex diseases like cancer, endocrine diseases, respiratory diseases etc. Further, a landmark study conducted in 2014, showed how the life expectancy increased faster in the reference country (by 0.084 years more each year) as compared to that in the petrochemical industrialised county between 1996 – 2007, and this discrepancy increased over time.

In the absence of even a basic public health system that is affordable and accessible to communities, what are the chances that already

vulnerable communities will have access to public health systems that can respond to these complex and life-threatening diseases? What then must be the financial burden that is put on people living in the vicinity of the petrochemical industry? Here is yet another example where profits are privatised while costs are socialised.

We hope that policymakers nationally and internationally can appreciate the unjust burden put on the people affected by the petrochemical and plastics industry. We hope that remediation and reparation mechanisms are put in place to address the serious health impacts and concerns arising from the activities of this extremely toxic industry.

Swathi Seshadri
Centre for Financial Accountability
March 2024

INTRODUCTION

The petrochemical industry, once hailed as the harbinger of progress and innovation, now finds itself at the epicentre of critical global discourse. The petrochemical industry is not just about automobiles and cooking fuels. It contributes to an array of products such as plastics, fertilisers, pesticides, fabrics, solvents, chemicals, synthetic rubbers, waxes, dyes and lubricants used across the globe in almost all aspects of life(1).

Consider the widespread use of plastics as an example. From single-use packaging to durable products, plastics have undoubtedly shaped the modern world, furnishing us with a multitude of conveniences and materials that enhance our daily lives. However, this convenience comes at a cost. For example, the plastic pollution crisis in oceans and waterways discarded plastic products harm marine life and ecosystems. Globally, the Great Pacific Garbage Patch (Fig 1), the largest offshore accumulation of floating plastic debris, located between Hawaii and California which covers an estimated surface area of 1.6 million square kilometres, illustrates the environmental challenges posed by the petrochemical industry(2).

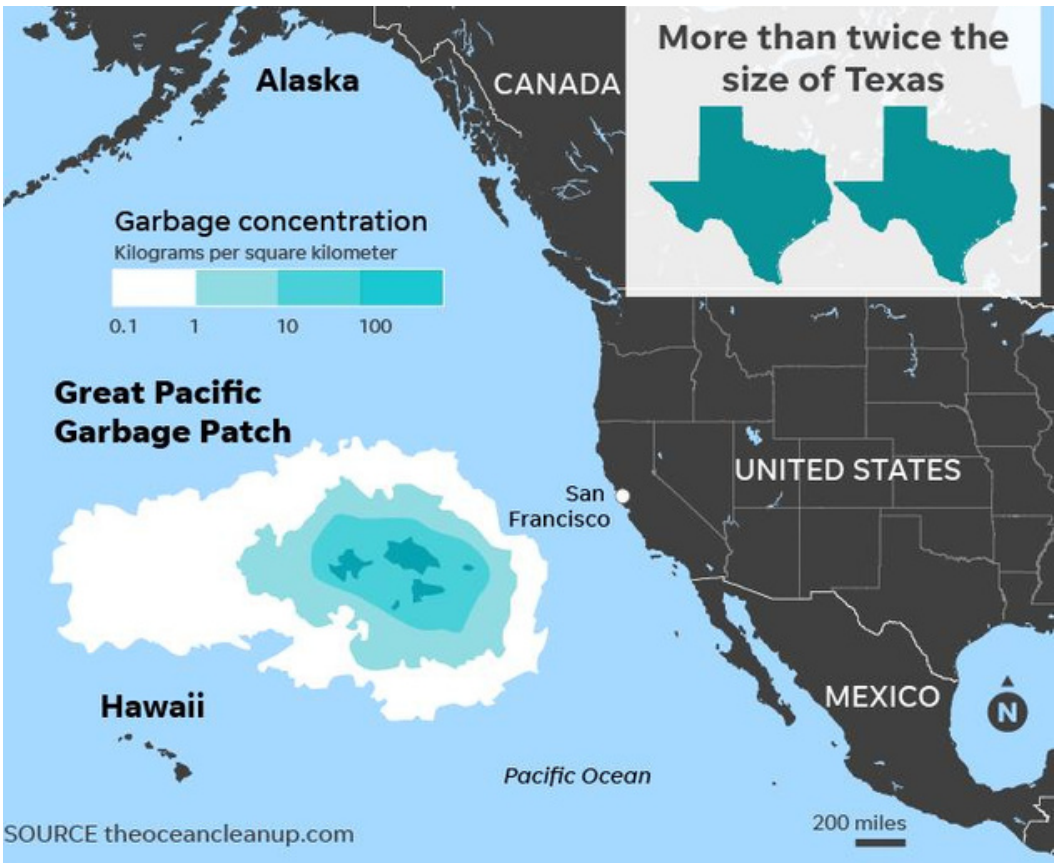


Fig 1: Great Pacific Garbage Patch

1. https://www.sciencedirect.com/science/article/abs/pii/B9780128001585000050?via%3Dihub
2. https://theoceancleanup.com/great-pacific-garbage-patch/

Similarly, in India, the widespread use of single-use plastics, particularly in packaging has taken a toll on solid waste management and resulted in the plastic waste crisis. The environmental toll is evident in cities like Mumbai(3), Chennai(4), Hyderabad(5), etc., where plastic waste clogs waterways and contributes to flooding during the monsoon season. The health implications extend to local communities, especially those involved in waste management, facing risks of exposure to hazardous substances present in petrochemical-derived plastics.

Beyond the gleaming pipes and sprawling factories lies a complex narrative of adversity, where the pursuit of profit has exacted a toll on the health of individuals and communities alike. Over the years, these industries have expanded their reach across continents, giving rise to economic growth and technological marvels. Yet, this progress has produced many environmental and health challenges.

The petrochemical and plastic industries are closely interconnected regarding the use of shared feedstock and chemicals, and the cumulative health impacts of the chemicals emitted during petrochemical extraction and processing which become feedstocks for plastic manufacturing. These chemicals can persist and interact throughout the plastic lifespan, potentially magnifying their health consequences.

Moreover, the health impacts of petrochemical-related activities extend beyond the factory walls and pose serious threats to the public health of the Communities situated near these industries. For instance, in Cancer Alley (Fig 2), a stretch between Baton Rouge and New Orleans along the Mississippi River in the United States where numerous petrochemical facilities coexist with predominantly African American communities, resulting in disproportionately high rates of cancer and respiratory illnesses(6).

The interconnectedness of the petrochemical and plastic industries in India mirrors the global scenario. As the petrochemical industry has expanded its footprint in India, particularly in states like Gujarat and Maharashtra, has come at an environmental, social and health cost. In places like Jamnagar, home to one of the world's largest oil refineries, residents have reported adverse health effects, attributing them to air and water pollution from petrochemical

3. https://www.sciencedirect.com/science/article/abs/pii/B9780128001585000050?via%3Dihub
4. https://theoceancleanup.com/great-pacific-garbage-patch/
5. https://timesofindia.indiatimes.com/city/hyderabad/floods-2-0-clogged-hyderabad-drains-continue-to-be-a-huge-concern/articleshow/84493323.cms
6. https://leanweb.org/uploads/doc/jtricamopalmer11Schwartzwald1.pdf

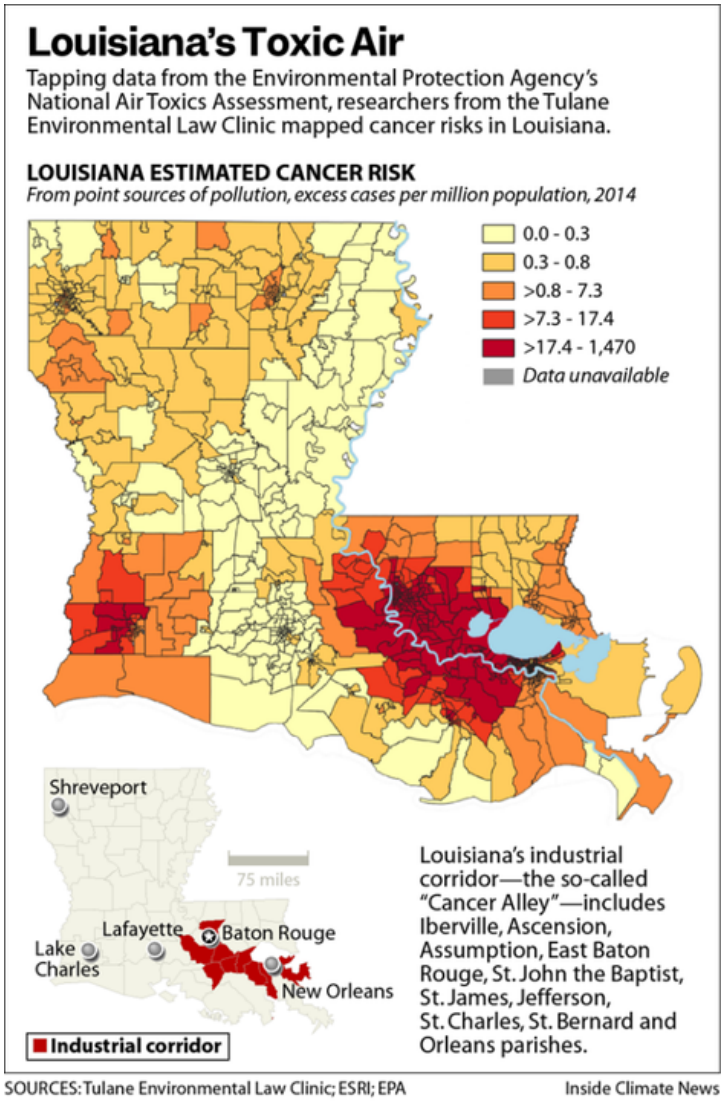


Fig 2: Cancer Alley, Lousiana, The United States

operations(7&8). Instances of groundwater contamination in regions surrounding petrochemical plants, like in Panipat, emphasise the pervasive environmental challenges(9&10).

This report aims to illuminate the profound and often hidden health impacts experienced by residents within the petrochemical and plastics industries.

Additionally, to understand the ground reality of the impacts of petrochemical industries on human health, this report consists of a case study conducted in villages of Panipat petrochemical industrial cluster.

7. https://www.downtoearth.org.in/news/mysterious-threat-17092
8. https://indianexpress.com/article/cities/ahmedabad/complaints-on-industrial-pollution-double-in-five-years-7544913/
9. https://greentribunal.gov.in/sites/default/files/news_updates/Joint%20Committee%20Report%20by%20HSPCB%20in%20OA%20No.%20738%20of%202018%20titled%20Satpal%20Singh%20Versus%20Indian%20Oil%20Corporation%20Ltd.%20Panipat%20Refinery.pdf
10. https://www.hindustantimes.com/chandigarh/all-villagers-around-panipat-refinery-to-undergo-health-check-up-by-june-30/story-OCMlCzFoUYdVZgjhiT9uHJ.html

In summary, studying the adverse health impacts of the petrochemical and plastic industries together provides a holistic understanding of the chemical exposures, environmental risks, and public health challenges associated with these interconnected sectors. This will also allow us to formulate comprehensive policies and regulations.

METHODOLOGY

This report aims to provide an overview of the negative implications of the chemicals associated with petrochemical and plastic products, and this is neither a systematic nor a comprehensive review. The impacts of petrochemicals and plastics on human health are described as seen across the plastic life span.

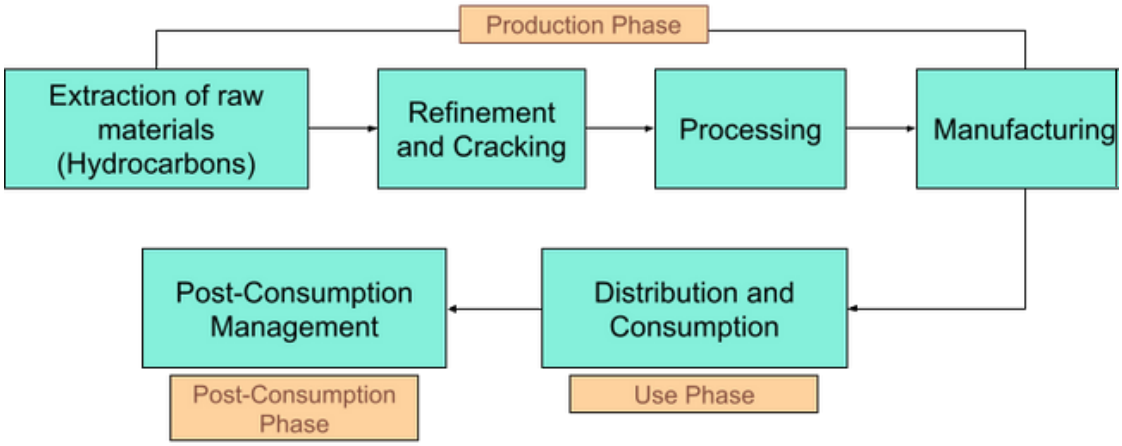
The methodological approach to this review, therefore, took 2 steps:

- The stages of the life span of plastics were categorised and described along with the chemicals that are potentially released from each stage.
- The health impacts of the chemicals associated with each stage of the life span of plastics are described.

The data collection process involved searching theoretical and empirical articles/reports using Google Search Engine, Google Scholar and ScienceDirect. The keywords, either individually or in combinations; under which the articles were sought and finally selected; were: additives; plastics; plastic waste; polymerisation; release; migration; hazardous chemicals; human health; and health impacts.

FINDINGS

The life span of plastics and chemicals associated with:
The life span of plastics involves various stages starting from the extraction of raw materials to waste management(11). The stages are as follows:



1. Extraction of raw materials:

Most plastics are derived from petrochemicals, viz., crude oil and natural gas. These hydrocarbons are extracted from underground reservoirs using various techniques based on the scale of extraction, type of reservoir and location. The most commonly used techniques are conventional drilling and hydraulic fracturing (fracking). During this process, the following chemicals are emitted into the ambient atmosphere(12):

a. Methane (CH_4)
b. Volatile Organic Compounds (VOCs) like ethane, propane, butane, benzene, toluene, and xylene.
c. Sulphur Dioxide (SO_2)
d. Nitrogen Oxides (NO_x)
e. Hydrogen Sulphide (H_2S)
f. Particulate Matter (PM)
g. Carbon Monoxide (CO)
h. Heavy Metals such as lead, arsenic, and mercury.
i. Polycyclic Aromatic Hydrocarbons (PAHs)
j. Radon

2. Refinement and Cracking:

These hydrocarbons are processed in refineries to produce basic building blocks for plastics, such as ethane and propane. Then, at the cracking plants, they are chemically broken down into ethylene, propylene, and styrene. Some plastics are also derived from

11. https://debrisfreeoceans.org/the-life-span-of-plastics/
12.https://www.epa.gov/controlling-air-pollution-oil-and-natural-gas-industry/basic-information-about-oil-and-natural-gas

renewable resources like plant-based polymers (e.g., PLA, made from cornstarch). During this stage, the following chemicals are emitted(13, 14&15):

a. Carbon Oxides (CO, CO2)
b. Sulphur compounds (SO2, SO3, H2S)
c. Nitrogen Oxides (NO, N2O, N2)
d. Butadiene
e. BTX (Benzene, Toluene and Xylene)
f. Particulate Matter
g. Polycyclic Aromatic Hydrocarbons (PAHs)
h. Cyanides (Hydrogen Cyanide (HCN))
i. Ammonia
j. Methane

3. Processing:

In this stage, the basic building blocks obtained from raw materials are chemically transformed into polymer resins through polymerisation processes. Polymerisation involves linking the individual monomers (small molecules) together to form long chains, creating various types of plastics with distinct properties. Based on the reaction mechanisms, the polymerisation reactions are classified as addition, condensation or step-growth, ring opening and other mechanisms (eg: chain transfer, plasma polymerisation)(16). The specific chemicals emitted or produced can vary depending on the type of plastic being manufactured and the processes involved. Here are some of the common chemicals emitted or produced during this process(17):

a. Monomers (Ethylene, Propylene, Styrene, Vinyl Chloride Monomer (VCM))
b. Catalysts (Ziegler-Natta Catalysts, Metallocene Catalysts)
c. Initiators (free radical initiators, isobutylene, acrylonitrile, butadiene, acrylates, ethylene oxide, and lactones)
d. Acid gases (eg: HCl in case of PVC production)

4. Manufacturing:

Once polymer resins are produced, they are sent to manufacturing facilities where they are processed into various plastic products. This can involve processes like extrusion, injection moulding, blow moulding, or thermoforming, depending on the intended product(18). Various chemicals (additives) with

13. https://www.aidic.it/cet/12/26/041.pdf
14. https://www.sciencedirect.com/science/article/abs/pii/B0122274105001538
15. https://link.springer.com/referenceworkentry/10.1007/978-1-4939-2493-6_70-3
16. https://www.sciencedirect.com/science/article/abs/pii/B9780323395007000022
17. Ibidis 16
18. https://www.sciencedirect.com/science/article/pii/S030438941730763X?ef=pdf_download&fr=RR-2&rr=805f73aabcc617ab

different functional properties are added to the polymers to achieve the desired properties in the plastic products. The differences in the management of plastic waste could be due to the chemical additives used in manufacturing plastic products. The additives can be classified into four categories(19&20):

a. Functional additives (stabilisers, antistatic agents, flame retardants, plasticisers, lubricants, biocides, etc.)
b. Colourants (pigments, soluble azocolorants, etc.)
c. Fillers (mica, talc, kaolin, clay, calcium carbonate, barium sulphate)
d. Reinforcements (e.g. glass fibres, carbon fibres)

5. Distribution and Consumption:

This is the phase where plastic products are used by consumers for various purposes as they are incredibly versatile and are used in a wide range of applications, including packaging, construction, transportation, electronics, and healthcare. Studies have found that the chemicals present in plastics can potentially migrate to the medium in contact (eg: food) during the transportation and/or consumption stage. Following are some of the chemicals that are potentially released from plastic products(21):

a. Brominated flame retardants (BFRs)
b. Short- or Medium-chained chlorinated paraffins(SCCPs/MCCPs)
c. Phthalates
d. Bisphenol-A
e. Bisphenol-A di-methacrylate
f. Heavy metals (lead, tin and cadmium)
g. Aldehydes (formaldehyde and acetaldehyde)
h. 4-nonylphenol
i. Methyl Tert-Butyl Ether (MTBE)
j. Benzene and many other volatile organic compounds

6. Post-Consumption Management:

The following are the most commonly used practices in managing plastic waste: a) Reuse; b) Recycle; c) Energy Recovery; d) Landfill; and e) Ocean Disposal. Based on the method used to manage the plastic waste, various hazardous

19. Ibidis 18
20. https://www.unep.org/resources/report/chemicals-plastics-technical-report
21. https://ipen.org/sites/default/files/documents/plastics_and_additives_final-low-o-en.pdf

chemicals are emitted from the wastewater. Some of the chemicals are as follows(22):

a. Phthalates
b. Polyfluorinated chemicals
c. Bisphenol-A
d. Brominated flame retardants
e. Antimony trioxide
f. Furans
g. Mercury
h. Dioxins
i. Polychlorinated biphenyls
j. Sulphur
k. Carbon oxides (CO, CO2)
l. Methane
m. Volatile Organic Compounds

22. https://www.sciencedirect.com/science/article/pii/S2666016421000645

Health impacts due to the hazardous chemicals associated with petrochemicals and plastics:

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Production	Methane (CH4) (23)	Colourless, odourless, highly flammable gas	High levels of methane can cause mood changes, slurred speech, vision problems,memory loss, nausea, vomiting, facial flushing and headache.	No
	Ethane (24)	Colourless, odourless and highly flammable gas	Asphyxiation, skin/eye contact leads to frostbite and neurotoxin.	No
	Propane(25)	Colorless gas with a faint petroleum-like odour	Dizziness, confusion, excitation, asphyxia, drowsiness, unconsciousness, cardiac arrhythmias, ataxia and respiratory depression.	No
	Butane(26)	Colourless gas with a faint petroleum-like odour	Targets the central nervous system and cardiovascular system. It is found lethal at high concentrations.	No conclusive evidence (May cause cancer)

23. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/769766/Methane_PHE_general_information__070119.pdf
24. https://pubchem.ncbi.nlm.nih.gov/compound/Ethane#section=Toxicity
25. https://pubchem.ncbi.nlm.nih.gov/compound/Propane
26. https://pubchem.ncbi.nlm.nih.gov/compound/Butane#section=Structures

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Production	Benzene(27)	Colorless or light yellow liquid at room temperature. It has a sweet odour and is highly flammable. Benzene evaporates into the air very quickly(28).	Acute occupational exposure to benzene may cause narcosis: headache,dizziness, drowsiness, confusion, tremors and unconsciousness.Chronic exposure leads to cancer, cytotoxicity and hematotoxicity.	Yes
	Toluene(29)	Clear, colorless liquid with a distinctive smell.	Acute exposure for more than 6 hours can lead to eye and upper airway irritation, headache, dizziness, a sensation of intoxication, fatigue, muscular weakness, confusion, impaired coordination and enlarged pupils.	No
	Xylene(30)	Colorless, flammable liquid with a sweet odour	Irritate the eyes, nose, skin, and throat. It can also cause headaches, dizziness, confusion, loss of muscle coordination, and in high doses, death.	No

27. https://www.who.int/teams/environment-climate-change-and-health/chemical-safety-and-health/health-impacts/chemicals/benzene
28. https://emergency.cdc.gov/agent/benzene/basics/facts.asp
29. https://pubchem.ncbi.nlm.nih.gov/compound/Toluene#section=Toxicity-Summary
30. https://www.cdc.gov/niosh/topics/xylene/default.html

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Production	Butadiene(31& 32)	Colorless gas with a gasoline-like odour.	Butadiene is associated with an increased incidence of Leukaemia. It causes inflammationof nasal tissues, changes to the lungs, heart, and reproductivetissues, neurological effects, and blood changes.	Yes
	Sulfur Dioxide (SO2)(33)	SO2 is a gaseous air pollutant composed of sulfur and oxygen.	Aggravates asthma, and causes wheezing, shortness of breath and chest tightness. Continuous exposure to high levels reduces the ability of lung function.	No(34)
	Sulfur Trioxide (SO3)(35)	Generally a colourless liquid but also exist as ice- or fibre-like crystals or as a gas.	Based on the route of exposure, the symptoms can include the following: cough, difficulty in breathing, sore throat, wheezing, shortness of breath, redness on the skin, skin burns, pain, blisters, redness of the eyes, pain, blurred vision, deep burns in the eyes, abdominal pain, nausea, and shock or collapse.	Yes

31. https://www.cancer.gov/about-cancer/causes-prevention/risk/substances/butadiene
32. https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=458&toxid=81
33. https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/sulfur-dioxide
34. https://assets.publishing.service.gov.uk/media/5a7df134e5274a2e8ab44d0d/hpa_Sulphur_dioxide_General_Information_v1.pdf
35. https://pubchem.ncbi.nlm.nih.gov/compound/Sulfur-trioxide

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Production	Hydrogen Sulfide (H2S) (36)	Colorless gas with a strong odour of rotten eggs	Irritation to the eyes and respiratory system, apnea, coma, convulsions; dizziness, headache, weakness, irritability, insomnia, stomach upset, and frostbite (if liquid).	No
	Nitrogen Oxides (NOx) (37&38)	Nitrogen Oxides are a family of poisonous, highly reactive gases.	At Low levels, it can irritate the eyes, nose, throat, & lungs, possibly causing cough & shortness of breath, tiredness, & nausea. At high levels, it can cause rapid burning, spasms, and swelling of tissues in the throat & upper respiratory tract, reduced oxygenation of body tissues, a build-up of fluid in the lungs, & death.	No
	Particulate Matter (PM) (39,40&41)	A mixture of solid particles and liquid droplets found in the air.	Depending on the size of the particulate pollutants, the effects may vary. It can cause premature death in people with heart/lung disease, non-fatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, and increased respiratory symptoms	Yes

36. https://www.cdc.gov/niosh/topics/hydrogensulfide/default.html
37. https://www3.epa.gov/region1/airquality/nox.html
38. https://www.atsdr.cdc.gov/toxfaqs/tfacts175.pdf
39. https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm
40. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3975184/
41. https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Production			such as irritation of the airways, coughing or difficulty breathing.	
	Carbon Monoxide (CO)(42&43)	Colourless, odorless gas that can be harmful when inhaled in large amounts	Inhaling high concentrations of CO results in fatal condition called CO poisoning. Early symptoms include mild headache, nausea and shortness of breath. Moderate exposure causes chest pain, dizziness, weakness, unconsciousness, loss of muscle coordination, mental confusion, severe headache, upset stomach, nausea and vomiting.	No
	Carbon Dioxide (CO_2) (44&45)	Colorless and non-flammable naturally occurring gas	Exposure to high concentrations of CO_2 (>1000ppm) can lead to various symptoms such as headaches, dizziness, restlessness, a tingling or pins or needles feeling, difficulty breathing, sweating, tiredness, increased heart rate, elevated blood pressure, coma, asphyxia, and convulsions.	No

42. https://www.epa.gov/co-pollution/basic-information-about-carbon-monoxide-co-outdoor-air-pollution
43. https://my.clevelandclinic.org/health/diseases/15663-carbon-monoxide-poisoning
44. https://scied.ucar.edu/learning-zone/how-climate-works/carbon-dioxide
45. https://www.dhs.wisconsin.gov/chemical/carbondioxide.htm

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Production	Heavy Metals such as lead(46,47&48), arsenic(49), and mercury(50&51)	**Lead** is a naturally occurring toxic metal found in the Earth's crust	Children are vulnerable to the toxic effects of lead and it can result in damage to the brain & nervous system, slowed growth and development, learning & behaviour problems, and hearing & speech problems. Long-term exposure in adults can cause increased risk of high blood pressure, cardiovascular problems and kidney damage. Exposure of pregnant women to high levels of lead can cause miscarriage, stillbirth, premature birth and low birth weight.	Yes
		Arsenic is a naturally occurring metal that can be found in air, water, and soil and is known to cause cancer	Arsenic has adverse effects on various organs and systems viz., cardiovascular system, endocrine system, immune system, Liver, kidney, bladder, nervous system, prostate glands, respiratory system and skin.	Yes

46. https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health
47. https://www.cdc.gov/nceh/lead/prevention/health-effects.htm
48. https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=93&toxid=22
49. https://www.niehs.nih.gov/health/topics/agents/arsenic/index.cfm
50. https://scdhec.gov/environment/your-home/mercury/health-risks-mercury
51. https://www.who.int/news-room/fact-sheets/detail/mercury-and-health

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Production		**Mercury** is a naturally occurring metal that exists in several forms	Exposure to even a small amount of mercury can lead to vision, speech, hearing & walking impairment, numbness in hands, feet & sometimes around the mouth, uncoordinated movement, muscle weakness, skin rashes, mood swings, memory loss & mental disturbances. Depending on the degree of exposure, it adversely affects the following organs & systems - nervous, digestive & immune systems, & on lungs, kidneys, skin & eyes.	No(52)
	Polycyclic Aromatic Hydrocarbons (PAHs) (53,54&55)	**PAHs** are a large group of various organic compounds that contain two or more fused aromatic rings.	They are known carcinogens, mutagens, & teratogens causing impacts on the skin, lungs, pancreas, oesophagus, bladder, colon, & breast. They are also found to be associated with various cardiovascular diseases such as atherosclerosis, thrombosis, hypertension, & myocardial infarction.	Most of the PAHs are carcinogens.

52. https://www.osha.gov/mercury/health-effects#:~:text=According%20to%20Agency%20for%20Toxic,mercury%20as%20possible%20human%20carcinogens.
53. https://www.sciencedirect.com/science/article/abs/pii/B9780123786128002122
54. https://pubmed.ncbi.nlm.nih.gov/35151703/
55. https://www.who.int/europe/publications/i/item/9789289056533

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Production	Radon(56&57)	Naturally occurring Colorless, odorless, radioactive gas	The established health impact due to Radon is Lung cancer.	Yes
	Cyanides (Hydrogen Cyanide (HCN))(58)	Dynamic, potentially fatal chemical that interferes with the body's ability to use oxygen	Following are the symptoms seen immediately after the exposure: chest pain & tightness, confusion, dizziness, eye pain, eye tearing, excitement, difficulty breathing, headache, nausea, rapid or slow heart rate, rapid or slow breathing, restlessness, shortness of breath, vomiting, weakness and wheezing. Exposure to large amounts results in coma, death, high or low blood pressure, loss of consciousness, lung injury and seizures.	No
	Ammonia(59& 60)	Colorless gas with a distinct odour.	Exposure to ammonia can cause headaches, loss of sense of smell, nausea, vomiting, nose and throat irritation, and eye irritation. At high	No

56. https://www.cdc.gov/nceh/features/protect-home-radon/index.html
57. https://www.atsdr.cdc.gov/csem/radon/health_effects.html
58. https://www.cdc.gov/chemicalemergencies/factsheets/cyanide.html
59. https://pubchem.ncbi.nlm.nih.gov/compound/Ammonia
60. https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=10&toxid=2

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Production			concentrations, it leads to hypertension, cardiac arrhythmias, pulmonary oedema and even cardiovascular prolapse.	
	Monomers(61& 62)(Ethylene, Propylene, Styrene, Vinyl Chloride Monomer (VCM), Bisphenol)	Molecules that can undergoPolymerization resulting in constitutionalunits of a macromolecule	Mutagenic, carcinogenic, reproductive toxicant, bioaccumulative and endocrine-disrupting.	Yes
	Initiators(63,64,65,66&67) (free radical initiators, isobutylene, acrylonitrile, butadiene, acrylates, ethylene oxide, and lactones)	Compounds that react with a monomer to form an intermediate compound capable of linking successively with a large number of other monomers into a polymer	Exposure to this category of chemicals results in a range of health impacts such as irritation of the eyes, nose, andthroat, headache, dizziness, lightheadedness, fatigue, carcinogenic (eg: acrylonitrile), itching, skin rash, breathing difficulty, pulmonary oedema, lung injury, diarrhoea and cyanosis. At higher concentrations, they can lead to coma and death.	Mostly Yes.

61. Ibidis 17
62. https://pubs.acs.org/doi/epdf/10.1021/acs.est.1c00976
63. https://www.britannica.com/science/initiator-polymerization
64. https://nj.gov/health/eoh/rtkweb/documents/fs/1045.pdf
65. https://www.cdc.gov/niosh/topics/acrylonitrile/default.html
66. https://www.nj.gov/health/eoh/rtkweb/documents/fs/0843.pdf
67. https://www.osha.gov/ethylene-oxide

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Production	Acid gases(68,69 &70) (eg: HCl in case of PVC production)	The gaseous substances with acidic PH that are known to be toxic, polluting and corrosive	Acid gases cause mild symptoms such as the production of tears, cough, sneeze, and runny nose; moderate symptoms such as difficulty in breathing, difficulty in opening the eyes, and chest pain; serious symptoms such as impossible to breathe, unconsciousness and even death.	Strong inorganic acid gases are carcinogenic (71&72)
	Functional Additives(73)	**Stabilisers** (UV stabilisers and heat stabilisers): **UV stabilisers** are used to prolong the lifespan of plastics by protecting them from photo-degradation (eg: Benzophenones, benzotriazoles (BZTs), hindered amine light stabilizers (HALS), etc). **Heat stabilisers**(74) are used to protect plastics from high heat they may encounter	The UV stabilisers are known to be ecotoxin, and endocrine disruptors, has ability to cause liver toxicity and induce allergies.	Certain UV stabilisers are Carcinogens.

68. https://www.tecnosida.com/acid-gases-nox-sox-h2s-hcl
69. https://www.sentryair.com/blog/industry-applications/chemical-solvents/hydrochloric-acid-vapor-health-risks/
70. https://www.envirotech-online.com/news/air-monitoring/6/breaking-news/what-is-an-acid-gas/49302
71. https://nj.gov/health/eoh/rtkweb/documents/fs/1761.pdf
72. https://www.ilo.org/dyn/icsc/showcard.display?p_lang=en&p_card_id=0183&p_version=2
73. Ibidis 20
74. https://www.sciencedirect.com/science/article/abs/pii/B9780323851268000023

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Production	Functional Additives	during storage or autoclaving (eg: Barium-Zinc formulations, Calcium-Zinc formulations, etc).		
		Flame Retardants (FRs) are used to reduce flammability and spread of fire in plastics. The most commonly used FRs are Brominated/Chlorinated FRs (BFRs/CFRs), Organophosphorous FRs (OPFRs) and Inorganic FRs.	As BFRs/CFRs are persistent and bioaccumulative in nature, they pose serious threats to human health including endocrine disruption, developmental neurotoxicity, and reproductive disorders. Similarly, OPFRs are associated with neurological, reproductive and endocrine-disrupting effects.	Mostly Yes
		Plasticisers are softeners used to enhance the pliability of the plastics (eg: Phthalates)	Phthalates can easily leach into the environment and exposure to the same is found to be associated with	Yes(75)

75. https://www.bcpp.org/resource/phthalates/

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Production	Functional Additives		reproductive disorders with potential transgenerational or multigenerational effects, endocrine disruption, asthma, allergies in children, cardiovascular disease, type 2 diabetes, obesity, hypertension, and increased levels of biomarkers indicative of chronic low-grade inflammation.	
		Biocides(76) are added in the production of plastics to protect the plastic from attack and degradation by microorganisms. Eg: tributyltin (TBT) and bis(tributyltin) oxide), arsenic and arsenic compounds.	Many biocides are irritants & sensitizers and act on the skin, eyes and mucous membranes. They can lead to allergic contact dermatitis and asthma, in particular for occupational users. TBT is genotoxic and shows endocrine effects.	No conclusive evidence.

76. Ibidis 20

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Use Phase	Short- or Medium-chained chlorinated paraffins(SCCPs/MCCPs)(77)	Chlorinated paraffins (CPs) are complex mixtures of chlorinated n-alkanes, usually with 30 to 70% chlorine content by mass.(78)	CPs were found to be associated with liver and kidney toxicity, developmental toxicity, neurotoxicity, endocrine disorders, immune dysfunction, and reproductive toxicity. Their presence was found in human blood, breast milk, placenta, and other tissues.	Yes
	Bisphenol-A and analogues(79&80)	It is commonly used as monomers in polycarbonate synthesis and plasticiser in the production of epoxy resins.	BPA have been shown to interact with estrogen receptors and play a role in the pathogenesis of several endocrine disorders including female and male infertility, precocious puberty, hormone-dependent tumours such as breast and prostate cancer and several metabolic	Yes

77. https://www.sciencedirect.com/science/article/abs/pii/S0048969723025743
78. https://www.agilent.com/cs/library/applications/an-6470-lc-ms-chlorinated-paraffins-5994-5807en-agilent.pdf
79. https://pubmed.ncbi.nlm.nih.gov/25813067/
80. https://www.sciencedirect.com/science/article/abs/pii/S001393511930372X

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Use Phase			disorders including polycystic ovary syndrome (PCOS). It is also associated with multi-organ toxicity affecting reproductive, developmental, metabolic, immune, respiratory, hepatic and renal systems.	
	Heavy metals (tin(81) and cadmium(82))	**Tin** is a naturally occurring soft, white, silvery metal that does not dissolve in water.	Acute exposure to organic Tin leads to eye and skin irritation, neurological problems and exposure to large doses may be lethal. Exposure to large amounts of inorganic Tin causes stomach ache, anaemia, and liver and kidney problems.	No
		Cadmium is a naturally occurring element and is found in combination with other elements such as oxygen, chlorine, or sulphur.	When ingested in large amounts, it can severely irritate the stomach and cause vomiting and diarrhoea. Inhaling high levels leads to lung damage, accumulation in kidneys, and fragile bones can also lead to death.	Yes

81. https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=542&toxid=98
82. https://www.cdc.gov/biomonitoring/Cadmium_FactSheet.html

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Use Phase	Aldehydes (formaldehyde (83) and acetaldehyde (84))	**Formaldehyde** is a colourless, highly toxic, and flammable gas at room temperature.	Formaldehyde exposure can irritate the skin, throat, lungs, and eyes. Chronic exposure can lead to cancer.	Yes.
		Acetaldehyde is a colourless mobile liquid that is flammable and miscible with water. It has a pungent odour but when diluted, has a fruity and pleasant odour.	Acute exposure leads to irritation of the eyes, skin, andrespiratory tract. At higher exposure levels, erythema, coughing, pulmonary edema, andnecrosis may also occur. Chronic intoxication resembles the symptoms of alcoholism.	Probable carcinogen.
	4-nonylphenol (85)	Nonylphenol is an organic compound of the wider family of alkylphenols. It is a product of industrial synthesis formed during the alkylation process of phenols.	Reproductive toxin also causes developmental effects, dermatotoxin and it can also result in toxic pneumonitis.	No

83. https://www.cdc.gov/niosh/topics/formaldehyde/default.html
84. https://www.epa.gov/sites/default/files/2016-09/documents/acetaldehyde.pdf
85. https://pubchem.ncbi.nlm.nih.gov/compound/4-Nonylphenol#section=Carcinogen-Classification

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Post-Consumption Phase	Per- and Poly-fluorinated Substances (PFAs) (86&87)	They are a group of man-made chemicals used to make fluoropolymer coatings.	Exposure to high levels of PFAs may lead to increased cholesterol levels, decreased vaccine response in children, changes in liver enzymes, increased risk of high blood pressure or pre-eclampsia in pregnant women, small decreases in infant birth weights, and increased risk of kidney or testicular cancer.	Yes(88)
	Antimony trioxide(89,90&91)	Antimony trioxide is formed by reacting antimony trichloride with water	Exposure to Antimony maycause respiratory irritation, pneumoconiosis, gastr ointestinal symptoms such as abdominal pain, diarrhea, vomiting, and ulcers, antimonial spots on skin, and impacts cardiovascular and reproductive systems.	Yes
	Dioxins, Furans and Polychlorinated Biphenyls (PCBs)(92)	These chemicals have similar toxicity and chemical characteristics.	Impacts due to low levels are unclear. However, exposure to high levels causes a skin condition	Dioxins and Furans are carcinogens. (93)

86. https://www.cdc.gov/biomonitoring/PFAS_FactSheet.html
87. https://www.atsdr.cdc.gov/pfas/health-effects/index.html
88. https://dceg.cancer.gov/research/what-we-study/pfas
89. Ibidis 20
90. https://www.ncbi.nlm.nih.gov/books/NBK225648/
91. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3037053/
92. https://www.cdc.gov/biomonitoring/DioxinLikeChemicals_FactSheet.html
93. https://environment.govt.nz/facts-and-science/air/air-pollutants/dioxins-furans-pcbs-effects-health/

Life span of Plastic (Phase)	Example of Hazardous Chemicals associated	Description of the Chemical	Health Impacts	Carcinogen
Post-Consumption Phase		They are not manufactured or produced intentionally but are created when other chemicals or products are made especially during burning of forests or plastics.	called chloracne, liver damage, elevated blood lipids (fats), birth defects, affects immune and reproductive systems and eye irritation.	
	Sulphur(94)	Sulphur is a naturally occurring element found in soil, plants and water.	In general, it is low in toxicity. However, exposure to high concentrations of sulphur leads to airway irritation, coughs, skin and eye irritation, and ingesting excess sulfur may cause a burning sensation and diarrhoea.	No

Overall health impacts due to the chemicals associated with petrochemicals and plastics:

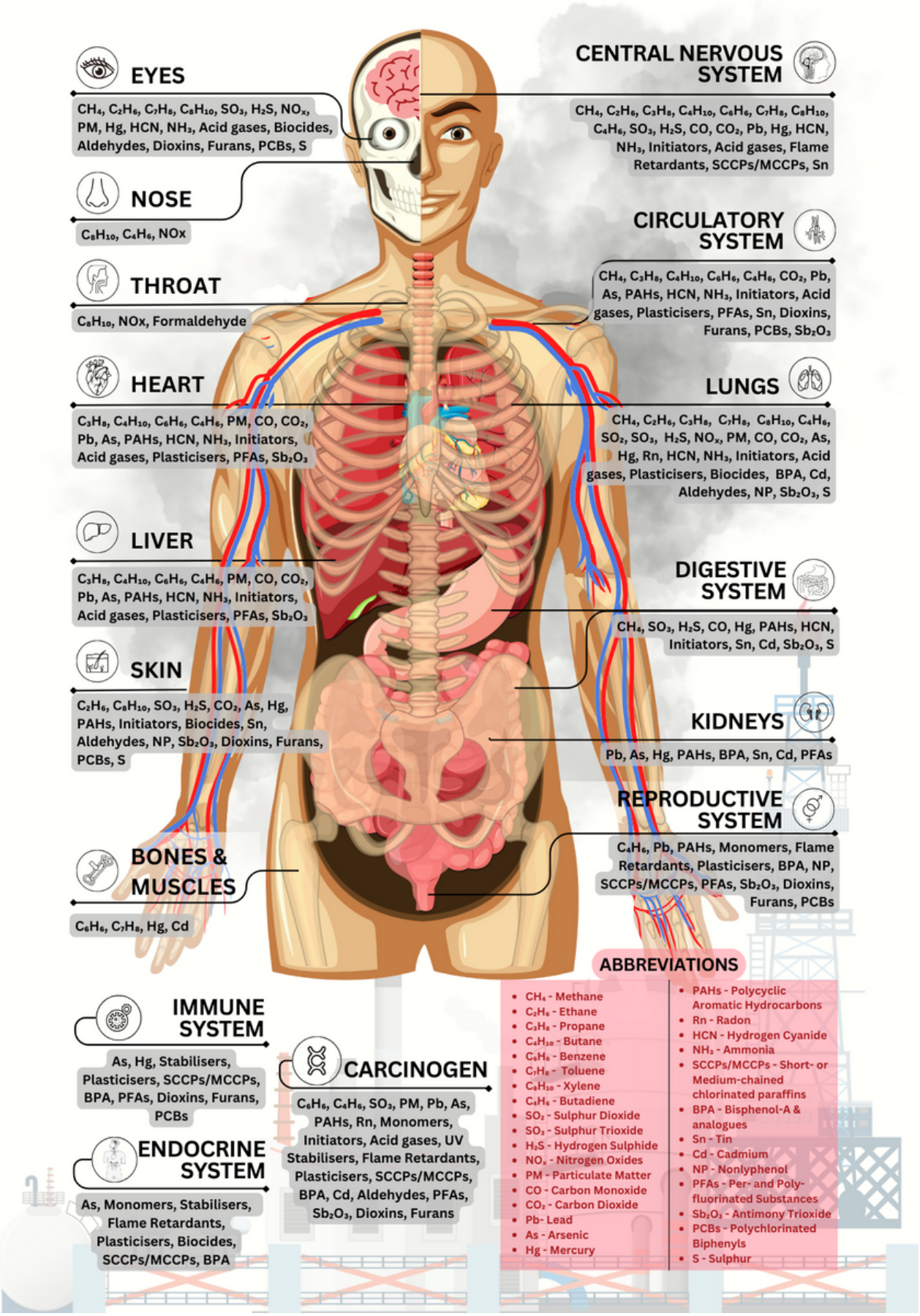
The specific health impacts can vary depending on the types and quantities of pollutants emitted, local environmental conditions, and the proximity of communities to petrochemicals or plastics manufacturing facilities. To understand the impacts of chemicals associated with plastics on human beings, the levels of exposure to the chemicals and the route of exposure are crucial. Human beings are exposed to the chemicals of concern through various exposure pathways such

94. http://npic.orst.edu/factsheets/sulfurgen.html

plastics can cause skin irritation and allergies upon contact with the skin. Additionally, pollutants in the air can lead to skin problems, especially in individuals with pre-existing skin conditions.

- Air Quality Issues: Petrochemical industries contribute to releasing air pollutants such as sulphur dioxide, nitrogen oxides, and ozone precursors. Poor air quality can lead to a range of health problems beyond those mentioned, including exacerbating existing conditions like allergies and weakening the immune system.
- Water Contamination: Petrochemical industries release contaminants into water bodies through wastewater discharge, which affects drinking water sources and aquatic ecosystems. Consuming or coming into contact with contaminated water can lead to various health issues.
- Long-Term Health Degradation: Prolonged exposure to pollution from petrochemical industries can result in chronic health problems that develop over time. These health issues may become more severe and challenging to manage as exposure continues.

95. https://www.sciencedirect.com/science/article/pii/S2772985023000418
96. https://www.news-medical.net/news/20100320/Impact-of-plastics-on-human-health-and-ecosystems.aspx
97. Ibidis 21



Illustrations Describing the Health Impacts Due to the Hazardous Chemicals Associated with Petrochemicals and Plastics

GROUND REALITY

A Case Study on the Public Health Impacts found among the residents around the Petrochemical Industrial Cluster in Panipat, Haryana.

Background:

Based on the analysis of existing literature, petrochemical industries have been extensively studied due to their potential detrimental effects on both the environment and nearby human populations. This case study delves into the health ramifications experienced by local communities residing close to these industries. Utilising firsthand accounts from residents living in these areas, this section of the report aims to elucidate the personal experiences, health-related challenges, and socio-economic repercussions encountered by individuals in these localities.

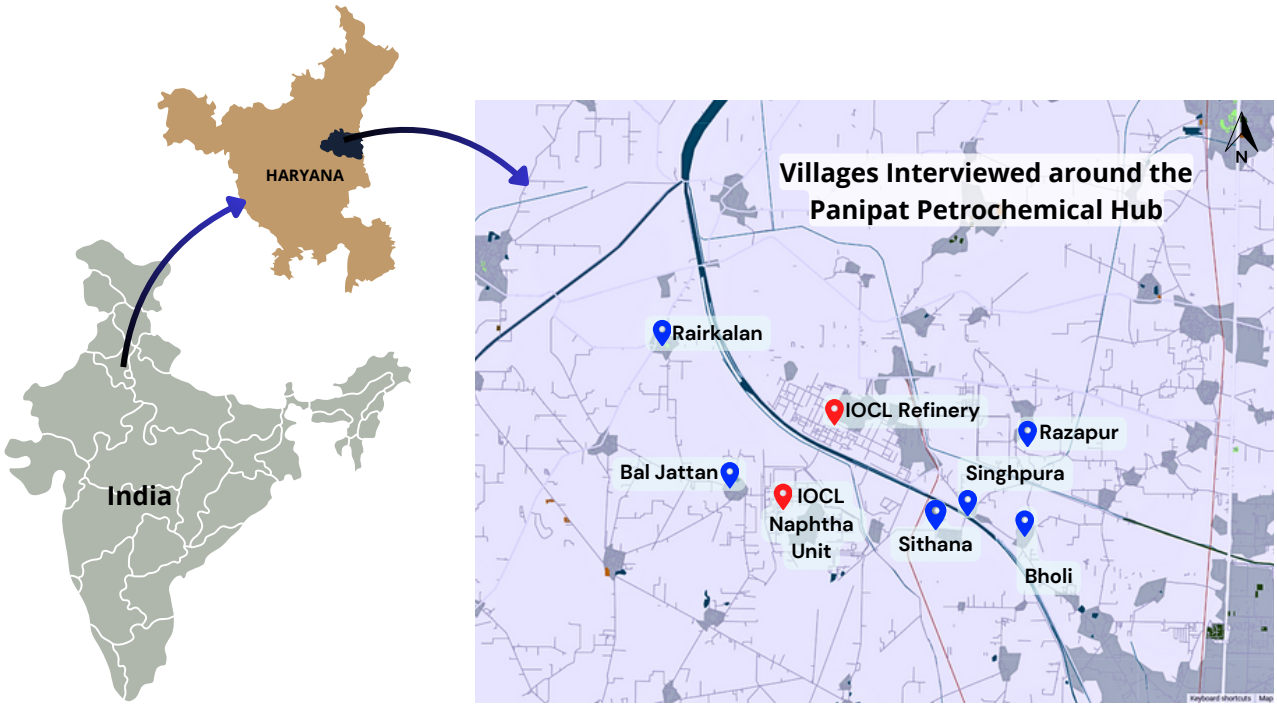
By aligning the real-life narratives of community members with established scientific knowledge, this study endeavours to reveal the similarities, intricacies, and implications of the health consequences endured by these populations. Through this approach, the study aims to provide a comprehensive understanding of the health impacts encountered by residents residing in the vicinity of petrochemical industries.

Methodology:

Structured interviews were carried out within a 5km radius of the Panipat petrochemical industrial hub in six neighbouring villages: Singhpura, Sithana, Bohli, Bal Jattan, Rear Kalan, and Razapur (Map 1). The interviews, conducted in September 2023, varied in duration from 25 to 90 minutes and involved 27 participants aged between 25 and 52 years. An interview guide was used during these sessions. Participants were selected through purposive sampling and verbal consent was sought from each of them. Interviews were conducted at locations and languages (Hindi) convenient for the respondents, ensuring confidentiality. Subsequently, the interviews were translated into English for analysis and reporting. The translated interviews were then analysed to generate codes, themes and statements as provided in Annexure I.

Findings:

These codes, themes, and statements provide a comprehensive overview of the interviews, highlighting the multifaceted challenges faced by



Map 1: Villages interviewed for the study, Panipat Petrochemical hub, Haryana

communities living near petrochemical industries, shedding light on their struggles, health issues, and the larger impact on their socioeconomic well-being.

These statements emphasise the urgent need for corporate accountability, improved healthcare, and sustainable environmental practices. The narratives highlight the human toll of industrial growth, underscoring the importance of a holistic approach to community well-being.

The findings are presented under five themes namely:

1. Health impacts
2. Environmental impacts
3. Livestock Impact
4. Socioeconomic impacts
5. Regulatory Negligence and Social Impact

1. Health Impacts

Living in the vicinity of petrochemical refineries exposes communities to a distressing cascade of health issues. It begins with prevalent respiratory problems, asthma, and skin allergies, especially in children who struggle with breathing difficulties necessitating the use of nebulizers. A respondent underscores this, stating, "The refinery's emissions have led to severe respiratory problems and skin allergies among villagers, especially children." Skin diseases like dermatitis (Fig 3 & 4) and premature hair whitening persist (Fig 5), marking a visible impact on the community's health.

Fig 3: Red lesions on the back of a male respondent

Fig 4: Skin lesion on the hands of a female respondent

Fig 5: Premature hair whitening

2. Environmental Degradation

The adverse impact of the refinery unfolds in a distressing sequence, beginning with air, water, and soil pollution. This has resulted in the degradation of agricultural landscapes, inducing crop damage and a sharp decline in productivity. Similarly, groundwater contamination has posed a serious threat to both ecosystems and communities. Ponds, once serene, bear witness to the refinery's adverse impacts with the presence of an oil film, further jeopardising the available surface water quality (Fig 6). Soot deposits on terraces mark the pervasive nature of pollution, leaving an indelible imprint on both natural and human landscapes. Respondents echo the gravity of the situation, with one noting, "Contamination of water sources and agricultural lands has created significant health and environmental

Fig 6: Polishing pond where effluent discharge from the refinery is collected

concerns." Another emphasizes, "The community across 11 villages faces continuous pollution issues from the refinery, resulting in a myriad of health problems and agricultural crises." Local farmers share their firsthand experience, reporting, "Local farmers witness a consistent decline in crop yield due to dust, emissions, and contamination from the refinery." As individuals shift to refinery-related work, access to agricultural labour declines, further exacerbating the agricultural crisis, as lamented by a respondent, "Access to agricultural labour has dwindled as individuals shift to refinery-related work, worsening the agricultural crisis." The once-fertile land now yields crops damaged by pollution, causing financial losses and despair among farmers, as expressed by a respondent, "Even basic necessities like clean water are a luxury." This distressing chain of events underscores the urgent need for environmental stewardship and mitigation measures to safeguard the well-being of both ecosystems and local populations.

3. Livestock Impact

The repercussions of the refinery extend beyond the human population, affecting the agricultural sector and livestock. The impact on cattle fodder crops is evident as the intense heat and pollution from the refinery cause crops to wither prematurely, fetching lower prices in the market (Fig 7). This decline in the quality and quantity of fodder further strains the livelihoods of those dependent on animal husbandry (Fig 8). The ramifications extend

Fig 7: A cattle in the residential area near the refinery

to the animal kingdom, with buffaloes experiencing irregular pregnancies and reduced milk yield. A respondent captures the gravity of the situation, stating, "Crops wither prematurely, fetching lower prices in the market, while buffaloes suffer irregular pregnancies and decreased milk yield due to the intense heat and pollution." This firsthand account underscores the interconnected challenges faced by the agricultural and livestock sectors due to the refinery's environmental impact. It highlights the urgent need for measures to mitigate these effects and safeguard the livelihoods of those dependent on agriculture and animal husbandry in the affected regions.

4. Socioeconomic Impacts

The ripple effects of the refinery's expansion extend far beyond its immediate environmental impact, profoundly altering the social and economic aspects of communities. The displacement of families due to land acquisition sets off a chain of challenges, with resettled areas lacking basic infrastructure, healthcare facilities, and accessible hospitals. A respondent emphasizes this struggle, stating, "Displaced families face ongoing challenges with limited access to healthcare and educational facilities, highlighting social disparities in the region." Educational opportunities are limited, amplifying the struggles faced by the displaced

individuals, especially the youth, who grapple with challenges in both education and employment. Another respondent speaks to the economic despair faced by the youth, noting, "Youth, once hopeful of refinery employment, are now burdened with odd jobs and meagre salaries, far below their aspirations. The promised development remains elusive, leaving the community in economic despair." The influx of migrant workers further complicates social dynamics, and the resulting high vehicular movement contributes to an alarming increase in road accidents. The displaced individuals face the challenge of limited employment opportunities, leading to financial instability and dependency on the refinery for livelihoods. The challenges extend to tenant farmers, as highlighted by a respondent, "Tenant farmers face a dual burned of reduced crop yield and landlords reaping governmental benefits, highlighting the stark economic disparities within the village." Additionally, the exploitation of workers by contractors, coupled with discrimination and threats against those who speak out, unveils a darker side of the refinery's impact on human rights and workers' well-being. The reduced agricultural productivity due to the expansion of the refinery adds another layer of complexity, causing financial losses and necessitating increased dependency on chemical interventions. The escalation in alcoholism-related domestic violence, as noted by a respondent, reveals the adverse effects on family structures and children's well-being. These multifaceted challenges underscore the urgent need for comprehensive measures to address the socio-economic repercussions of the refinery's expansion and safeguard the well-being of the affected communities.

5. Regulatory Negligence and its Social Impact

The persistent pollution issues despite court orders stemming from the refinery's operations paint a concerning picture, revealing a sequence of negligence and disregard for both environmental and community well-being, as emphasized by a respondent, "Despite court orders, the refinery's negligent implementation of environmental measures continues, aggravating health issues and environmental degradation." The refinery's failure to maintain green belts further exacerbates the environmental impact, with effluents affecting surrounding water bodies, leading to contaminated drinking water and an urgent need for water purification systems. The refinery's negligence extends to employment

employment opportunities, as it fails to provide assured jobs despite documented evidence, leading to an increasing reliance on contract workers who often face exploitation and lack of labour rights. The inadequate response to community petitions and grievances, coupled with the silencing of local leaders through contract works, further limits their ability to advocate for the community's rights. A respondent highlights this, stating, "Despite numerous petitions to various authorities, the refinery's response has been insufficient, leaving villagers in a perpetual state of struggle." As noted by another respondent, "The silence of local leaders, silenced through contract works, echoes the community's despair. The promise of a better life has been shattered, leaving residents disillusioned and disheartened." The pervasive atmosphere of fear, threats, and silence hinders open discussion, deepening the social impact and mental health challenges faced by the community. Another respondent underlines the need for transparency, stating, "Transparent fund utilization and regular health camps are crucial steps that the refinery must take to address the pressing health concerns of the affected communities." The corporation's unresponsiveness fuels a growing sense of resentment, encapsulated by a respondent, "Promises of development ring hollow as the refinery's presence exacerbates social issues, with migrants facing exploitation and increased crime. The corporation's unresponsiveness fuels a growing sense of resentment." This cumulative pattern of neglect demands urgent attention and corrective action to rectify the environmental, social, and economic imbalances caused by the refinery's operations.

DISCUSSION AND CONCLUSION

This report underscores the imperative of prioritising human health considerations in addressing pollution from the petrochemical and plastic industries. While environmental concerns have historically taken precedence, a fundamental shift towards the welfare of human populations is essential. This discussion highlights the pivotal need to transition towards public health measures over conventional environmental remediations.

The spectrum of chemicals released/migrated across the entire life span of plastics poses profound health risks. The health impacts range from mild respiratory symptoms to cancer and even death in extreme cases. Critically, these theoretical ramifications resonate with the conditions prevalent within communities situated in proximity to these industries. Therefore, any mitigation strategy must pivot towards safeguarding their health. Traditionally, our efforts have leaned towards environmental remediations and regulatory compliances. While these approaches remain essential, shifting our focus towards public health is paramount. This shift necessitates a reduction in environmental degradation alongside an unwavering commitment to protect the health and well-being of communities.

Similarly, from the findings of the testimonies of the communities residing near petrochemical industries and comparing these experiences with the findings from the literature review reported in the previous section of the report, striking similarities have emerged, underscoring the profound impact of these industrial complexes on human health. The narratives of skin allergies, respiratory issues, complications during pregnancies, and various other health challenges vividly align with the established knowledge about the chemicals associated with petrochemical industries.

The resonance between lived experiences and scientific understanding emphasises the urgent need for comprehensive regulatory measures, corporate accountability, and community-oriented healthcare interventions. Addressing the health disparities and socio-economic struggles faced by these communities requires a multifaceted approach

that encompasses stringent environmental policies, improved healthcare infrastructure, and meaningful community engagement. This study not only amplifies the voices of the affected communities but also provides a compelling need for further research, policy reform, and advocacy efforts aimed at safeguarding the public health of populations living in proximity to petrochemical industries.

Safeguarding public health mandates equitable access to health information and services. Often, vulnerable communities disproportionately bear the brunt of petrochemical and plastic-related health impacts. Therefore, an equitable framework should facilitate access to information regarding potential health risks and preventive measures.

Ultimately, advocating for a paradigm shift towards safer alternatives and sustainable practices within the petrochemical and plastics industries is quintessential. Beyond curtailing environmental pollution, this transition advocates for developing and adopting materials and processes intrinsically less detrimental to human health. This approach ensures the long-term safety of communities, guaranteeing that the true cost of petrochemical and plastic production does not have a major impact on human health.

In conclusion, we emphasise the importance of prioritising human health. We must attain an equilibrium between our environmental regulations and the protection of human well-being.

Annexure I - Themes, Codes and Statements

Themes	Codes	Statements
Health Impact	• Respiratory problems, asthma, skin allergies. • Breathing issues in children, necessitating nebulizers. • Dental issues in children. • Growth issues in children, both height and weight. • Skin allergies, dermatitis, and hair whitening. • Stomach ache and diarrhoea due to contaminated water. • Impact on pregnant women, including low birth weight and anaemia. • Incidence of epilepsy. • High occurrence of TB and asthma. • Increase in alcoholism-related domestic violence. • High medical expenses incurred by families due to refinery-related health issues. • Increased incidence of cancer, TB, allergies, and complications during childbirth. • Lack of access to medical insurance for many villagers. • Deterioration of overall health, impacting both physical and mental well-being.	"Families in the affected villages incur substantial medical expenses, struggling to cope with health problems stemming from refinery pollution." "The refinery's emissions have led to severe respiratory problems and skin allergies among villagers, especially children." "Limited access to medical insurance compounds healthcare challenges, leaving many without proper treatment options." "The village faces a grave health crisis, with skin allergies, respiratory issues, and even cancer becoming alarmingly common." "For us, pregnancies have become stressful as women face complications, leading to extreme situations like miscarriage" "Despite continuous medication, skin allergies persist, affecting nearly half the population. The lack of proper medical facilities exacerbates the suffering."

Themes	Codes	Statements
Environmental degradation	• Pollution of air, water, and soil. • Crop damage and agricultural productivity decline. • Contamination of groundwater. • Presence of oil film in ponds affecting water quality. • Presence of carbon deposits on terraces. • Impact on wildlife and forest due to land acquisition by the refinery. • Presence of sulphur and LPG smells during emissions.	"Contamination of water sources and agricultural lands has created significant health and environmental concerns." "The community across 11 villages faces continuous pollution issues from the refinery, resulting in a myriad of health problems and agricultural crises." "Local farmers witness a consistent decline in crop yield due to dust, emissions, and contamination from the refinery." "Access to agricultural labour has dwindled as individuals shift to refinery-related work, exacerbating the agricultural crisis." "The once fertile land now yields crops marred by pollution, causing financial losses and despair among farmers. Even basic necessities like clean water are a luxury."
Livestock Impact	• Impact on cattle fodder crops. • Irregular pregnancies and reduced milk yield among buffaloes.	"Crops wither prematurely, fetching lower prices in the market, while buffaloes suffer irregular pregnancies and decreased milk yield due to the intense heat and pollution."

Themes	Codes	Statements
Socioeconomic impacts	• Displacement of families due to land acquisition. • Lack of basic infrastructure in resettled areas. • Limited access to healthcare facilities, and distant hospitals. • Inadequate medical facilities and lack of access to essential medicines. • Limited educational facilities. • Presence of migrant workers affecting social dynamics. • Increase in road accidents due to high vehicular movement. • Limited employment opportunities for displaced individuals. • Challenges in education and employment opportunities for the youth, especially in the refinery. • Reduced agricultural productivity, leading to financial losses and increased dependency on chemical interventions. • Exploitative practices by contractors, impacting workers' financial stability. • Discrimination against workers, exploitation, and threats for speaking out.	“Displaced families face ongoing challenges with limited access to healthcare and educational facilities, highlighting social disparities in the region.” “Alcoholism-related domestic violence has surged, adversely affecting family structures and children's well-being.” "Youth, once hopeful of refinery employment, are now burdened with odd jobs and meagre salaries, far below their aspirations. The promised development remains elusive, leaving the community in economic despair." "Tenant farmers face a dual burden of reduced crop yield and landlords reaping governmental benefits, highlighting the stark economic disparities within the village."

Themes	Codes	Statements
Regulatory Negligence and its Social Impact	• Non-implementation of NGT court orders. • Excessive gas leaks and emissions, particularly at night. • Refinery neglecting green belt maintenance. • Refinery effluents affecting surrounding water bodies. • Refinery impact on local schools and students, hindering growth and concentration capacity. • Absence of health camps organized by the refinery. • Refinery neglecting CSR fund utilization in affected villages. • Refinery failing to provide assured jobs despite documented evidence. • Negligence in providing technical training and employment opportunities for locals. • Contaminated drinking water, requiring urgent installation of water purification systems. • Increasing reliance on contract workers, leading to exploitation and lack of labour rights. • Inadequate response to community petitions and grievances. • Silencing local leaders through contract works, limiting their ability to advocate for the community's rights. • Migrant influx leading to increased crime rates and social challenges.	"Despite court orders, the refinery's negligent implementation of environmental measures continues, aggravating health issues and environmental degradation." "Transparent fund utilization and regular health camps are crucial steps that the refinery must take to address the pressing health concerns of the affected communities." "Despite numerous petitions to various authorities, the refinery's response has been insufficient, leaving villagers in a perpetual state of struggle." "Refinery's unfulfilled promises regarding jobs and technical training showcase corporate negligence, intensifying the social and economic plight of villagers." "The pervasive atmosphere of fear, threats, and silence hinders open discussion, deepening the social impact and mental health challenges faced by the community." "Promises of development ring hollow as the refinery's presence exacerbates social issues, with migrants facing exploitation and increased crime. The corporation's unresponsiveness fuels a growing sense of resentment." "The silence of local leaders, silenced through contract works, echoes the community's despair. The promise of a better life has been shattered, leaving residents disillusioned and disheartened."

TOXIC TRAITS

This report highlights the profound and often hidden human health impacts caused by chemicals associated with the petrochemical Industries and across the life span of plastics.