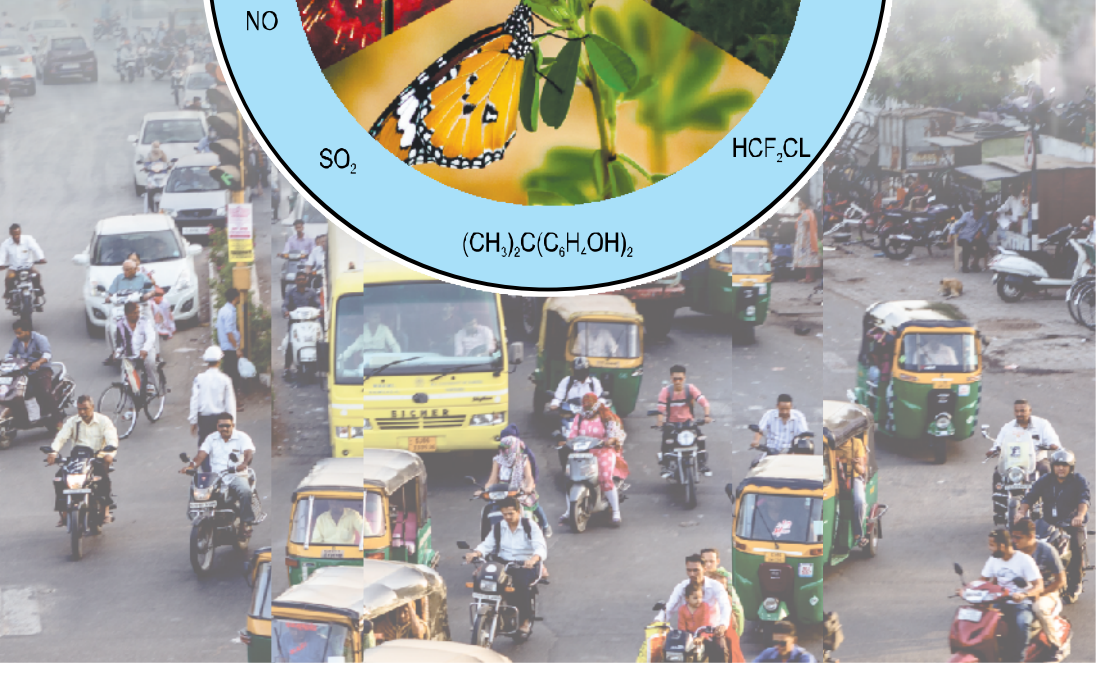
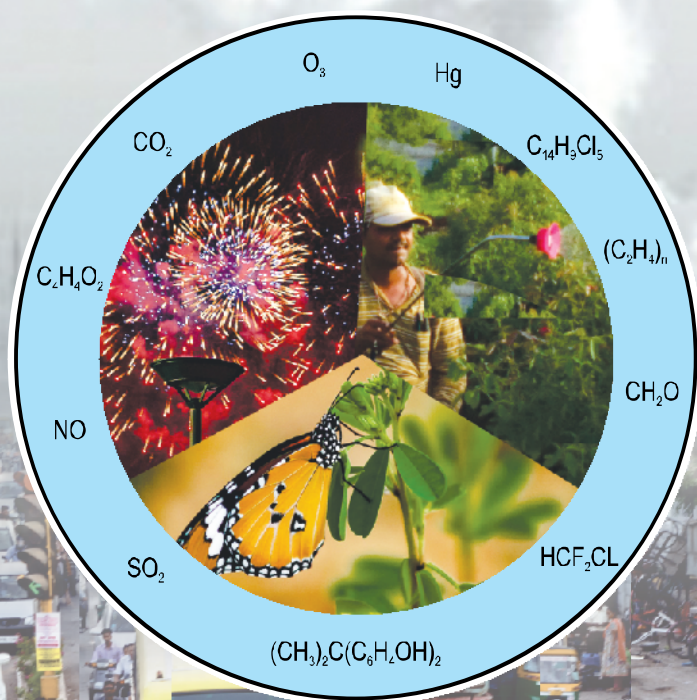


Pollution and Our Health

Dr. Kishor P. Mistry
MD, PhD



Do you Know ?



Half of total plastic items are discarded after one time use.



10% of total solid waste is contributed by plastic.



Every year we use 500 billion plastic bags.



Every minute we purchase 1 million plastic bottles.



1.7 million barrels of oil is used just for plastic bottles production.



Instead of producing new plastic, it's recycling saves 88% energy.



Recycling of 1 ton of plastic can save 1000-2000 gallons of oil.



Prefer to reuse the plastic items.

Photo & Content - Source : Bhumiputra, Dt. 1-6-2018



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Dr. Kishor P. Mistry,
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Preface

Pollution is becoming a critical factor affecting our health by increasing incidence of heart attack, stroke, asthma, Chronic Obstructive Pulmonary Diseases (COPD), cancer, reproductive disorder, diabetes, brain development impairment, etc. Pollution not only affects human, but also other animals and plants. This booklet is written for common people, social workers, students, industrialists and policy makers to increase the awareness for the relation between pollution and health. Through this booklet, I have tried to compile systematically various pieces of information available related to pollution and health. Most of the information has been collected from online resources.

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Your suggestions to improve this booklet will be highly appreciated.

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Abbreviations

BHA = Butylatedhydroxyanisole
BHC = Benzene Hexachloride
BHT= Butylated Hydroxytoluene
BPA = Bisphenol A
CFC = Chlorofluorocarbons
COPD = Chronic Obstructive Pulmonary Diseases
CPCB = Central Pollution Control Board
DBCP = Dibromochloropropane
DDE = Dichlorodiphenyldichloroethylene
DDT = Dichloro-diphenyl-trichloroethane
DEA = Diethanolamine
DECA = Decabromodiphenyl Ether
DES = Diethylstilbestrol
DNA = Deoxyribonucleic Acid
EDCs = Endocrine Disrupting Chemicals
GDP = Gross Domestic Product
IQ = Intelligent Quotient
IR = Infra Red
PAH = Polycyclic Aromatic Hydrocarbon
PBBs = Polybrominated Biphenyls
PBDE = Polybrominated Diphenyl Ethers
PCBs = Polychlorinated Biphenyls
PFCs = Perfluorinated Compounds
PM= Particulate Matter
PPB = Parts Per Billion
PPM = Parts Per Million
POP = Persistent Organic Pollutant
PVC = Polyvinylchloride
TB = Tuberculosis
UV = Ultraviolet
VOC = Volatile Organic Compounds
WHO = World Health Organization

Glossary

Acid rain: Increase in acid concentration of rain water from nitric acid (formed from air pollutant nitric oxides) and sulfuric acid (formed from air pollutant sulfur dioxides). The acidic rain is irritating to skin and damaging to the physical structures.

ADHD (Attention Deficit and Hyperactivity Disorder): A disease in childhood causing child to reduce attention and become physically hyperactive.

Alzheimer's disease: Disease of older person, resulting in difficulty in short term memory and learning new skills.

Autism: A childhood disease resulting into difficulty in communication and forming relation with others. They also exhibit repetitive patterns of behavior.

Asthma: Lung disease caused by allergy from environment. It results into recurrent cough and shortness of breath.

Atherosclerosis: Narrowing of blood vessels by depositing the bad cholesterol.

Biomass: The fuel material derived from plants (wood, dried leaves) and dung.

Biodegradable: A substance is called biodegradable if 80% of it is broken down naturally (mostly by bacteria) within 21 days.

Blue baby syndrome: A disease in child resulting in blue skin from decreased oxygen in blood.

Cardiovascular diseases: Diseases related to blockage of blood vessels in heart and brain, resulting into heart attacks and strokes.

Carcinogens: The chemicals or other agent known to cause cancer.

Chronic Obstructive Pulmonary Disease (COPD): Lung disease caused by smoking and or other causes resulting into recurrent cough and shortness of breath.

Cognition development: Development related to the thinking pattern.

Dengue: A viral disease spread by mosquito causing fever, sore throat, body ache, headache, reduced platelet counts, rash in body and blood in urine.

Dyslexia: Learning disorders in child affecting ability to read and write.

Electromagnetic waves: Energy in the wave form, e.g. microwaves (used in radio, TV, microwave oven), infrared (IR-heat waves), visible light, ultraviolet (UV), X-ray and cosmic waves.

Endocrine Disrupting Chemicals (EDCs): They are the chemicals disrupting the hormone functions. Hormones are secreted in very small quantity from endocrine glands such as thyroid, adrenal, pancreas, pituitary, testes, ovaries, etc. Hormones affect our body by multiple mechanisms including metabolism, growth, sugar control, stress control, sexual functions, etc.

Epigenetic effect: A mechanism in which the chemical affects the expression of genes without causing genetic mutation. Epigenetic effect involves DNA methylation, histone modification, chromatin remodeling, and non-coding RNAs.

Eutrophication: Water pollution by nitrates (from fertilizer) and phosphates (from fertilizer and detergent) act as nutrients to cause excessive growth of algae covering the surface of water and killing other aquatic organisms.

Flame retardant: These are the chemicals (organic compounds containing bromine, phosphorus, nitrogen, chlorine, etc) used in products to inhibit fire initiation and spreading. They are used in the products prone to catch fire, e.g. TV, refrigerator, mobile phones, textile, plastics, furniture, etc.

Fossil fuel: The fuel recovered from deep earth which is formed from the fossils (dead plants and animals) million years ago. They include coal, petrol and natural gas.

Greenhouse effect: Warming of the global atmosphere due to increased concentrations of carbon dioxide, nitrous oxides and methane. These greenhouse gases increase the global temperature by reflecting back the heat (Infrared) waves.

Hypothyroid: Reduced function of thyroid gland, resulting into weight gain, tiredness, constipation, depression, hoarse voice, cold intolerance, etc.

Leukemia: A kind of blood cancer arising from white blood cells.

Lymphoma: Cancer arising from lymph node.

Lyme: A viral disease spread by insect. It causes fever, headache, body ache, joint pain and skin rash.

Leishmania: A parasitic disease spread by sand fly. It causes fever, swelling of spleen and reduction in white cell count.

Parkinson's disease: A disease of older person resulting in resting tremors in fingers or other parts, rigidity of hands and legs, difficulty in walking, slow speech and memory loss.

Particulate Matter (PM): The small particles in the air. They are designated

according to the size in micrometer (μm), for example $\text{PM}_{2.5}$ is of size smaller than $2.5 \mu\text{m}$, i.e. $1/30^{\text{th}}$ width of the human hair. PM particles contain mixture of PAH (Polycyclic Aromatic Hydrocarbon), soot, black carbon, water vapor, sulfuric and nitric acid droplets, metals, organic material and other toxins.

Persistent Organic Pollutants (POPs): The organic (carbon containing) compounds accumulating in fat tissue because they are fat soluble and metabolized very slowly in our body. Thus they can stay in our body for decades to cause toxicity.

Personal care products: They are the products used as soap, body lotion, shampoo, cosmetics, bubble bath, toothpaste, mouthwash, hair spray/gel/pomade, shaving cream, moisturizing lotion, nail polish, perfume, deodorant and antiperspirant and cosmetics like foundation, concealer, mascara, eye shadow, eyeliner, lipstick, lip gloss, etc. About 10,000 varieties of chemicals are used in producing personal care products.

Pesticides: Chemicals mainly used in agriculture to kill pests including insects (insecticide), fungi (fungicide) and weeds (herbicide).

PPM (Parts Per Million): Concentration expressed in terms of how many micro liter or milligram of the substance is present in 1 liter of air or water.

Smog: Smog word is derived from smoke (particulate matter) and fog (water vapor near earth). Smog is caused by air pollution. Typically in winter the smog is formed from particulate matter (derived from vehicles, coal burning, dry waste burning, industry) and fog mixture. During warm weather the smog is formed by photochemical reaction with a mixture of exhaust from vehicles (containing nitrogen oxides, volatile organic compounds), ozone and sunlight. Smog reduces vision resulting in increased road accidents and causes increased asthma, heat attack and stroke.

West Nile Virus: A viral disease spread by mosquito. It causes fever, headache and inflammation in brain and spinal cord.

1. Introduction

Pollution has become one of the most critical issues in our modern time. It has been attributed to increased deaths, global warming and extinction of plants and animals. In 2012, the World Health Organization (WHO) calculated that the exposure to pollution resulted in 8.9 million deaths worldwide. In other words, one out of every eight deaths or 1000 deaths per hour due to pollution.^(1, 2) The uncontrolled pollution can threaten the very existence of our life.

Pollution can be defined as any physical, chemical or biological alteration in the nature (air, water or soil) that can be harmful to the life (human, animal or plant) or to the physical structures (such as building and monuments). The agent causing pollution is called pollutant.

There are various ways of classifying the pollution; one of them is based on the type of pollutant:

a) Pollutants from burning fuel or garbage: Burning of fossil fuel (petrol, coal, and natural gas), biomass (wood, leaves, dung) or garbage creates pollutants in air. They generate pollutants like carbon dioxide, sulfur dioxide, nitrogen dioxide, ozone, volatile organic compounds and Particulate Matter (PM).

b) Pollutants from mining and use of minerals: Minerals such as iron, aluminum, gold, silver, chromium, cadmium, nickel, lead, mercury, etc are extracted and used in various technologies. The process of mining releases toxins, e.g. mercury and cyanides are released in atmosphere during gold extraction. The extracted minerals also can reach to air, water or soil to cause toxicity.

c) Pollutants from sewage: The untreated sewage containing harmful microorganisms (viruses, bacteria, and parasites) and chemicals (e.g. industries, personal care products) are released into water. They pollute water and land.

d) Man-made chemicals: These are the chemicals created by human beings, e.g. chemicals used in plastic, color, fragrance, medicine, pesticide, fertilizer, cosmetic, etc. They can pollute air, water and soil.

e) Miscellaneous pollutants: They include thermal, electromagnetic waves (e.g. microwaves, Infra Red, visible light, Ultra Violet radiations), radioactivity, noise, etc.

Second method of classifying pollution is based upon the types of media polluted, according to which it can be pollution of air, water, soil and food.

The third type of classifying pollution is based on its toxicity, e.g. cancer, endocrine (hormone related) dysfunction, heart attack, stroke, asthma, reproductive dysfunction, immune dysfunction, damage to cellular structure and DNA (genetic material) and development of body.

The major sources of pollution in cities are vehicles and industries, while in villages they are indoor biomass burning, agriculture and mining. Common sources of pollution in both rural and urban areas are sewage and personal consumer products such as soap, detergent, shampoo, cosmetics, perfumes, etc.

The industrialization during last two centuries has gifted us many inventions such as machines, railway, vehicles, electricity, telephone, TV, computer, pesticides, fertilizers, medicines, plastics, colors, fragrances, preservatives, fabrics, etc. Inventions have increased our capacity of industrial and agricultural productions, accelerated the speed of transport, enhanced communication, protected us against diseases and provided safety against natural disasters. Now our life is safe, comfortable and luxurious. Globally, the human life span has increased from around 30 years in 15th century to 67 years in 2010 and in many developed countries it has reached to 80 years. Deaths from famines are rare. During 1804 to 2015, even though the human population increased seven fold (from 1 to 7 billion); the GDP (thus the prosperity) per capita has increased 10 fold. This spectacular growth is unfortunately associated with pollution. For example, the agriculture production has increased almost four folds during last 65 years because of irrigation, hybrid seeds, chemical fertilizers and pesticides. Just 1-3% population working as farmers are able to feed the rest of others in US/Europe. This is a miracle of technology. However, there are two hidden costs associated with industrialization of agriculture. One is the pollution from fertilizer and pesticides.⁽³⁾ The other issue is a use of very high amount of fossil fuel energy. If we count the energy used in tractor, irrigation, synthesis of fertilizer and pesticides, processing, packaging, transport, etc, then the result is an input of 10 calories of fossil fuel to obtain an output of 1 calorie in food. This kind of food production is not sustainable due to its dependency on exhaustible fossil fuel.⁽⁴⁾

Thus, economic growth depends on the technological uses of natural resources such as non-renewable fossil fuels and minerals. In fact per capita use of fossil fuel energy is directly related with GDP. Minerals are non-renewable but recyclable. Fossil fuels are non-renewable and non-recyclable, that means they are lost forever after one time use. It takes millions of years to produce fossil fuels by

nature. Currently, average human being uses natural resources 1.6 times more (4-6 times more for Western lifestyle) than the earth's regenerative capacity, which is obviously unsustainable.⁽⁵⁾

Every day we are exposed to man-made (artificial) chemicals through soap, detergent, fabrics, paints, artificial fragrance, perfumes, preservatives in food, cosmetics, hair dyes, pesticides, fertilizers, medicines, plastic, etc. These chemicals can enter our body through breathing, eating, drinking, and/or penetrating the skin. Since the production of chemicals is a continuous process, their concentrations in air, water, soil, food and body will rise along with increased toxicity.⁽⁶⁾

The issues related to man-made chemicals are complex and multiple:

- a) Human synthesizes about 140,000 chemicals (compared to 25,000 naturally occurring chemicals in our food) and introduces 1000 new chemicals each year. Of the 140,000 man-made chemicals, 93% chemicals are used without knowing the toxicities. There are no government regulations mandating the toxicity study of chemicals

(besides medicines) before they are produced and marketed for the public use.^(7,8)

Human is using 140,000 synthetic chemicals, out of which only 7% are studied properly for toxicity. Of them about 1000 are identified as endocrine (hormone) disruptors and 248 as carcinogens.

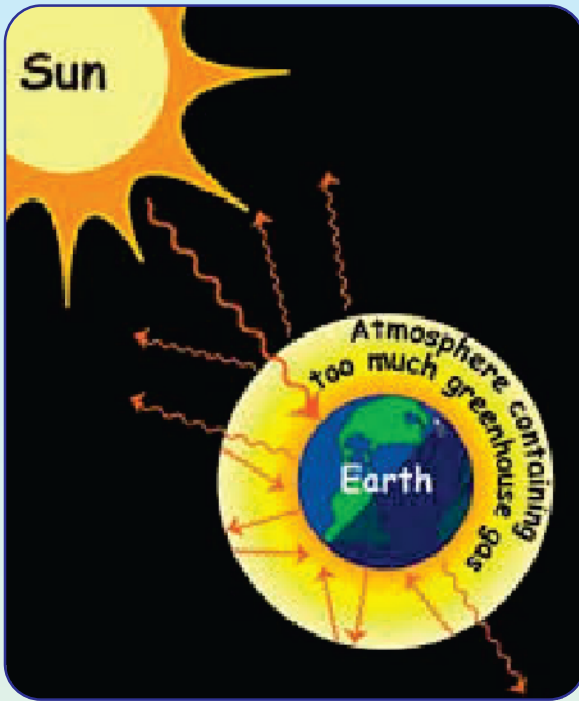
- b) Chemicals can be harmful to many parts of our body through multiple mechanisms. Thus, it is highly complex, time consuming and expensive to study the multiple toxicities. The toxicity study becomes more complex for the various mixtures as they occur in real life. For example, tobacco smoking coupled with asbestos exposure increases the risk of lung cancer by 25-fold—a risk much higher than that is resulting from the sum of the risks of the individual agents.⁽⁹⁾ The complexity for studying the toxicity is further increased for the chemicals which are converted to another toxic compounds in the body, e.g. DDT is degraded into DDE toxin.
- c) The toxic effects can take decades to realize. Mosquito controlling DDT was introduced in 1939. In 1962 a scientist, Rachel Carson, published a book “Silent Spring” showing toxicity of DDT in animals; however, that time she was ridiculed. Finally, DDT was banned in 1969 after 30 years of use and 75



Indoor pollution from using biomass fuel kills people prematurely due to stroke, heart attack, Chronic Obstructive Pulmonary Disease, pneumonia, TB and cancer. (Photo : Vasant Panchal)

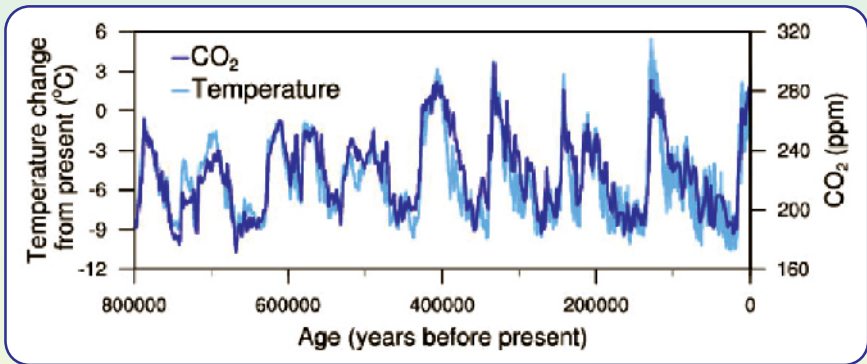


Firecracker use releases pollutants including carbon dioxide, carbon monoxide, nitrogen oxides, hydrogen sulfide, PM and toxic metals. (Photo: Vasant Panchal)



About half of the solar radiation reaches earth, other half is absorbed or reflected by earth's atmosphere. The solar energy absorbed by the earth is radiated in the form of heat (IR) waves. These heat waves are absorbed and re-radiated by the greenhouse gases in earth's atmosphere, thus warming up the earth like a closed glass house in which plants are grown.

(Source : <https://climatekids.nasa.gov/review/greenhouse-effect/>)

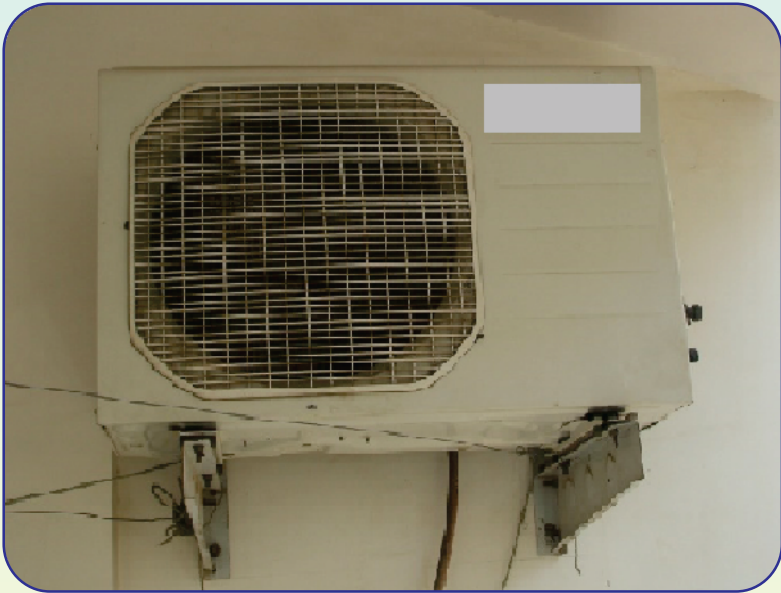


During last 800,000 years the cyclic variations in carbon dioxide levels have matched with temperature changes.

(Source : <https://www.ncdc.noaa.gov/global-warming/temperature-change>)



Cyclic changes in atmospheric carbon dioxide during last 400,000 years ranged 180-300 ppm; however, recently it has crossed 400 ppm. This unprecedented increase in carbon dioxide is feared to cause excessive global warming. (Source: <https://globalclimate.ucr.edu/resources.html>)



AC cannot be the solution for global warming, because it can reduce temperature in a room, but releases heat more outside because of 1/3 efficiency, thus AC can exacerbate global warming.

(Photo: Kishor Mistry)



Idol immersion in lake, river or ocean leads to pollution from Plaster of Paris, plastic, paper, thermocol and toxic colors. From such activity about 6 feet Plaster of Paris is accumulated in the lake of Sursagar of Vadodara, cleaning of which may cost Rs 7 crore.

(Photo: Vasant Panchal)



Textile industries use about 10,000 man-made chemicals, of them few are known carcinogens. (Photo: Kishor Mistry)

years later it has been declared as cancer causing chemical. Thus, it can take years to formulate the safe limits for the toxicant. For example, the safe level of lead in the child's blood was gradually reduced by American government from 60 µg/dl in 1960, to 30 µg/dl in 1975, 10 µg/dl in 1991 to 5 µg/dl in 2012. Now, according to WHO, there is no safe level of lead in the body. A similar doubt is raised against the currently suggested safe level of PM_{2.5} (Particulate Matter smaller than 2.5 µg) in air.^(2,10)

- d) Many chemicals can stay in our body for decades to cause toxicity, e.g. POPs (Persistent Organic Pollutants), methyl mercury and lead. DDT (a kind of POP) was detected in American blood after 33 years of its ban.
- e) The toxic chemicals can reach to unborn baby through mother's placenta and after the birth it can reach the infant through breast milk. Such an early exposure can affect the development permanently. For example, prenatal exposure to lead, methyl mercury or pesticide chlorpyrifos can impair the brain development irreversibly.⁽¹¹⁾ A drug thalidomide was first marketed in 1957 for insomnia and morning nausea in pregnancy. However, it caused a serious birth defect called phocomelia (very short hands and legs) in 10,000 newborn babies and it was banned in 1961.
- f) The industrialists are generally not interested in studying the chemical toxicity since it is not a legal requirement except in case of medicines. In fact they may manipulate the media and policy makers for their financial interest. This has been documented historically in cases of lead, tobacco and DDT. In 1920s a company advertised that "Lead helps to guard your health" and the safety of lead paint was advocated by showing children painting toys, cabinets and walls. That time the lead was not tested for its toxicity. Later on, the studies showed that the lead exposure can result into a permanent brain damage by lowering IQ and school performances. The industrialists rejected these reports. Then they attacked the scientists by accusing them for scientific fraud and even filed charges against their university in USA. The assault went on for three years. Finally the fraud charges were proven baseless and the use of lead in petrol was discontinued in 1975. Now the use of lead in paints is also restricted.⁽¹²⁾

Our body is interconnected with the surrounding air, water and soil. Every day, an adult breaths 11,000 liters of air, drinks 6 liters of water and consumes food (equivalent to 500 gram cereals) derived from soil, water and air. Thus, all of us are

interconnected with shared sources of air, water and land. When we discard anything in garbage or flush into toilet or burn off in air or let it wear and tear; it does not disappear, but it

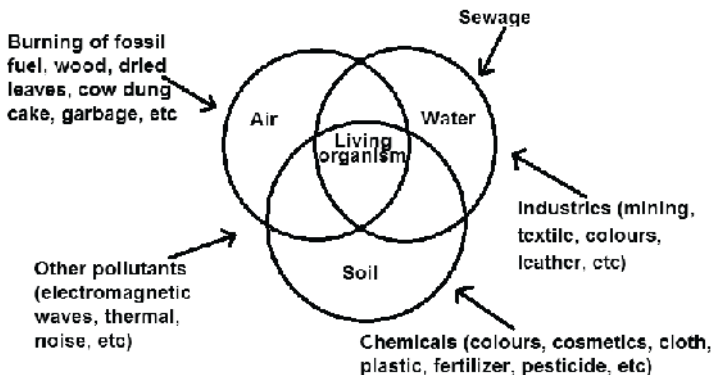
All of us are interconnected with common sources of air, water and land. Thus, someday the pollutant from air, water or soil can reach our body.

becomes a part of our common source of air, water and soil. Thus, it is not surprising that any pollution potentially can reach our body. In fact scientists have identified more than 200 industrial chemicals in human blood and breast milk. The man-made chemicals have also reached to distant Polar Regions where there are no industries. Thus, the sin of pollution generation can be local but its toxic punishment is global.

There are many ways to measure the impact of pollution, e.g. number of premature deaths, disability and loss of GDP. Disability is measured as the DALY (Disability Adjusted Life Year), i.e. a loss of human life years due to disability or death. For example, the top ten causes of chemical pollution are: lead battery recycling, lead smelting, mining, solid waste, chemical manufacturing, dye industry and product manufacturing. The DALY calculated from these ten causes is 17 million years, which is bigger than 7 million DALY from combined causes of malaria, HIV and TB.^[6]

Pollution not only affects human beings, but also other animals and plants. For example the vulture population declined drastically due to the toxicity of a pain

Interconnection of environment and life



medicine, diclofenac, used for animals. After banning its use for animal in 2013, the vulture population started rising. During last few decades, the populations of butterfly, frog, sparrow and crows are declining probably due to pollution. Animals and plants not only make our life more enjoyable, but they are also useful for our survival directly or indirectly.

Historical studies have revealed disappearance of ancient cultures due to over exploitation of nature. The Mayan empire in Central America peaked during AD 600 and started declining in AD 850, which is thought to be due to the drought from excessive deforestation. Similarly, human population in Easter Island flourished between 400-1500 AD, then it almost disappeared by 17th century due to deforestation and soil erosion, leading to starvation and even cannibalism (human being eating human being). We can extrapolate such destructive model for the earth which is like a big island and the only planet known habitable to us. That is why it is essential to save this earth from pollution.

2. Air Pollution & Health

Air is our basic and vital need, and its free availability is taken for granted. But time has changed now that we have to worry from the news like “In Delhi the schools are closed due to high level of air pollution” or “Air pollution kills 5000 Indians everyday”.⁽¹³⁾

Natural air contains 78% nitrogen, 21% oxygen and 1% other gases like argon and carbon dioxide. Major air pollutants are: Particulate Matter (PM), sulfur dioxides, nitrogen oxides, excess carbon dioxide, carbon monoxide, ozone and volatile organic compounds.

PM particles contain mixture of PAH (Polycyclic Aromatic Hydrocarbon), soot, black carbon, water vapor, sulfuric and nitric acid droplets, metals, organic material and other toxins. Effect of PM depends upon its size: the particle of size $>11\ \mu\text{m}$ is trapped in nose, $2.5\text{-}10\ \mu\text{m}$ (PM_{10}) can reach to the lungs and $<2.5\ \mu\text{m}$ ($\text{PM}_{2.5}$) ($1/30^{\text{th}}$ the width of a human hair which is $70\ \mu\text{m}$) can penetrate the blood vessels. $\text{PM} >10\ \mu\text{m}$ can settle on ground but smaller particles are carried over long distances. WHO reported that about 71% of cities in the world have higher levels of $\text{PM}_{2.5}$ in the air than recommended.

Air quality guidelines (Average annual levels in $\mu\text{g}/\text{m}^3$)

Agency	$\text{PM}_{2.5}$	PM_{10}	Nitrogen dioxide	Sulfur dioxide	Ozone
WHO	10	20	40	20	100
CPCB (India)	40	60	40	50	100

$1\ \mu\text{g} = 1/1000\ \text{mg}$

WHO = World Health Organization

PM = Particulate Matter

CPCB = Central Pollution Control Board

Sources of air pollution:



Adult human needs 2000 kcal from food. Every day, an American uses the fossil fuel equivalent to food calories needed for 100 persons. Fossil fuel is non-renewable and it is a major source of air pollution as well as for global warming. Obviously, such a life style is non-sustainable.

Air pollution related to fossil fuel use: About 90% of all energy that we use to maintain the lifestyle (transport, electricity, industrial and agricultural productions, etc.) comes

from non-renewable fossil fuel. In every second the world burns 166,000 liter oil, 284,000 kg coal and 108 billion liter of gas, which is equivalent to five Hiroshima bombs blast. Average American uses fossil fuel energy equivalent to the food energy needed for 100 persons. Fossil fuel dependent growth is non-sustainable since fossil fuel will be exhausted someday. Fossil fuel burning generates 21 billion tons of carbon dioxide annually, of which half is absorbed by natural processes (e.g. by plant's photosynthesis) and the remaining 11 billion tons is added to our atmosphere every year. During 2015, the fossil fuel burning also produced 80 million tons of sulfur dioxide and 107 million tons of nitrogen dioxides. Fossil fuel use is the main culprit to air pollution since it contributes to >99% of sulfur dioxide, >99% of Nitrogen oxides, 85% of PM_{2.5}, 92% of carbon monoxide and 66% of Volatile Organic Compounds in the air. Every year one car dumps over four tons (about 80 times the weight of an adult person) of pollutants in the air. Vehicles use has also reduced walking exercise resulting into increased incidences of obesity, diabetes and heart diseases.^(3,13,14)

Air pollution related to biomass burning: Common people think that wood is a natural non-harmful substance. However, its burning emits many pollutants such as PM (2-10 μm), carbon dioxide, carbon monoxide, sulfur dioxide, nitrogen oxides, phenols, cresols, benzene, styrene, formaldehyde, benzopyrene and other PAHs, naphthalene, hydrocarbons, lead, etc. Near the cooking location the concentration of PM can exceed more than 100 times the safe level. According to 2010 census, in India 87% of rural and 26% of urban population uses biomass for cooking.⁽²⁾ Cremation of one dead body requires burning of about 500 kg of wood that produces air pollutants.

Air pollution related to ozone: Both the increase and decrease of ozone can be harmful depending upon where it occurs. Air pollution from nitrogen dioxides and volatile organic compounds increase the ozone formation near land, which causes respiratory problems and smog formation. On the other hand air pollutant chlorofluorocarbons (CFCs - chemicals used in Air Conditioners and refrigerators)

caused ozone depletion in stratosphere leading to increased exposure to UV light to our body.

Pollution from second hand smoke: In tobacco smoke there are 172 toxins, of which 67 are carcinogens. Now many countries have banned smoking in public space; however, it continues as indoor pollutant that finally mixes with outdoor air.

Air pollution related to fireworks use: Fireworks are made from paper, sulfur, nitrate, perchlorate and various toxic metals. The metals are added for color displays, for example strontium for red, aluminum for white, copper for blue, barium for green and rubidium for purple colors. Firecracker use releases pollutants including carbon dioxide, carbon monoxide, nitrogen oxides, hydrogen sulfide, PM and metal particles.

Air pollution from man-made chemicals: Volatile chemicals used inside and outside the home contribute to air pollution. Examples are: volatile organic compounds from wall or furniture painting, petrol, spraying pesticides, use of perfumes, etc.

According to a 2015 report, 11 out of the world's 20 worst air polluted cities are in India. The average PM in Indian cities was found six times the upper limit set by WHO, and in New Delhi it can reach up to 13 folds. This is expected to get worse from growing Indian economy. In many Indian cities the average PM was $153 \mu\text{g}/\text{m}^3$ which is about 10 times higher than in the cities of developed countries such as New York and London. Thus, a better public policy implementation is crucial in controlling the air pollution.^(2,2)

Air pollution and diseases:

Air pollution contributes to 72% of total deaths due to all pollution. During 2015, the air pollution killed 6.5 million people worldwide, in other words 18000 deaths every day! In India air pollution killed 5000 people per day during 2015. Air pollution in India is associated with a reduced life span of 2-3 years. As a cause of death the air pollution is ranked 4th after poor diet, high blood pressure and smoking.⁽¹³⁾

Air pollution increases the incidence of lung diseases (asthma, Chronic Obstructive Pulmonary Disease, pneumonia, TB, lung cancer), cardiovascular diseases (heart attack, stroke, high blood pressure, atherosclerosis, blood clotting), and reproductive diseases (preterm babies, low birth weight, miscarriage, still birth). Few examples of such relations:

- a) A study in Hyderabad showed that fireworks during Deepavali increased the levels of potassium, aluminum, and strontium by 25, 18 and 15 folds respectively as compared to a normal day. This was associated with 125% increase in cardiovascular (heart attack, stroke) deaths. Another study documented that during Deepavali in Kolkata, the $PM_{2.5}$ increased 34 times the upper limit recommended. Also, the concentrations of toxic metals like barium, copper, cadmium, lead, mercury and aluminum increased by 57, 79, 17, 15, 12 and 6 folds respectively compared to the previous day.⁽¹⁵⁾
- b) During 2012, the indoor pollution killed 4.3 million people prematurely in the world mainly from stroke, heart attack, Chronic Obstructive Pulmonary Disease, pneumonia, still births and lung cancer. Indoor pollution increases risk for Chronic Obstructive Pulmonary Disease 2.5 fold, lung cancer 1.7 fold, asthma 1.6 fold, cataracts 1.3 fold and TB 1.5 fold.^(1,16,17)
- c) Multiple studies have shown the toxicity of $PM_{2.5}$ is associated with increased incidence of lung cancer, heart attack, stroke, autism, ADHD (Attention Deficit Hyperactivity Disorder), lower IQ, asthma, Chronic Obstructive Pulmonary Disease, reduced immunity and decreased brain volume.^(10,18)
- d) A study in Bengaluru showed 54% residents suffered from cough and 25% with dust allergy. Another study showed that about 47% of Kolkata's population suffered from lower respiratory tract symptoms, which was seven times higher than their rural counterparts.⁽¹⁹⁾
- e) New Delhi is one of the worst air polluted city in the world. This is associated with four fold increase in cardiovascular diseases (stroke and heart attack) and 1.7 times respiratory diseases compared to nearby rural population.⁽⁶⁾ One study estimated a loss of 6.4 years of life span in New Delhi residents due to air pollution.⁽²⁰⁾
- f) Studies have shown that air pollution can reduce the lung function permanently in children.⁽²¹⁾
- g) European study found that the number of new cases of Chronic Obstructive Pulmonary Disease (COPD) was directly related to how close the person lived to the busy roads and the severity of exposure to nitrogen oxides in the air.⁽²²⁾

- h) Mosquito coil burning is common in India to repel mosquito. It releases toxic ingredients such as allethrin (causing itching, tingling, burning sensation and potential convulsion), octachlorodipropylether (a lung carcinogen) and other carcinogens (formaldehydes, benzene, benzo[a]pyrene, benzo[b] fluoranthene and benzo[k] fluoranthene). One coil burning releases PM_{2.5} particles equivalent to burning of 75-137 cigarettes and formaldehyde equivalent to burning of 51 cigarettes.⁽²³⁾

Toxic effects of air pollution

Air pollutant	Toxicity
Particulate Matter (PM)	Lung cancer, asthma, Chronic Obstructive Pulmonary Disease (COPD), heart attack, stroke, diabetes
Carbon dioxide	Global warming, ocean acidity
Carbon monoxide	Headache, unconsciousness, death, smog, miscarriage, low birth weight
Methane	Global warming
Sulfur dioxide	Acid rain, asthma, reduction of agriculture production
Nitrogen oxides	Asthma, Chronic Obstructive Pulmonary Disease (COPD), acid rain, global warming
Ozone	Asthma, Chronic Obstructive Pulmonary Disease (COPD), reduces agriculture production, smog
Volatile Organic Compounds	Benzene, toluene & xylene can cause leukemia, irritation of eye and throat, headache

3. Air Pollution & Global Warming

Globally, the average temperature of land and ocean has risen by 0.85 °C during 1880 to 2012. Recent three years (2014, 2015 and 2016) were the hottest in the last 137 years of record. Compared to natural fluctuations of temperature this global warming is 25 times faster. The greenhouse gases (carbon dioxide, nitrous oxides and methane) increase the global temperature by reflecting back the heat (Infrared) waves, thus acting like a blanket. Our survival is made possible by the natural greenhouse effect, without which the earth temperature will be -20 °C instead of current 15 °C degree. However, too high levels of the greenhouse gases can be disastrous due to excessive global warming. Since 1750 the concentrations of greenhouse gases carbon dioxide, methane and nitrous oxide have increased by 40%, 150% and 20% respectively.⁽²⁵⁾ Carbon dioxide concentration in the atmosphere has increased from 280 ppm in 1800s to 403 parts per million (ppm) in 2016. The carbon dioxide (mainly from fossil fuels burning) is a major contributor (76%) to the greenhouse effect. The greenhouse contributions of other gases are 13% by methane (from biomass burning, animals, and rice paddies), 6% by nitrogen oxides (from biomass burning, fossil fuel burning) and 5% by chlorofluorocarbon aerosols (from AC and refrigerator). The potency for greenhouse effect relative to carbon dioxide is 62 fold for methane, 275 fold for nitrous oxides, and 4900-10200 fold for CFC; however, their relative concentrations are much lower than carbon dioxide.^(2,16,24)

During the last 65,000 years, seven natural cycles of temperature changes are linked with small change in the earth axis. However, warming of earth observed since the middle of 20th century is too high to be explained by such natural cycle. Natural causes of warming include changes in earth axis, sun output, earth's volcanic activity, etc. In fact most warming has occurred during the last 35 years. The solar energy output has not changed much since 1750, thus it does not look to be responsible for recent global warming. The Intergovernmental Panel on Climate Change has analyzed the effects of natural events such as sunspots and volcanic eruptions on the climate; however, they cannot explain fully the recent warming trend.

The greenhouse effect of carbon dioxide is supported by many observations:

- a) Industrialization has resulted in increased carbon dioxide and global temperature.

- b) Depending upon the amount of carbon dioxide in the atmosphere of planet, its average temperature is determined. Venus planet has air density 93 times that of earth along with 97% carbon dioxide in its atmosphere, and these are associated with very high temperature of 440 °C. On other side the Mars is too cold (temperature -53 °C) because of its air density is 1/150th of the earth. Compared to these the earth temperature is 15 °C. Thus life is possible on earth but not on Venus or Mars.
- c) Experimentally it has been shown that greenhouse gases increase temperature.

Two main objections have been raised against the association between carbon dioxide and global warming:

- a) One is the observation that the historic rise in global temperature has preceded the carbon dioxide increase, which is reverse to the expectation. The reason for this disparity is not yet fully understood.
- b) Another objection raised is that during 1940-70 the global temperature dropped even though the increased use of fossil fuels was associated with increased carbon dioxide in air. This was probably due to increased amounts of sulfate aerosols in the atmosphere and slight downturn in solar activity. However, in later part of the 20th century the temperatures rose well above the level of 1940s.⁽²⁶⁾

In order to explain such objections, we should consider the contributions of multiple factors rather than focusing on carbon dioxide. One of such factors is increased entropy during use of energy in performing any work, i.e. increased disorder associated with heat generation. Any work that we perform (e.g. driving vehicle, electricity generation, gadget use, an industrial production, etc) has an efficiency of about 30%. That means about 2/3 of the used energy is lost mainly in heat leading to increased surrounding temperature. For example, we feel hot in a closed theatre (unless Air Conditioner is nullifying it) packed with many people who are discharging heat while using food energy to keep their body functioning. As per the rule of entropy, the use of AC will finally lead to higher global temperature than not using it. To understand the involvement of multiple factors in global warming, let us review the mechanisms involved in faster warming of cities. Cities are warmer than villages by 1-3 °C during day time and up to 12 °C during night time. This phenomenon is known as Urban Heat Island effect. The reasons for warmer urban areas are multiple. Compared to villages, cities have

about 50 times higher density of human population and they consume about 75% of total fossil fuel, both of which leads to more heat release into surrounding. Cities also have more roads covered with black asphalt which absorbs more solar energy, fewer trees (thus reduced cooling effect of transpiration, i.e. a process of water vaporization from leaves), more pollution, etc.^[27] The level of carbon dioxide in urban atmosphere is reported to be about 5% higher than that of rural, thus it cannot fully explain Urban Heat Island effect.^[28] If we assume that the urban life is a major contributor to global warming, then the various factors listed here for Urban Heat Island make better sense in explaining global warming rather than narrow focusing on carbon dioxide.

When the temperature is increased, the water vapor is increased in air, which is a strong greenhouse gas creating a vicious cycle of global warming. But in all these various explanations, the origin of problem lies in the fossil fuel use acting like an extra burner on earth. Thus the only way to reduce global warming is to reduce fossil fuel energy consumption.

Further studies are needed to determine more precisely the relative contribution of multiple factors of human activities versus natural cycles in the rise of global temperature.

Consequences of increased greenhouse gases and global warming:^[10, 29, 30, 31]

- a) **Ocean warming:** The water of the ocean covers about 71% of the earth surface ($360\,600\,000\text{ km}^2$) with an enormous volume of $1,334,900,000\text{ km}^3$. This huge volume and higher heat storage capacity compared to air, makes the ocean water to absorb the heat 4000 times more effectively than air. One estimate shows that ocean has absorbed more than 93% of the heat generated by anthropogenic (man-made) global warming. We do not fully understand its consequences. A worldwide study has revealed that during 2001 to 2010, glaciers have melted at an alarming 2-3 times faster than the average during 20th century. This can affect the 10% world population living close to sea due to ocean flooding. The other potential consequence can be the depletion of ocean oxygen which can adversely affect the ocean lives. The global warming may accelerate the release of green house gases such as carbon dioxide and the frozen 2.5 Giga ton of methane hydrate lying in the sea floor, both of which can further increase the global warming. Carbon dioxide is also absorbed by ocean water making it more acidic. During past 30 years about half of the corals have died in the Great Barrier Reef due to climate changes. Acidification also leads to increased release of toxins (e.g. microcystins) from algae.

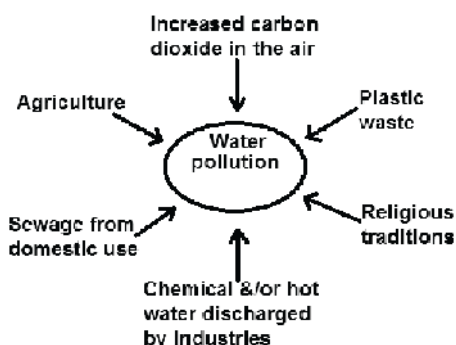
- b) **Increased insect born diseases:** Potentially global warming will increase the multiplication and survival of insects like mosquito, ticks, fleas, flies, etc. This will increase the vector transmitted diseases such as malaria, dengue fever, leishmaniasis, yellow fever, West Nile Virus, Lyme, plague, etc. In fact an increase in dengue fever is documented.
- c) **Increased heat waves and extreme weather:** During 2003, the European heat wave killed 70,000 persons from stroke, heart attack, lung diseases, etc. Also, there are increased events of other extreme weather such as floods, droughts, tropical cyclones and wild fires.
- d) **Increased ozone formation:** Elevated temperature enhances the ozone formation, which worsens the lung diseases.
- e) **Direct effects on human health:** Higher atmospheric temperature disturbs sleep that in turn increases risks for cardiovascular diseases, obesity and diabetes. A recent study in Hong Kong showed that beyond 28.2 °C the increase in each degree Centigrade temperature was linked with 1.8% increased mortality from heart attack, stroke and respiratory infections. In India also such heat related mortality threshold of around 28 °C is reported. It is a common experience that in India the efficiency of work and quality of sleep are better in winter than in hot summer, and a study also reported that during 2000-2016 the global warming was associated with 5% reduction in outdoor manual productivity.
- f) **Reduction in agriculture production:** For each increase in 1 °C, there is 6-10% reduction in wheat and rice production.

There may be few advantages from global warming, e.g. reduced need of fuel in cold countries to keep homes warm, more rain due to increased vaporization thus converting ocean's salty water into usable water, etc. However, over all the disadvantages are more.

4. Water Pollution & Health

Like the air, water is a basic need for our survival. Nature has created a beautiful system of water cycle with rain, lake, river and ocean. Indian culture regards river as sacred mother. People take sacred bath in river, make journey around it and immerse the ash of the cremated body into river. However, now the reality is that most of the rivers are polluted in India.

Sources of water pollution:



Major sources of water pollution are: a) Sewage containing urine/fecal material, soap, shampoo, cosmetics, hair dyes, medicines, detergents, etc., b) Industries like refineries, chemicals, coal, paints and dyes, leather, textiles, paper, detergents, acids, salts, heavy metals, rubber, sugar, etc. and c) Agricultural use of pesticides, fertilizers, etc. Toxins from water can reach our body through drinking water and food.

The river Ganga is the most polluted river in the world with very high incidence of gall bladder and prostate cancers among the nearby residents.

Water pollution from sewage:

Currently in India, only 10% of the generated sewage is treated for pollution, thus 90% gets dumped into river finally reaching to the ocean.^(32,33)

In India about 75% of water pollution is contributed by domestic sewage. According to Central Pollution Control Board report, the River Ganga is polluted by fecal bacteria in its entire length to variable degree.⁽³⁴⁾ Each human being daily excretes about 1 trillion bacteria in feces which can potentially make 5 lakh liter of water unhygienic. About 20% of all global deaths under age five are caused by diarrhea resulting from pollution of drinking water mainly by fecal bacteria.⁽²⁾

The traditional oil soap is a salt of fatty acid. It is easily biodegradable. However, fancy bath soap has many toxic chemicals added for color, smell, anti-bacterial

property, etc. Detergent powder is more effective cleaner than traditional soap; however, it contains toxic surfactants like alkylbenzine sulfonate and sodium triphosphates. The alkylbenzine sulfonate is non-biodegradable and its benzene portion is carcinogen. The sodium triphosphate is quickly degraded into phosphate causing excessive growth of algae (eutrophication). Pollution from non-biodegradable detergents was responsible for 10 feet high froths looking like snow reported in Bengaluru.

Water pollution from cultural activities: In India, the tradition of immersing statues of god and goddesses, taking bath in river, washing clothes, defecation near bank of river, burning dead bodies on the bank of river, etc also contribute significantly to the water pollution. Immersion of idols in water releases toxic materials like metals from colors (chromium, lead, mercury, copper, cadmium, etc.), Plaster of Paris, plastic, thermocol, paper, etc.^[34,44]

Water pollution from industries: Textile industry is a major industry causing water pollution. It uses around 10,000 types of chemicals including 3600 dyes. Many of them are carcinogens e.g. benzidine, naphthalene, azo and other aromatic compounds. Dyeing process releases 10-50% unused dyes, flame retardants, formaldehyde, dioxins, heavy metals (like copper, arsenic, lead, cadmium, mercury, nickel, and cobalt) into the surrounding water.^[35]

Leather processing in tanneries uses various chemicals such as lime, sodium carbonate, sodium bi-carbonate, common salt, sodium sulphate, chrome sulphate, vegetable oils and dyes. One tannery can pollute groundwater in a radius of 7 to 8 km, making it unfit for drinking or irrigation.^[36] Higher levels of chromium and arsenic are detected near tanneries in UP and Tamil Nadu.

Water pollution related to toxic metals: Water can be contaminated by toxic metals from industry, agriculture or pumping the water from deeper layers of earth due to receding underground water levels. Common toxic metals found in water are arsenic, chromium, lead and fluoride. Major sources of chromium and lead are industries; while for arsenic and fluoride they are the surrounding rocks.^[37,38,39]

Water pollution related to pesticides and fertilizers: The efficiency of chemicals used for the specific purpose can be highly limited. For example only about 1% of pesticides reach the targeted pest, about 10-70% medicines are utilized by human body and about 30-60% of fertilizes reach to the plants.^[40] Thus, the majority of these chemicals become pollutants in water and soil. Many of these chemicals are

detected in drinking water at very low concentrations (in nano gram to micro gram) and their toxic effects are unknown. Increased use of synthetic fertilizers is linked with elevated nitrates and phosphates in water leading to excess growth of algae forming green layer over water. This can reduce the oxygen level in water killing other organisms and creating dead zones. High levels of nitrates in ground water are found in Punjab, Haryana, Gujarat, West Bengal, Uttar Pradesh and Tamil Nadu. Nitrate toxicity is linked with cancer and blue baby syndrome. About 10,000 different types of chemicals are used in personal care products and they finally end up in water. This topic is discussed under separate heading.

Water pollution from plastics: Plastic particles (e.g. polyethylene, polypropylene, polymethylmethacrylate, nylon, etc) smaller than 5 mm are called microbeads. They are released from personal care products such as toothpaste, shampoo, shower gel, deodorant, eye shadows, mascara, shaving cream, hair dyes, nail polish, etc. Microbeads are also formed from the wear and tear of plastic objects e.g. wearing of tyres, plastic bags, plastic scrubber and synthetic clothes. Each cycle of washing synthetic cloths in machine releases more than 7 lakh microplastic fibers. We do not visualize this wear and tear but the tiny plastic particles can stay in the atmosphere for thousand of years. Microplastics are detected in drinking water, sugar and table salt. Nano sized microbeads can cross the human gastrointestinal tracts to reach blood and even to the unborn fetuses. Little is known about the toxicity of microbeads.^(7,39)

Water pollution from oil spillage: Occasionally during transport, the pollution from oil spillage in ocean kills the sea animals.

Thermal pollution: Industries like thermal, nuclear, chemical, etc. use water for cooling and discharge the hot water resulting in thermal pollution. This can affect aquatic life due to increased temperature and decreased dissolved oxygen content.

Water pollution and diseases:

- a) River Ganga is the most polluted river in the world from sewage, garbage, industries, and animal remains. Population living near polluted river Ganga shows very high incidence of gall bladder cancer which is second highest in whole world and prostate cancer that is highest in the country. These high incidences of cancers are attributed to the toxicity of heavy metal (such as chromium, arsenic) and other pollution from industries such as leather.⁽⁴¹⁾
- b) Bhabha Atomic Research Centre study detected cancer causing chemical

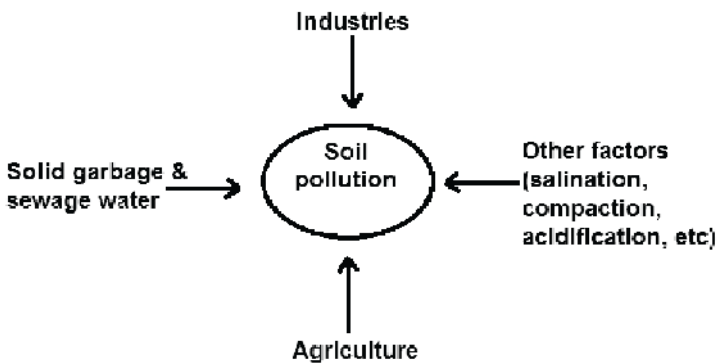
bromide in bottled water in Mumbai.⁽⁴²⁾

- c) Alarming high levels of lead and arsenic are found in the waters of Damodar, Safi, Ganga, Adjai rivers in Jharkhand, and West Bengal. A study revealed that one-fourth of children living along Delhi's Yamuna river have more than 10 µg/dl of lead in their blood. Higher fluoride (>1.5 mg/L) in drinking water is found in 19 states including Andhra Pradesh, Gujarat, Rajasthan, Bihar, Haryana, Karnataka, Madhya Pradesh, Kerala, etc. Arsenic can cause heart disease and cancers of skin, kidney, liver and bladder. Fluoride at low level protects from dental caries but at high level it increases bone fracture and arthritis. Lead toxicity is linked with low IQ, anemia, liver damage.^(37,38,43)
- d) About 31-50 kinds of medicines have been detected in drinking water of European countries. Ethinyl estradiol causes feminization and reduces sperm production in male fish. Antidepressant in water alters spawning and larval release in bivalves and disrupts locomotion in snails. Legal standards for residues of medicines in rivers and drinking waters are not established.⁽³⁹⁾

5. Soil Pollution & Health

Major sources of soil pollution are solid waste (garbage, plastics, e-waste, packing material, etc.), industries (mining, chemical residues and metallic), agriculture (fertilizers and pesticides) and construction. Currently, one third of the world's soil is moderately to highly degraded from erosion, salination, compaction, acidification and chemical pollution. This can threaten the basic needs of the future generations.⁽⁴⁵⁾

Sources of soil pollution:



Solid waste and soil pollution: According to 2015 report by International Solid Waste Association, world produced 7-10 billion tons of solid waste. This solid waste is becoming a thorny issue for disposal in cities. During 2013, the world produced about 300 million tons of plastic, which comes to 50 kg per person. Only about 10% plastic gets recycled, the rest is dumped into garbage. Plastic garbage can block the drainage, entangles the aquatic animals and chokes them up to death. Burning of plastic generates toxic gases like carbon monoxide, carbon dioxide, phosgene, dioxin and other poisonous chlorinated compounds. Plastic takes thousand of years to breakdown. We do not know the toxicity of “inert” plastics. However, chemicals added to the plastics are known to be hazardous and they can slowly leach into water or food, e.g. BPA (Bisphenol A).^(45,46,47)

e-waste and soil pollution: Electrical and electronics waste (e-waste) is generated from the discarded refrigerators, air conditioners, washing machines, dryers, computers, monitors, printers, keyboards, i-pods, mobile phones and chargers,

headphones, batteries, LCD/Plasma TVs, remotes, VCRs, stereos, compact discs, copiers, fax machines, etc. They contain more than 1000 different chemicals and some of them are toxic. For example: cathode ray tubes of televisions and computers contain lead, mercury, cadmium, beryllium and brominated flame retardants. A mobile phone/ smart phone contains more than 50 different components with copper, tin cobalt, indium, antimony, silver, gold, palladium, nickel, lithium, aluminum, iron, lead, mercury, arsenic, cadmium, selenium, hexavalent chromium, barium, selenium, zinc, flame retardants like PCBs and PBDEs, etc. It is estimated that about 50 million tones e-waste is generated annually all over the world. India generates about 1 million tons of e-waste, and it is rising. Commonly, the e-waste is dumped into the developing country for recycling. The major toxins associated with e-waste are metals (mercury, lead, cadmium, arsenic, beryllium, and chromium), POPs and flame-retardant.^(16,48)

Mining and soil pollution: Mining is used to extract the stone (for roads and buildings), cement, iron, clay, phosphorus, copper, lead, gold, aluminum, cadmium, nickel, etc. The mining activity worldwide mobilizes more than 50 billion metric tons of soil per year, which is equivalent to about 20 kg per person every day.⁽¹⁴⁾ For extraction of every kg of metals (such as gold, nickel or copper), about 1000,000 kg of waste is generated. One common method of gold extraction annually releases 100 tons of mercury in atmosphere. Exposures to heavy metals (arsenic, cadmium, copper, cobalt, lead, manganese, mercury, nickel and zinc) can cause hypertension, kidney disorders, cramps and cancer. In addition to these, metals are also reported to cause significant changes in DNA methylation and histone modifications in DNA leading to epigenetic (i.e. gene function changes without mutation) silencing of gene expression.^(14,49)

Lead and soil pollution: Major sources of lead exposure are wall paint and recycling of lead-acid batteries. A report by Toxics Link found that more than 84% of enamel paints in India contained lead levels higher than the upper limit (1,000

In India, the majority of enamel paints contain lead level higher than recommended. Lead paint is a main source for lead toxicity in children which can cause low IQ.

ppm) prescribed by a voluntary agency Bureau of Indian Standards. About 60% the paints had lead more than 6 times the upper limit. According to

the WHO, there is no safe low limit to lead exposure. Lead toxicity can cause

varieties of health problems such as: hyperactivity, deficits in fine motor function, and lowered IQ, increased blood pressure, decreased fertility, cataracts, nerve disorders, muscle and joint pain, and memory or concentration problems.⁽⁵⁰⁾

Mercury and soil pollution: Mercury is released in air by burning coal and mining activities. This mercury finally ends up in water where microorganisms convert it into more toxic form of methyl mercury. Methyl mercury accumulation multiplies in the food chain. For example the concentration of methyl mercury increases 109 fold in the fish compared to the surrounding water level. Due to consumption of such contaminated fish, the Japanese people in Mina Mata Bay developed mercury toxicity causing mental retardation, gait disturbance, speech disturbance, swallowing difficulty, etc.⁽⁴⁰⁾

Agriculture and soil pollution: Use of pesticides and synthetic fertilizers in modern agriculture is a major source of soil pollution. Fertilizer is also a significant source of contaminated heavy metals such as mercury, cadmium, arsenic, lead, copper and nickel; and natural radionuclide like uranium, thorium and polonium. Synthetic pesticides (includes insecticides, herbicides and fungicides) are used since 1950s. Americans use about 2 kg of pesticides per capita annually, of which 99% end up as pollutants in soil and water. The pesticides in soils may adversely affect micro-organisms, earthworms, fungi, etc which are useful in maintaining natural structure and function of soil. Continued use of pesticides has resulted in to the development of the resistance in 1,000 major agricultural pests. This “pesticide treadmill” may prompt farmers to use stronger concentrations or more frequent pesticide applications, further raising the risk of toxicity.^(10,51)

Organically grown vegetable and fruit have better flavor, last longer and are free from pesticides. Organic farming needs less water and thus reduces soil salination. It also promotes bacteria, organic compounds, earth worms which make land healthier for farming.

Examples of soil toxicity:^(10,48,52)

- a) In regions of China where e-waste is processed, an increase in pollution is reported in air, water and soil from heavy metals, PAHs, PBDEs, etc. The Chinese workers handling the e-waste developed higher incidence of skin diseases, birth defects, low immunity, TB, lung cancer, impaired brain development, etc.
- b) In ground water of USA and Canada 39 types of pesticides are detected.

Pesticides are also detected in bottled water. More than 20 types of pesticides are classified as carcinogens. They increase the risks for childhood leukemia and cancers of brain, bone, colon, lung, melanoma, and lymphoma. They can also cause low IQ, decreased immunity, disrupt the hormonal function and increase the risk for Parkinson's disease.

- c) During 2005, the city of Mumbai experienced massive monsoon flooding, resulting in about 1,000 deaths and more injuries. Out of many causes, one was a clogging of drainage by the discarded plastic bags.

6. Pollution from Personal Care Products & Health

Personal Care Products include: soap, body wash, shampoo, conditioner, toothpaste, mouthwash, hair dyes, shaving cream, moisturizing lotion, nail polish, perfume, deodorant and cosmetics like concealer, mascara, eye shadow, eyeliner, lipstick, etc.

In USA on average a woman uses 12 personal care products containing 168 chemicals, a man uses 6 products with 85 chemicals and a child is exposed to an average of 61 chemicals daily. The average numbers of chemicals used in various products are: 250 in perfume, 32 in body lotion, 31 in nail varnish, 26 in eye shadow, 26 in lipstick, 15 in shampoo, 15 in deodorant, 11 in hair spray and 8-24 in toothpaste. Many chemicals used in perfumes cause endocrine (hormone) disruption; however, all of them may not be listed on label since they are considered to be trade secret. Most cosmetics contain toxic metals: 96% have lead, 90% have beryllium, 51% have cadmium and 20% have arsenic.^(48, 49) More than 10,000 different chemicals are used in making the personal care products, which can penetrate our body through contaminated water. For example, triclosan is detected in 97% of breast milk and 75% of urine samples. The toxic chemicals used in personal care products can be carcinogens, reproductive toxins and endocrine disruptors.^(53, 54)

Now a day synthetic colors are used to celebrate Holi festival in India. These colors contain toxic metals like copper for green color (causes eye allergy and temporary blindness), lead for black color (causes renal failure, learning disorder), chromium for purple color (exacerbates asthma), aluminum for silvery color (carcinogen), mercury for red color (can cause skin cancer).

Toxic substances in personal care products (10, 53, 54)

Toxic substance	Used in	Toxicities
Triclosan	Antibacterial soap, toothpaste, deodorant, face and body wash, cosmetics, mouthwash, toys, furniture, clothes	Antibiotic resistance in bacteria, endocrine disruption (lowers the thyroid hormone level), converted to dioxin (a carcinogen)
Alkylbenzine sulfonate	Detergent	Bioaccumulates, it is slowly broken down into benzene (a carcinogen)
Sodium triphosphate	Detergent	Degraded to phosphate which causes overgrowth (eutrophication) of algae & creating "dead-zones" by killing surrounding organisms
Parabens	Used as preservatives in moisturizers, face and skin cleansers, shampoo, conditioner, sunscreen, toothpaste, makeup	Linked to cancer, endocrine disruption, reproductive toxicity, immunotoxicity, neurotoxicity, skin irritation
Formaldehydes	Used as a preservative in nail polish, eyelash glue, shampoo, conditioner, styling gel/lotion, body wash, moisturizer, eye shadow, facial powder, mascara	Carcinogen, asthmagen, neurotoxicant, developmental toxicant and skin irritant
Phthalates	Nail polish, hair spray, tooth brush, toys, insect repellent, and solvents and perfumes	Diabetes, asthma, bioaccumulates, interfere with reproduction and thyroid function
Coal tar	Anti-dandruff, lipsticks and eye Shadows	Carcinogen, neurotoxic, immunotoxic, and skin irritant
Toluene	Nail polish	Headache, throat and skin irritation
Mercury	Skin cream, soaps and lotion	Damage the kidney and nervous system
BHA (Butylatedhydroxyanisole) BHT (Butylated Hydroxytoluene)	Moisturizers and makeup	Endocrine (hormone) disruptors, carcinogen
DEA (Diethanolamine)	Used as creamy and foaming agents in moisturizers and shampoos	Converted to nitrosamines (a carcinogen)
Siloxanes	Cosmetics	Endocrine (hormone) disruptors, reproductive toxicant
Sodium lauryl sulfate	Toothpaste	Mouth (aphthous) ulcers

7. Pollution from Persistent Organic Pollutants (POPs) & Health

POPs are man-made fat soluble chemicals which persist in body for many years due to slow degradation. They are also called as Persistent Bio accumulative and Toxic (PBT), which include both POPs and metals such as cadmium, lead and mercury because they can also accumulate in the body. Common examples of POPs are pesticides (e.g. DDT), industrial chemicals (e.g. PCBs used in transformers and capacitors) and dioxins (generated as side product in chemical industries or during combustion). Since POPs are slow to biodegrade, they accumulate in body and their concentration multiply with higher food chain. For example, the concentration of DDT in water can be 0.2 ppm, which increases to 77 ppm in algae (that consumes water), then to 500-600 ppm in fish (that consumes algae) and to 1700 ppm in pelican bird (that consumes fish). Thus, DDT which is used in small quantities to kill mosquitoes can enter the food chain and may get highly concentrated in birds making their eggs fragile and thus reducing their population. Similar bioaccumulation is documented for methyl mercury in fish and finally in human. POPs get transported even to far Arctic regions through air, water and migrating animals, for example mothers in Arctic (where there are no chemical industries) regions have one of the highest levels of PCBs in their breast milk.^(10, 35)

Persistent Organic Pollutants (POPs) stay in body for many years. Their examples are pesticides, chemicals used in non-stick cooking pans and industrial products. They can increase possibility of cancers, infertility, diabetes, obesity, etc.

In 2001 a treaty was signed by world leaders to reduce and eventually eliminate twelve POPs called "Dirty Dozen". These twelve POPs include eight pesticides (endrin, toxaphene, aldrin, dieldrin, heptachlor, chlordane, mirex, and DDT), two industrial chemicals (hexachlorobenzene [HCB] and polychlorinated biphenyls [PCBs]) and two side products (dioxins and furans).

Toxicities related to POPs reported are:^(10 35)

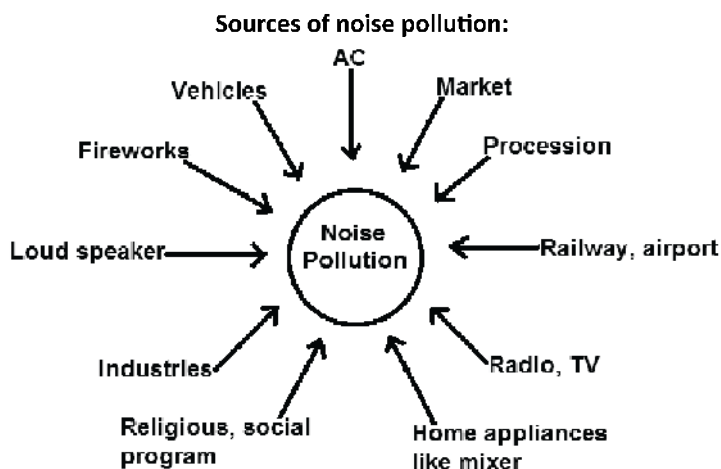
- a) Cancers e.g. breast, pancreas, soft tissue sarcoma, non-Hodgkin's lymphoma, and adult onset leukemia.
- b) Abnormal sperm, miscarriages, pre-term delivery, low birth weight, shortened lactation period, and menstruation complications.

- c) Neurological disorders including Attention Deficit Disorder (ADD), behavior problems (e.g. aggression and delinquency), learning disabilities and impaired memory.
- d) Developmental dysfunctions, immune suppression, type II diabetes, endometriosis (pelvic pain due to uterine tissue growth in pelvis), hepatitis, and cirrhosis (liver inflammation).
- e) Perfluorinated compounds (PFCs) are a group of POPs chemicals used in making non-stick frying pans, waterproof clothing, stain-resistant fabrics, food packaging (e.g. pizza and popcorn), and many other products. They can cause liver toxicity, endocrine disruption, neonatal toxicity, neurobehavioral disorders, testicular cancer, hypothyroidism, obesity, etc.

8. Miscellaneous Pollution & Health

Noise Pollution

Any unwanted sound is a noise pollution. The sources of noise pollution include loudspeakers, radio, TV, AC, rallies, markets, religious/social/cultural functions, fire crackers, home appliances, vehicles, railways, airports, industries, etc. Noise level is measured in decibels (dB). In urban India 2/3 of noise pollution results from traffic mainly the two and three wheelers.⁽⁵⁶⁾



Recommended standards for noise (dB)

	WHO recommendation	Gov of India recommendation (CPCB)
Day time in residential area	<45	<55
Night time in residential area	<35	<45
Industrial area	-	70-75
Hazardous	>80	-

WHO = World Health Organization

CPCB = Central Pollution Control Board

In India most cultural and religious celebrations are linked with noise pollution from loud speakers & fireworks. Driving is associated with excessive horn blowing. Noise pollution harms our body even when we are not conscious of it.

A noise level of quiet conversation is 20-30 dB and from heavy truck/aircraft it is 90-120 dB. During festivals like Navratri, Durga Puja, Ganesh, Dipawali, wedding ceremonies, etc it can reach to 75-125 dB.⁽⁵⁷⁾ One study

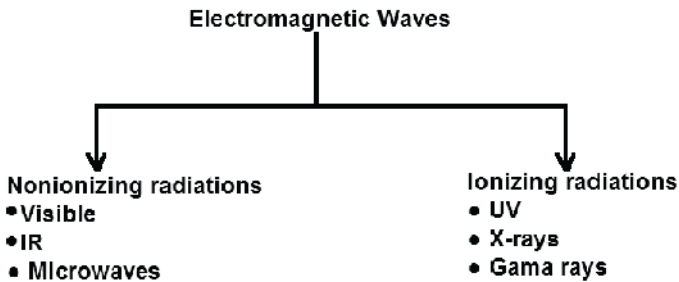
in Surat roads showed an average noise level of 92-98 dB which is hazardous as per WHO guidelines.⁽⁵⁸⁾

Adverse effects of noise pollution:⁽⁵⁸⁾

- a) Annoying, disturbs sleep, reduces work performance.
- b) Studies have shown increased risks of high blood pressure, heart disease and stroke in the persons exposed to road traffic noise.
- c) Several studies have linked noise exposure in school children with increased headaches, tiredness, elevated stress hormone in the blood and reduced learning performance.
- d) Hearing loss with chronic noise exposure.
- e) The health damage is also documented even from the night time unconscious exposure to the noise.

Radiation pollution

Radiation can be divided into non-ionizing (includes visible, IR and microwaves) and ionizing (includes alpha particles, beta particles, UV, X-ray, gamma rays and cosmic rays).



Pollution from microwaves: Microwaves are low energy radiation coming out from mobile phone, radio-tower and wireless network can increase the risk for glioma which is one type of brain cancer.

Pollution from ionization radiation: The ionizing (also known as nuclear) radiation produced from radioactivity has high energy causing knocking out of electrons from atoms to produce ions in proteins, DNA and other molecules. This can damage or kill the cells, create mutations, cause cancer, sterility, etc. Proximity to the nuclear facilities and occupational exposure of ionizing radiation

can increase the incidence of leukemia, lung, skin, and thyroid cancers. There is no safe level of ionization radiation. One CT scan exposes a person to ionizing radiation equivalent of 100-1000 chest X-rays, and that can increase the cancer risk in 1 out of 2000 patients.⁽⁹⁾

The fatal damages caused by ionizing radiation are well documented from atom bombs attacks in Hiroshima/Nagasaki, Japan in 1945 and nuclear power plant accident at Chernobyl, Russia in 1986. The atom bombs killed 340,000 Japanese people. It also increased cancers of leukemia, thyroid, breast, colon, lung and ovary. The Chernobyl disaster spilled the radioactivity over 11260 square kilometers area, reaching to other countries of Sweden, Norway, UK and Germany killing about 50 people and 66% of birds. It is also associated with increased incidence of cancers (thyroid, breast and leukemia), cerebrovascular diseases, lung diseases, cataract, still birth, and mental diseases. After 30 years of Chernobyl disaster, the mushroom in Germany is still classified as radio waste due to high radioactivity. It will take another 300 years to normalize the radioactivity level.⁽¹⁰⁾

Pollution from visible light: Light and dark cycles control our body rhythm through hormones, e.g. modulating melatonin release from the brain's pineal gland. The negative effects of artificial light are:⁽⁵²⁾

- a) The artificial light disturbs the circadian cycle which is linked with increased risks of obesity, diabetes, depression, mood disorder, reproductive problems, and insomnia.
- b) Night time light affects nocturnal animals active in night for food and mating. About 30% of all vertebrate (animals with vertebral column, e.g. fish, frog, lizard, birds, etc) species and 60% of invertebrate (e.g. earthworm, insects, etc) species on earth are nocturnal. Artificial light at night time can kill the migrating birds that fly into lighted buildings. It can also disrupt the migration and breeding cycles.
- c) Beautiful night time sky stars are masked by artificial lights in most of the urban areas.

Genetic Pollution

By using genetic engineering technology the genetically modified plants and animals are created, which are known as GMOs (Genetically Modified Organisms). The genetically modified plants seeds are marketed commercially. The genetically modified organisms can exchange the modified genes with the naturally occurring

organisms. Such undesired and uncontrolled exchange of genetic material is called as Genetic Pollution. Once such undesirable genetic exchange occurs, it is almost impossible to reverse it. The consequences of genetic pollution are not fully studied, but potentially they can make the naturally occurring varieties extinct and thus reduce the biodiversity, can create undesirable characteristics from genetic combinations, can create resistance against pesticides or can transform the wild plants into uncontrollable 'super-weeds'. The prevention of genetic pollution is possible if such organisms are studied properly before marketing.⁽⁵⁰⁾

Space pollution

Human beings are polluting not only earth but also the space outside earth. During the last 50 years, about 28,000 man-made satellites are launched in the space for communication/ broadcasting, navigation (GPS), scientific study and military purpose. About 1/3 of them are still orbiting (at the speed of 27,400 km/h) and only 6% of them are functional, thus 94% of them are garbage. They are located between 300-36,000 km distances from earth, compared to the earth diameter of 12,742 km. They have resulted into collision with each other or explosion or even falling on the earth, fortunately most of them either burn or fall into ocean. From their disintegration, about 10-100 million small debris are produced. With addition of more such satellites in future, it will increase possibilities of accidents. This does not mean we should stop exploration of the space, but we can develop a technology to retrieve the dysfunctional satellite.⁽⁵¹⁾

9. Pollution and Specific Diseases

Toxins from air, water and soil can finally reach to our body through breathing air, drinking water and eating food. Children are the most vulnerable to the toxins, since they consume more food and water per kg of body weight plus their development can be impaired permanently.

Examples of toxins found in food and body are:

- In 2016, the government of India ordered a withdrawal of Maggi Instant Noodles from market for the higher level of lead (17 ppb against allowed 2.5 ppb). About 1/3 of tap water in India has lead level higher than WHO recommended limit of 10 ppb.⁽⁶²⁾
- A report showed presence of 300 chemical pollutants in umbilical cord blood of newborn babies indicating that the pollution reaches the baby before they are born.⁽²⁰⁾
- Persistent organic pollutants are found in pregnant and lactating women across the globe.⁽¹¹⁾
- Accumulation of lead content in contemporary human body has increased by 500-1000 folds compared to pre-industrial human bodies.⁽⁵⁰⁾
- Microplastics are detected in drinking water, sugar and table salt.^(7,39)

Toxins reaching our body can increase possibility of many diseases.

List of common diseases linked to the pollutants

Disease	Pollutants linked with the disease
Diabetes	Particulate Matter (PM), dioxins, polychlorinated biphenyls (PCBs), DDT, flame retardants, arsenic, bisphenol A (BPA), phthalates, organotins and organophosphate, carbamate pesticides
Obesity	Dioxins, polychlorinated biphenyls (PCBs) and certain organochlorine pesticides (OCPs), perfluorinated chemicals (PFCs), brominated flame retardants (BFRs), bisphenol A (BPA), organotins, diethylstilbestrol (DES), phthalates, organophosphate pesticides, lead, pre-natal nicotine exposure, diesel exhaust and some antipsychotic drugs
Stroke	Particulate matter (PM), smog
Heart attacks	Smog
Asthma, COPD	Outdoor/indoor air pollution
Cancers	Pesticides, hair dyes, talcum powder, oral contraceptive, tobacco, asbestos, beryllium, cadmium, chromium, nickel, arsenic, vinyl chloride, benzene, benzidine, nitrate, butadiene, formaldehyde, ethylene oxide, o-toluidine, radioactivity
Low IQ	Lead, phthalate

Endocrine Disrupting Chemicals (EDCs)

As the name suggests, they are the chemicals altering the function of endocrine (hormone related) system and affecting the body in many ways. Hormones are synthesized by endocrine glands (e.g. thyroid, adrenal, pancreas, pituitary, testes, ovaries, etc.) and secreted into blood, from where they reach various organs and affect body functions. EDCs can disrupt metabolism, development, immune function, reproduction, intelligence and behavior. Such chemicals are used in plastics, flame retardants, pesticides, fragrances, toys, clothes, cosmetics, furniture, computers, phones, appliances, carpet, electronics goods, packaging, etc. About 1000 such EDCs have been identified. Prenatal exposure to EDC can trigger cancer in later life, e.g. leukemia, brain, breast, uterine, lung (from maternal smoking), liver, kidney, and lymphoma. One study detected EDCs (bisphenol A, phthalates) in all urine samples of 4000 pregnant women tested in France.^(65,66,67)

Recently, incidence of many hormone related diseases have suddenly increased possibly due to EDCs exposure, e.g. low semen quality, testicular cancer, undescended testis, genital malformations, preterm birth and low birth weight, neurobehavioral disorders associated with thyroid disruption, endocrine related cancers, early onset of breast development in young girls and type 2 diabetes.

Evidences for EDCs toxicities:

- a) About 15 chemicals are known to cause obesity, e.g. Bisphenol A, PBDEs, PCBs, some pesticides, phthalates, etc.^(10 35)
- b) In females, the exposure to diethylstilbestrol, a potent synthetic estrogen, resulted in increased cancer of vagina, cervix and breast. It also increased incidence of hypospadias (abnormal urethra opening) in male children.⁽⁷¹⁾
- c) Polychlorinated biphenyls (PCBs) are a group of 209 chemicals used in the past for electric appliances and as lubricant. They affect the semen quality in man. In female porpoises it caused reproductive failure, fetal death and miscarriage. Their use is banned since last 30 years; however, because of their persistent property, the toxicity is still detectable.⁽³⁰⁾
- d) Bisphenol A (BPA) is used in manufacturing polycarbonate plastic bottles, food container linings and in thermal paper for cash receipts. Its use has been banned in baby bottles and children's toys in Europe due to its concern of

affecting the child development^[67]

- e) During 1973-2011, the sperm count in male semen has declined 59% in America, Europe, Australia and New Zealand. Sperm count reduction is also found in China. Many causes are speculated for such decline in sperm count including pollution, alcohol, smoking, lifestyle, obesity, stress, etc.^[68]
- f) The bigger fear is the permanent adverse effect of EDCs on the development of babies. Such adverse effects include spontaneous abortion by solvents, impaired fetal growth by pesticides, decreased birth weight and increased birth defects by toluene, premature births by phthalates, low birth weight by polychlorinated biphenyls (PCBs) and perfluorinated compounds, impaired memories and increased Attention Deficit Hyperactivity Disorder (ADHD) due to pesticides, decreased IQ by lead and PCBs, reduced cognitive performance and psychomotor outcomes with methyl mercury, attention deficit by polybrominated diphenol ethers and polycyclic aromatic hydrocarbons, aggressive behavior with bisphenol-A, etc.^[11]

Pollution and diabetes mellitus

Causes for diabetes are multiple: genes, lack of exercise, obesity, malnutrition, pollution, etc. One study in India showed that the prevalence of type 2 diabetes (commonly found diabetes in adults) has increased in urban population from 2.5% to 12-18% and in rural population from 0.5% to 2.5% during 1960-2010.^[53] This increasing trend is linked with change in lifestyles (decreased physical work, increased calorie intake and obesity) and pollution.

The association of pollution and diabetes is shown in many studies:

- a) Exposure to air Particulate Matter (PM) increases insulin resistance thus increasing the risk of diabetes.^[64]
- b) Chemical pollutants linked with diabetes are Persistent Organic Pollutants (POPs, such as dioxins, PCBs, organochlorine pesticides like DDT and flame retardants), arsenic, BPA (bisphenol A), phthalates, organotin, organophosphate and carbamate pesticides.^[39]
- c) Environmental obesogens are the chemicals shown to increase obesity by disrupting the fat tissue metabolism. Examples of such chemicals are persistent organic pollutants [POPs such as dioxins, polychlorinated biphenyls (PCBs) and certain organochlorine pesticides (OCPs), perfluorinated chemicals (PFCs) and brominated flame retardants (BFRs)], bisphenol A (BPA),

organotins, diethylstilbestrol (DES), phthalates, organophosphate pesticides, lead, pre-natal nicotine exposure, diesel exhaust and some antipsychotic medicines. Obesity in turn increases the risk for diabetes.^(10,32)

Pollution and cardiovascular (heart attack and stroke) diseases

Causes for cardiovascular diseases are multiple: genes, lack of exercise, obesity, cholesterol, high blood pressure, diabetes, salt intake, smoking, alcohol, pollution, etc. Pollution is linked with obstruction in blood circulation possibly by increased inflammation and oxidative damages.

The studies showing relation between pollution and cardiovascular diseases include:^(16,18,23)

- a) PM_{2.5} toxicity is related to 46% increase of silent stroke (Trans Ischemic Attacks). PM_{2.5} toxicity is also associated with a decrease in cerebral brain volume equivalent to about one year of pre-mature aging. European study found a 19% increased stroke and 13% increase in heart attacks due to 5 µg/m³ increase in PM_{2.5}.
- b) Historically the 1952 Great Smog of London led to increased deaths due to cardiovascular and respiratory diseases.
- c) Exposure to traffic has been linked to trigger the heart attacks within hours. Animal experiments have shown an increased arterial thrombosis due to activation of platelets within 30 min inhalation of diesel exhaust particles.
- d) New Delhi is one of the worst air polluted city in the world. This is associated with four fold increase in stroke and heart attack compared to nearby rural population.

Pollution and lung diseases

Causes for lung diseases are multiple: genes, smoking, allergy, infection, pollution, etc. Pollutants can increase the incidences of lung diseases like asthma, Chronic Obstructive Pulmonary Disease (COPD) and lung cancer.⁽⁹⁾

The evidences supporting association between pollution and lung diseases include:

- a) Air pollution is associated with the exacerbation, development and higher mortality of Chronic Obstructive Pulmonary Disease (COPD). The women living within 100 meter of a busy road had increased risk of Chronic Obstructive Pulmonary Disease by 1.8 fold. Particulate matter (PM), ozone and nitrogen oxides produce deleterious effects on the airway, such as

increase in bronchial reactivity, airway oxidative stress, pulmonary and systemic inflammation, amplification of viral infections, and reduction in airway biliary activity.⁽⁶⁹⁾

- b) Risk of chronic obstructive pulmonary disease (COPD) is increased by 1.5 fold in second hand smoke exposure and 2.4 fold in women due to use of biomass (e.g. wood, cow dung cake) in cooking.⁽⁶⁵⁾
- c) A study in Bengaluru (India) showed that 54% residents suffered from cough and 25% had dust allergy. Another study showed that 47% of Kolkata's population had lower respiratory tract symptoms, which was seven times higher than their rural counterparts.⁽¹⁹⁾
- d) New Delhi is one of the worst air polluted city in the world. Its population has 1.7 times increase in respiratory diseases compared to nearby rural population.⁽⁸⁾
- e) Studies have shown that air pollution can reduce the lung function irreversibly in children.⁽²²⁾
- f) European study found that the number of new cases of Chronic Obstructive Pulmonary Disease (COPD) was directly related to how close the persons live to the busy roads and the severity of exposure to nitrogen oxides in the air.⁽²²⁾
- g) Indoor pollution increases risk for Chronic Obstructive Pulmonary Disease (2.0 fold), lung cancer (1.7 fold), asthma (1.5 fold) and TB (1.5 fold).^(16, 21)

Pollution and cancer

There are multiple causes for cancer: genes, diet, infection, radiation, alcohol, tobacco, obesity, sedentary life and pollution.

Studies showing association between pollution and cancer are:

- a) In 2016 Report on Carcinogens identified 248 chemicals as cancer causing agents (carcinogens). Out of 900 pesticides used currently, 20 are definitely known as cancer causing agents and other 145 are suspected as carcinogens.⁽¹⁷⁾
- b) There is a train running between Bathinda (Punjab) to Bikaner (Rajasthan) popularly called 'Cancer Train' transporting patients to the cancer hospital. The relatively higher incidence of cancer in the Bathinda and other districts (Faridkot, Moga, Muktsar, Ferozepur, Sangrur and Mansa) of Punjab is linked with higher uses of pesticides and chemical fertilizers in agriculture. Compared to national average, the Punjab uses fivefold of pesticides and double the amount of fertilizers per hectare of farm land. In Punjab water,

the concentrations of pollutants such as nitrates, arsenic, cadmium, etc are found higher than the recommended standard. In Punjab the pesticides such as DDT and BHC (benzene hexachloride) are also detected in mother's milk, human blood and water. The prevalence of cancer in Punjab is reported as 90-136 against national average of 80 per 100,000 population.⁽⁷⁰⁾

- c) Population living near polluted river Ganga shows very high incidence of gall bladder cancer which is second highest in the whole world and prostate cancer is the highest in the country. These high incidences of cancers are attributed to the heavy metal (such as chromium, arsenic) and other pollution from industries such as leather.⁽⁴²⁾
- d) The WHO's International Agency for Research on Cancer (IARC) announced that DDT probably causes cancer, with scientific evidence linking it to Non-Hodgkin lymphoma (NHL), testicular cancer and liver cancers.⁽²⁾
- e) Indoor pollution increases the risk for lung cancer by 1.7 fold. Worldwide 1/6 of lung cancers are attributed to the indoor pollution.^(15, 17)
- f) Pollution due to occupational pollution is attributed to 660,000 cancers annually in the world.⁽⁵⁾

List of some carcinogens (agents causing cancer)

Type of Cancer	Pollutants acting as carcinogen
Oral	Tobacco
Lung	Tobacco smoke, radon, asbestos, beryllium, cadmium, chromium, nickel, 2,3,7,8 Tetrachlorobdibenzo-p-dioxin (TCDD), vinyl chloride, erionite, mustard gas
Breast	Oral contraceptives, tobacco smoke, benzidine, melphalan, tamoxifen
Cervical	Tobacco smoke, diethylstilbestrol (DES)
Pancrease	Tobacco smoke
Prostate	Cadmium
Colon	Nitrates, nitrites
Esophagus	Soots, nitrosamines
Ovarian	Talcum powder, melphalan
Lymphoma	Azathioprine, 1,3 butadiene, cyclosporine-A, ethylene oxide, 2,3,7,8 tetrachlorobdibenzo-p-dioxin (TCDD)
Leukemia	1,3 Butadiene, thiopeta, benzene, chlorambucil, formaldehyde
Larynx	Tobacco smoke, asbestos, nickel, ethylene oxide
Liver	Tobacco smoke, vinyl chloride, aflatoxins, benzidine, soots, arsenic, oral contraceptive
Gastric	Ethylene oxide, arsenic, tobacco smoke
Skin	Arsenic, azathioprine, methoxasalen/psoralen
Uterine	Tamoxifen, estrogen
Urinary Bladder	Tobacco smoke, 4-aminobiphenyl, benzidine, cyclophosphamide, soots, benzene, arsenic
Kidney	Tobacco smoke, cadmium, pesticides
Thyroid	Radioactivity

- g) People living close to heavy-traffic roads have higher risk of lung cancer.⁽⁷²⁾
- h) Talcum powder exposure increases the risk of ovarian cancer by 92%.⁽⁷²⁾

Mental diseases & pollution

There are multiple factors involved in brain development: genetic, nutrition, social, economic, cultural, pollution, etc. Relation between pollution and mental diseases is evolving. Autism, Attention Deficit Hyperactivity Disorder (ADHD), dyslexia, low IQ and other disorders of learning, development, and behavior are showing increasing trends, and a part of reason for this can be pollution.

Studies indicating relationship between pollution and mental illness are:

- a) Lead pollution affects children through IQ impairment, autism, Attention Deficit Hyperactivity Disorder (ADHD), dyslexia and cognitive impairments.⁽⁷³⁾
- b) Mercury toxicity increases mental retardation, autism, ADHD, gait disturbance.⁽¹⁰⁾
- c) PCBs (polychlorinated biphenyls) can increase ADHD and learning disorders.⁽¹⁰⁾
- d) Phthalates used in plastic making is shown to reduce IQ in the children.⁽³⁹⁾
- e) BPA (bisphenol A) is linked with altered behavior in children.⁽⁷³⁾
- f) Organochlorine pesticides are associated with decreased psychomotor function, memory and attention⁽⁷³⁾
- g) PM_{2.5} toxicity is associated with a decrease in brain volume equivalent to one year pre-mature aging.⁽¹⁵⁾

10. Pollution & Biodiversity

During last few decades the plants and animal species are disappearing 100 times faster than natural process. Now it is hard to find butterfly, sparrow, crow, frog, etc. For this one of the reasons is pollution.

Pollution not only affects human beings, but also other animals and plants. Our life is dependent on plants and animals for food and medicines. All lives on earth are dependent on solar energy

using which the plants make food. Every animal survives on plants directly or indirectly. On the other side plants need insects for crop pollination, bacteria for recycling the waste products and earthworm like animals for agriculture. Thus, our life is interconnected and co-dependent on other plants and animals.

It is estimated that we have identified less than 10% of total existing varieties (species) of plants and animals on earth, thus we do not have full understanding of how they are useful to our life. Scientists have studied the extinction of animals by using fossil records. They found that the current extinction rate is 100 times faster than in periods when earth was not going through a mass extinction event. Since 1900, the report indicates, more than 400 vertebrate (with back bone) animals have disappeared. Such a loss would normally be seen over a period of up to 10,000 years. This accelerated extinction of species is linked with habitat loss due to converting land for human use (e.g. for agriculture, housing, industry, etc.), deforestation, mining, fishing, hunting, climate change and pollution. According to the International Union for Conservation of Nature (IUCN), at least 50 animals species have moved closer to extinction every year. Around 41% of all amphibians (like frog) and 25% of mammals (like chimpanzee, elephant, tiger, lion, whale) are threatened with extinction.⁽⁷⁵⁾ Experts estimate that we have lost half of the world's plants food varieties over the past century. Selective growing of high yield crop varieties needs expensive chemical fertilizers and toxic pesticides. Also, by losing other varieties we may lose genes useful for the future.

Biologist E.O. Wilson explained in his book, *The Diversity of Life*, the threat from such disruption of natural symbiosis (co-dependency). He postulated in 1992 that by the end of the century over half of the world's species could disappear due to man-made ecological hardships called the "sixth extinction." The last such extinction occurred 65 million years ago wiping out dinosaurs.⁽⁷⁴⁾

Effect of pollution on animals and plants is documented in many ways:

- a) On an average, population of 3706 monitored species declined by 58 per cent between 1970 and 2012. Specifically this drop included 41% in tropical forest species, 33% in grassland butterfly species, 81% in species of the freshwater system and 25% in all marine fish species.⁽⁶⁵⁾
- b) Vulture's population declined by 99% in two decades. Later on the research attributed it to the toxicity of medicine diclofenac used in animals to control pain. When the diclofenac containing animal carcasses are consumed by vultures, it resulted in death from kidney toxicity. The drug was banned in 2006 and that resulted into increased number of vultures.⁽⁷⁶⁾
- c) Neonicotinoids are among the world's most effective and widely used insecticides. However, they are attributed to a sudden decline in the 1/3 population of honey bees in one year, resulting into Colony Collapse Disorder. The U.N. Food and Agriculture Organization reported that 71 of the 100 crops that provide 90 percent of human food are pollinated by bees.⁽⁷⁷⁾
- d) The number of house sparrow has declined by 90% in Gujarat and 71% in London. There are many factors attributed to this drop: loss of space for nesting, reduced availability of water and food (e.g. Bajra, Jovar), reduced trees, pollution, etc.⁽⁷⁸⁾
- e) Frogs have survived for about 300 million years. Recently, their population has declined worldwide significantly. Since 1980 about 200 species of frogs have disappeared against natural rate of extinction of one species in 500 years. Frog's skin is extremely sensitive to pollution since it is highly permeable and its fertilization is external. Thus the survival of frog is a good indicator of water pollution. Pesticides such as DDT, dieldrin and malathion can impair the immunity of frogs. The recent rise in mosquito spreading diseases such as dengue is associated with reduced number of frogs that eat the mosquito.⁽⁷⁹⁾
- f) Butterfly population in UK dropped by 69% in cities and 45% in villages over 20 years from 1995 mainly due to the pesticide toxicity.⁽⁸⁰⁾

11. Preventive Action

The obvious question arises in our mind, if there are so many toxic chemicals used in everyday products, how can we live without them? The purpose of book is not to scare people but to make them aware of pollution, to choose products with fewer toxins, to reduce pollution due to consumerism and to do more research in the field of pollution.

Protection of self from pollution:

- a) When there is high alert of low Air Quality Index (AQI) or if the vision is <2-3 km, then avoid outdoor activities such as exercise. Person with asthma/COPD may need more frequent use of inhaler.
- b) Use of M95 grade face mask can filter out 85% PM_{2.5} particles. Compared to this the efficiencies of surgical mask is about 30% and for ordinary cloth mask it is only 10%. Face mask can protect from PM but not from pollutant gases like ozone, nitrogen oxide, sulfur dioxide, carbon monoxide or volatile organic compounds. Also, there are no definite studies proving respiratory disease prevention by using the face mask.
- c) HEPA (High Efficiency Particulate Air) filters are used to clean indoor home air. They can remove particulate matter such as tobacco smoke, fungal spores, pollen, etc. However, there are no studies documenting prevention of respiratory diseases by its use.
- d) Reverse Osmosis (RO) can remove excess salt from water and can also remove toxins like arsenic and fluoride. In other situation its usefulness is questionable especially in municipal water after chlorine treatment. In fact RO filtration also removes useful minerals such as calcium, magnesium, zinc, etc. Home filtration unit with charcoal can remove bad smell and organic impurities. The UV treatment kills bacteria and viruses.
- e) During epidemic of contaminated water infection (such as diarrhea, vomiting, hepatitis), boil the drinking water for 2 min to kill bacteria and viruses.
- f) Cook at home to avoid processed and packed food or drink, since they contain more preservatives and additives.
- g) Prefer organic food to reduce toxicity from synthetic fertilizers and

pesticides. Support organic farmers by making friend circle to promote this.

- h) Wash thoroughly and peel off (unless you are sure that is grown organically) the vegetables and fruits before consuming them to reduce the exposure of pesticides and other pollutants.
- i) Do not store water, drink or food in plastics containers. Do not microwave food in plastic container. Avoid using plastic utensils (plate, cups) at home or in parties. Toxins like BPA (bisphenol A) and dioxin are released from plastic containers especially from hot drinks and foods.
- j) Read the labels before buying any product to know chemicals added to it and prefer to use product with fewer toxic chemicals. Avoid products with toxic chemicals like parabens, flame retardants, antimicrobials such as triclosan, fragrance, phthalates, bisphenols, formaldehyde, retinylpalmitate, retinyl acetate, solvents (like toluene, benzene) alpha and beta hydroxy acids, known POPs (e.g. PFOA, PFOS), toxic metals (like mercury, arsenic, cadmium, lead) and carcinogens. For the alternative safer consumer products visit the websites <http://safecosmeticsact.org>, www.prhe.ucsf.edu/prhe/tmlinks.html#personalcare, <http://www.sixclasses.org/>

Many things can be done at individual level to reduce pollution:

- a) Cut down the unnecessary consumption, e.g. ornaments, cosmetics, fashion (clothes, shoes, vehicles, gadgets, etc.), decorations, etc. Do not discard/replace/donate the usable clothes (or other items) for the fashion. With rise in GDP, the consumerism is also on rise. There are more shopping malls than high schools in USA. Worldwide, on average we bought one pair of shoes in 1950 and now we buy three pairs every year even though we

Individual actions to reduce pollution:
a) *Reduce, reuse & recycle*
b) *Be vegetarian & organic in diet*
c) *Use products with fewer toxins*
d) *Walk or use cycle instead of scooter or car*

walk less. British research found that the average 10-year of child possesses 238 toys but plays regularly with just 12. Keep in mind the resources used to produce any item, e.g. water needed to produce one cotton shirt is 2500 liters and for one 8 x 12 inch paper it is 11 liters. We consume 50% more natural resources of land and water than they can be naturally regenerated,

obviously such a lifestyle is unsustainable.^(21,22)

- b) Use pressure cooker for cooking to save fuel consumption and to better preserve the nutrients. Cook in steel vessel instead of harmful aluminium.
- c) Shift to vegetarian from non-veg diet. It takes an estimated 0.3 square meters of farmland to produce an edible kilogram of vegetables; however, the production of 1 kg of meat requires 7-21 square meters of farmland. Similarly water needed to get 1 kg meat is 4000-15,000 liters versus 200-2000 liters for vegetables and grains. Producing one calorie of meat needs 5-10 calories from plant food. The intensive breeding of animals is also related to recent rise in wild infections such as Ebola, bird flu, West Nile Virus, Zika virus, Swine flu, etc.^(7,83) We can get all the nutrients needed from vegetarian food supplemented by milk.
- d) Worldwide, about 1/3rd of food is wasted, reduce it, think of resources wasted to grow them, including energy, water, pesticides and fertilizers.
- e) Reuse the plastic bags or switch to the reusable cloth bags. Many ladies purchase vegetables at home from street vendor in new plastic bags (instead of plate) and then throw away the bags in garbage.
- f) Do not burn waste material such as plastics, papers, rubber, thermocol, packing material, etc., since it releases toxins in air. Instead of that help to recycle them.
- g) Instead of mosquito coil burning use mosquito net.
- h) Avoid artificial fragrance, because 95% are toxic and many are allergic. Use fragrance-free personal care product to avoid phthalates exposure.
- i) Do not use antibacterial soap since it creates bacterial resistance.
- j) Instead of using hazardous chemicals for cleaning, use a baking soda or a mixture of two-thirds of water and one-third of white distilled vinegar. To cut the vinegar smell, add a few drops of an essential oil like lemon grass, sage or grapefruit. Prefer soap (biodegradable) over detergent (non-biodegradable). For details visit website www.prhe.ucsf.edu/prhe/tmlinks.html#cleaningproducts.
- k) Avoid using toxic pesticide to control the pests such as ants or cockroaches. Instead of that, try to seal the cracks in walls and floor where they reside, and keep such places clean, dry and ventilated. To find the pesticide-free alternatives visit www.prhe.ucsf.edu/prhe/tmlinks.html#pestcontrol.

- l) Reduce pollution from fireworks and loudspeakers. Adjust volume of loudspeaker so that it does not go beyond the invited guests.
- m) Use energy efficient CFL/LED light bulbs, CFL saves 65% of electricity and LED can save 80% against the use of incandescent bulb. The typical life of CFL bulb is 10 years and for LED it can be 20 years. Government of India's plan for distributing LED bulb is highly admirable.
- n) Reduce futile use of energy, e.g. one side employing machines for household work and on the other hand using machines for exercise. Let your routine household work (such as sweeping, mopping, cleaning, washing, cooking, gardening) become a regular exercise. Turn off the lights/fan/gadgets when leaving the room.
- o) Develop habit of walking, cycling and public transport over the use of personal vehicles and avoid journey through cars and planes.
- p) Air dry the clothes instead of machine dry.
- q) Remove your shoes before entering home.
- r) Instead of wood, prefer electric or gas cremation for the dead body.
- s) Reduce water pollution due to idols immersion by using idols made from natural clay instead of Plaster of Paris and natural colors instead of synthetic toxic colors. The other alternatives are to use reusable idols and performing symbolic immersion at home or in small pond instead in public water.
- t) Replace the synthetic toxic colors used during Holi festival by naturally made colors.
- u) Get involved in advocacy against pollution.

Actions at collective level to protect from or reduce pollution:

History of "ozone hole" illustrates how the collective action can be successful. Ozone in the stratosphere (atmosphere in outer layer of earth) protects us from excessive UV exposure. Chlorofluorocarbons (CFCs) were used in refrigeration, air conditioning, fire extinguishers, cleaning solvents, aerosols (spray cans of perfumes, insecticide). Studies proved that CFC caused the depletion of ozone layer; therefore, its use was banned in 1987 by an international treaty. After this ban the size of "ozone hole" has started shrinking; however, its full recovery may take more than 50 years.^[84]

Another example of successful public policy is seen in air pollution control. The

combined emission of the six common pollutants and their precursors ($PM_{2.5}$ and PM_{10} , sulfur dioxide, nitrogen oxides, volatile organic compounds, carbon monoxide and lead) was reduced by 41% in USA during 1990 to 2008. This improvement occurred while the economy grew by 64%, driving miles increased by 36%, and 22% increase in population and 19% increase in energy use. Similarly, a decreasing trend in sulfur dioxide is observed in India due to various measures taken such as reduction of sulfur in diesel, use of LPG instead of coal as domestic fuel and conversion of diesel vehicles to CNG.⁽⁸⁵⁾

Research ideas to study pollution for scientists:

Science of pollution is relatively new, there are many unresolved issues: for example, we do not know the toxicity of more than 90% man-made chemicals, the toxic effects of low concentrations of toxins detected in body and food, relative contributions of human and natural forces in global warming, mechanism of toxicity in various diseases and species extinction. Few specific research ideas to study pollution and health are:

- a) Study the toxicity for all the chemicals.
- b) More research on POPs (Persistent Organic Pollutants) & EDCs (Endocrine Disrupting Chemicals)
- c) Research on disappearing species.
- d) Toxicity of plastic use for tea, cold drinks & food storage.
- e) Research on absorption of toxins by plant cells.
- f) Measure toxin levels in blood, food, water.
- g) Measure toxins in table salt which can potentially come from polluted ocean.
- h) Correlate industrial toxins with cancer & other diseases.
- i) More research on effect of global warming on body.
- j) Pollutants in milk from cows those are roaming around and consuming polluted food e.g. with plastic, paper, garbage, industrial waste, etc.
- k) Currently, most of the toxicity studies are based on showing association in survey studies, and not the cause. It is almost impossible to do direct human experiments for toxicity. Therefore, studies are needed to find out the mechanism of toxicity at cellular or molecular level.
- l) Toxicity of plastic microbeads.

- m) Toxicity of low concentrations of drugs, pesticides and other toxins found in water and food.
- n) Health side effect of RO (Reverse Osmosis) water in drinking water and cooking, e.g. removal of useful minerals, B12 vitamin, etc.
- o) Protective effects of face mask and home air filter against allergy, asthma, COPD (Chronic Obstructive Pulmonary Disease), etc.
- p) Reducing cost of solar energy use.

Following are some examples for future collective action against pollution:

- a) Subsidize the recycling of products, e.g. metal, paper, glass, plastic, etc. Discourage a business trick of using unique shapes of the product, e.g. light on car or two-wheeler is unique for each model. Thus, consumer is forced to buy it from that company during replacement. To make such items easily recyclable/replaceable, subsidize the development of “universal models” for window, door, spare-parts of vehicles (such as light source, mirror, glass, etc.), gadgets, computers, etc.
- b) Incorporate a tax on producers and consumers to cover the cost arising from pollution, e.g. cost of treating cancer or diseases like asthma due to air pollution from fossil fuel use.
- c) Create a system to recycle the nitrogenous compounds from human and animal excreta. This will reduce a vicious cycle of continued production of fertilizers, reduce toxicity, and save energy and resources.
- d) Improve public transport and subsidize it with higher tax on personal vehicles. Private vehicle transport consumes 2-3 times more fuel. There is an increasing trend for personalized vehicles, currently in India two and four wheelers constitute to more than 90% vehicles and buses less than 1%.
- e) Develop infrastructure for safe walk and biking. Biking infrastructure (like roads or parking) can be 20-80 times cheaper than it is for automobile. A car emits 282 grams of carbon dioxide per kilometer. Walking or biking will also reduce the health cost related to obesity, diabetes, heart attacks and strokes.⁽⁸⁶⁾
- f) Develop technology to increase efficiency of existing machines, appliances, car, two-wheeler, fan, light bulb, AC, refrigerator, etc.
- g) Develop the system to increase the efficiency of the chemicals used as

pesticide, medicines, fertilizer or personal care products.

- h) Shift from fossil to solar or other renewable energy to reduce global warming. This will also generate more employment. The amount of solar energy

reaching to earth is about 3500 times more than the currently used worldwide total energy, thus this is a vast potential source to tap in. Government of India's scheme for solar roof is a good step.

- i) Reduce the indoor pollution by providing efficient stoves, improving ventilation and replacing solid biomass fuel with gas cooking. Government of India is doing a commendable job to provide cooking gas connection to the poor.
- j) Control human population by improving access to the contraceptives and making high school education free and compulsory.
- k) Grow more trees and stop deforestation.
- l) Develop and implement sewage and industrial waste treatment. About 20% of all deaths under age five are caused by diarrhea resulting from pollution of drinking water by fecal bacteria.
- m) Monitor and strictly implement the vehicle exhaust and other (air, water, land) pollution regulations.
- n) Ban the use of artificial color or flavors in food, since nature has enough varieties of them.
- o) Make it compulsory to study the toxicity of newly created chemical before marketing. Also, create a time line to study the toxicity of the existing chemicals. This kind of action needs international collaborations. Finance the toxicity studies by taxing the producers and consumers.
- p) Introduce a curriculum on "Sustainability, Reduce, Reuse and Recycle" concept in schools.

Collective actions against pollution

- a) *Promote recycling*
b) *Develop affordable public transport*
c) *Develop & promote renewable energy*
d) *Treat sewage*
e) *Control population*
f) *Study toxicity of all man-made chemicals*
g) *Introduce curriculum on "Sustainability, Reduce, Reuse & Recycle" in school*

12. Summary

- a) Pollution is becoming a major factor affecting our health by increasing the incidence of heart attack, stroke, asthma, Chronic Obstructive Pulmonary Disease (COPD), cancer, brain development impairment, reproduction dysfunction, diabetes, hormone dysfunction, etc. Pollution is attributed to one out of every eight deaths. Effects of pollution can be irreversible, e.g. brain development impairment by lead toxicity, decreased lung capacity by air pollution, etc.
- b) For air pollution the major sources are fossil fuel burning (for transport, industry, electricity, etc.) and cooking with biomass (wood, cow dung cake, etc); for water pollution the sources are sewage, personal care products, agriculture, and industries; and for soil pollution the sources are garbage (plastics, e-waste, etc.), agriculture, mining and other industries.
- c) In every second the world burns fossil fuels equivalent to five Hiroshima bombs blast. By burning fossil fuels we add 11 billion tons of carbon dioxide in air annually. This is associated with global warming. The global temperature has increased by 0.85 °C during 1880-2012, which is 25 times faster than seen in natural cycles. The glaciers are melting faster, that can lead to flooding from ocean.
- d) Globally average human uses 20 kg of new minerals per day. Average American needs fossil fuel energy equivalent to 100 people food energy! We are using natural resources from land and water 50% faster than they can be regenerated. Such a lifestyle is neither sustainable nor desirable.
- e) More than 140,000 of chemicals are synthesized and used, out of which 93% are not tested properly for toxicity. Since it is not a legal requirement, the industries are not interested in studying the toxicity except in cases of medicines. It can take decades to know the toxicity. For example it took 30 years to ban DDT use and 75 years to declare it as carcinogen. The efficiencies of the chemicals used are highly limited for the specific target, e.g. for pesticides it is about 1%, for medicines it is 10-70% and for fertilizers it is 30-60%. Thus, most of them end up as pollutants. About 1000 different chemicals are known to cause hormonal dysfunction, e.g. obesity, diabetes, sexual dysfunction, development problems, etc. There are 248 chemicals identified as cancer causing agents.

- f) In everyday life we are exposed to many chemicals, e.g. about 10,000 chemicals are used in textile and personal care products (e.g. soap, detergent, shampoo, hair dye, lipsticks, perfumes, etc.).
- g) Many pollutants take years to degrade, e.g. methyl mercury, lead and POPs. Such pollutants get accumulated in the body to cause toxicity.
- h) More than 90% of plastic is not recycled and it ends up as pollutant. Similarly 90% of untreated sewage ends up into river.
- i) Human activities are causing disappearance of plants and animals 100 times faster than the natural rate. We have barely identified 10% of varieties of such plants and animals, and we do not know how their disappearance will affect us.
- j) Our life is co-dependent on plants and other animals. We all share common sources of air, water and land. Therefore, a pollution created by any country or industry will reach to all of us some day. India has the world most air polluted cities and its 70% of surface water is polluted. Now pollutants are detected in drinking water, food, blood, breast milk and even in newborn baby. Currently, we do not know the consequences of low levels many pollutants, but it is a wakeup call to act before it can be too late.
- k) The science and technology cannot solve all of our problems. For example, AC cannot be a solution for hot climate because it will add more heat due to its 30% efficiency. Even using clean energy such as electric car will need more energy to generate electricity from fossil fuel such as coal, oil or gas. Similarly the future technology to trap atmospheric carbon dioxide will not be able to remove the heat released from fossil fuels use. Bottom line is that we have to change our life style to make it sustainable.
- l) Preventive measures for pollution are: control consumerism, switch to vegetarian food, prefer organic food, do not use plastics for food/drink storage, do not burn solid waste, read labels and avoid harmful toxicants, save energy, let our household labor become regular exercise, reduce pollution from fireworks and loudspeakers, get involved in raising awareness/policy change for developing public transport, growing more trees, developing renewable energy, reducing pollution from home cooking with wood/coal/dung, stopping deforestation, recycling nitrogenous waste and sewage, etc.
- m) Some skeptics argue that the studies are showing association between

pollution and diseases, but not proving the cause. However, such epidemiological evidences cannot be ignored. This is what the history has taught us in cases of toxicity of lead, tobacco smoking and DDT. On other side, we do not need extreme activism to oppose blindly the developments of science and technology in the name of environment. What we need is to encourage and support the scientific approach to the pollution.

n) In short the two major sources of pollution are man-made chemicals and fossil fuel use. The pollution causes human diseases, adversely affects agriculture, accelerates animal species extinction and global warming. Thus, the protection from pollution includes restricting the uses of man-made chemicals and fossil fuels.

o) We have choices before us and we are capable of choosing them wisely:

- To continue consumerism in the name of progress and threaten our own existence; *OR* to take step towards sustainable life style.
- To neglect climate change resulting mainly from the fossil fuel use and pay higher cost later; *OR* to start taking steps towards renewable energy.
- To continue using machines for household work and gym exercise; *OR* to incorporate physical labor in daily work.
- To keep using man-made chemicals without testing their toxicity; *OR* to start testing them for toxicity.
- To continue spending our wealth for ornaments, cosmetics, or fashions; *OR* to use it to explore universe, to cure human diseases, to do research for renewable energy and sustainable life, increasing efficiencies of machines/appliances, etc.
- To keep increasing the meat consumption because we can afford it and not because we need it even though it is less healthy and more resource consuming; *OR* switch to more vegetarian food.
- To neglect disappearance of plants and animals; *OR* to take action to preserve this beautiful world of nature.

All these choices will decide not only our own fate but also for other plants and animals.

13. Summary of Pollutants, Sources & Toxicities

Pollutant	Exposure media	Major sources	Major toxicities
Particulate Matter (PM)	Air	Construction, vehicles, industries, indoor cooking with biomass, brick kilns, power plants, fossil fuel burning, garbage burning, forest fire	Lung cancer, Chronic Obstructive Pulmonary Disease (COPD), asthma, heart attacks, strokes, diabetes
Gases			
Carbon dioxide	Air	Vehicles, burning of fossil fuels, indoor cooking with biomass, burning garbage, forest fire, industries	Greenhouse effect (global warming), ocean water acidification
Carbon monoxide (colorless & odorless gas)	Air	Incomplete combustion in vehicles, industries, indoor cooking with biomass	Smog, headache, nausea, unconsciousness, death, miscarriage, stillbirth, low birth weight, reduced oxygen carrying capacity for hemoglobin
Methane	Air	Oil and coal extraction, incomplete burning of biomass, animal husbandry, rice cultivation	Greenhouse effect (global warming)
Nitrogen oxides (reddish brown gas with sharp odor)	Air	Diesel burning, industries, indoor cooking with solid fuels, use of nitrogenous fertilizers	Asthma and COPD exacerbation, acid rain (because formation of nitric acid with water), greenhouse effect (global warming)
Ozone (colorless & odorless)	Air	Diesel burning, vehicles, industries, indoor cooking with solid fuel, secondarily formed from nitrogen oxides and volatile organic compounds	Asthma and COPD exacerbation, cough, decreases agricultural crop yield by reducing photosynthesis
Sulfur oxides (colorless gas with annoying odor)	Air	Coal burning, sulfur containing fuel used in vehicles, industries, indoor cooking with biomass	Irritates eyes and respiratory tract, asthma, acid rain (because formation of sulfuric acid with water) causing building damage and depletion of soil minerals, loss of chlorophylls in plants and reduced agricultural crop yield
Volatile Organic compounds (VOC) and Solvents	Air, water, skin	Industries, oil based paints, adhesives, shoe polish, cosmetics, markers, sprays, nail polish remover, dry cleaning	Irritation of throat & eyes, headaches, dizziness, cancer (by benzene)
Metals			
Aluminium	Water, food, dust	Fireworks, industries, cooking with aluminium vessel	Alzheimer's disease



Green algae's excessive growth forms a layer in the pond due to pollution from pesticide and detergent. It kills the nearby aquatic organisms by depleting oxygen. (Photo : Ajay Patel)



(Photo Courtesy : "Bhumiputri"-1-6-2018)

During every minute the world produces 96 lakh plastic bags and 10 lakh of plastic bottles, after one time use most of them are dumped into garbage that can kill aquatic animals and choke up the gutter lines.

(<https://www.theguardian.com/environment/2017/jun/28/a-million-a-minute-worlds-plastic-bottle-binge-as-dangerous-as-climate-change>)



Making of one golden ring produces about 20,000 kg of garbage from mining. Also, purification of gold releases poisons like mercury and cyanide.

(Photo: Vasant Panchal)

Chemicals used in synthetic pesticides can cause cancer and Parkinson's disease.

(Photo: Harish Desai)





Production of cosmetic like Personal Care Products uses about 10,000 chemicals. They can be carcinogenic and endocrine (hormonal) disruptors. (Photo: Kishor Mistry)



Butterfly population in UK dropped to half over past 20 years mainly due to the pesticide toxicity. (Photo : Vasant Panchal)

During last twenty years bird like crow has almost disappeared, for which one of the reasons is pollution.

(Photo : Vasant Panchal)



The number of house sparrow has declined by more than 70% due to loss of space for nesting, reduced availability of water and food, reduced trees, pollution, etc.

(Photo: Vasant Panchal)

During last 30 years about 200 species of frogs have become extinct. Natural rate of extinction is one species per 500 years. The main cause of accelerated extinction looks to be water pollution.

(Photo: Vasant Panchal)



Arsenic	Water, food, dust	Rocks, smelting, thermal plants, fuel burning, e-waste	Diabetes, ischemic heart disease, cancers (lung, bladder, kidney, skin), impairs brain development, hyperpigmentation in hands and feet, gangrene in legs, reduced immunity, peripheral neuropathy
Cadmium	Water, food, dust	Industries (pigment work, textiles, electroplating, chemical plants, mining), plastics, contaminated water, cosmetics, waste batteries, e-waste, incinerators and fuel combustion, smoking, fireworks, phosphate fertilizer	Destruction of Red Blood Cells, impairment of bone marrow, increased bone fractures (Itai Itai disease), kidney damage, cancers (lung, prostate, kidney), diarrhea, abdominal pain, testicular damage, hyperactivity, reduced IQ
Chromium (hexavalent) (Trivalent chromium is essential for body in small amount)	Water, food, dust	Industries (steel, alloys, plating, dyes, chemicals), mining, leather tanning, e-waste	Kidney damage, nasal septum perforation, cancers (lung, nasal, gall bladder, prostate), skin allergic and ulcerative reactions, asthma exacerbation
Copper	Water, food, dust	Mining, electroplating, smelting, fireworks, e-waste	Hypertension, sporadic fever, uremia, coma
Fluoride	Water, food	Toothpaste, drinking water, rocks	Fluorosis of bones, arthritis, and teeth mottling (white spots on teeth)
Lead	Dust, water, food	Paints, lead batteries, industries, indoor cooking with biomass, vehicles, burning of coal, burning of plastics or papers, crematorium, iron and steel production, lead smelters, tobacco smoke, ceramic glazers, mines, lead-based water pipes, e-waste, cosmetics (e.g. lipstick, Kajal, hair dyes), food container and solder, folk remedies (herbal and Unani)	Mild mental retardation (reduces IQ), anemia, kidney and liver damage, hearing loss, hypertension, miscarriage, stillbirth, carcinogen, heart attacks & strokes

Mercury	Air, water, food	Coal burning, industries (mining, paint, paper, chlorine, caustic soda, fertilizers and pesticides), e- waste, plastic waste, dental waste, thermometers, fluorescent lamps (CFL), soaps and lotion, crematoria, thermal plants, hospital waste, gold processing, contaminated fish eating	Reduced IQ, autism, ADHD, low birth weight, vision and hearing problem, kidney damage, liver damage, accumulates in ocean fish and reaches to human causing Mina Mata disease , increased coagulation of blood, endocrine disruptor, affects immune system
Nickel	Water, food, dust	Cosmetics, smelting, thermal power plants, battery industry, e-waste	Lung cancer, skin allergy, kidney and liver damage
Endocrine Disrupting Chemicals (EDCs)			
BHA (Butylatedhydroxyanisole)	Water, food	Food, cosmetics	Promotes cancer, endocrine disruptor
BPA (Bisphenol A)	Water, food, dust	Plastic bottles, linings of canned food, eye glass, CVD/DVD, cell phone, electronics, epoxy resins, automotive primers, dental sealants, plastic wraps, thermal paper	Acts like estrogen, causes early puberty in females (with early menses and breast development), polycystic ovarian syndrome, uterine fibroid, miscarriages, breast cancer, obesity, diabetes, prostate cancer, heart diseases, impairs brain development, reduces immunity
DDT (banned in many countries)	Water, food	Pesticide	Infertility, miscarriages, breast cancer, diabetes
DES (Diethylstilbestrol)	Water, food	Synthetic estrogen	Early puberty in females (with early menses and breast development), uterine fibroid, endometriosis, cancers of vagina/cervix/breast, hypospadias (abnormal urethral opening) in male children, obesity
Dioxins	Food, air	Byproducts in manufacturing and incineration of plastic, municipal and medical wastes, fatty non-veg food, indoor cooking, vehicle, e-waste	It accumulates in body (POP), endometriosis, obesity, diabetes, liver cancer, disruption of immunity, learning disorders
Parabens	Water	Sunscreens, lip balm, moisturizer, shampoo, toothpaste, makeup	Endocrine disruptor, low birth weight, affects male reproductive function, cancer, immunotoxic, neurotoxic

PBBs (Polybrominated biphenyls)	Food, water, dust	Flame retardant in electrical appliances, textile, plastic foams	Early puberty in females (with early menses and breast development)
PCBs (Polychlorinated biphenyls) (banned in 1972)	Food (beef, pork, dairy, fish, breast milk)	Coolant and insulation in electrical equipment (transformer, capacitor, appliances), e-waste	It is a POP, early puberty in females (with early menses and breast development), reduces semen quality in males, endometriosis, carcinogen, obesity, diabetes, reduced IQ, ADHD
PFCs (Perfluorinated compounds e.g. PFOS and PFOA)	Food, water, dust	PFOS is used as stain and water repellants in apparel, carpets, fabrics, leather, food containers, non-stick cookware, paints, paper coatings, floor polishes, insect formulations, photographic film, cosmetics, shampoos, denture cleaners, fire-fighting foams and fire protection products, alkaline cleaners, coatings, surfactants, including mining and oil wells, and in metal plating and electronic etching baths PFOA is used in breathable waterproof fabrics, biomaterials, insulations for electrical wiring, and foam fire extinguishers.	Reproductive abnormality, obesity, liver toxicity, neonatal toxicity, neurobehavioral, cancers (testis, bladder), endocrine disruption (hypothyroidism, obesity), bioaccumulates (POP)
Phthalates (banned in children products)	Air, water, dust	Cosmetics, fragrances and medical devices, food packaging, soaps, shampoos, hairspray, nail polish, pharmaceuticals, nutritional supplements, herbal remedies, building materials, vinyl flooring, paints, adhesives, detergents, solvents, lubricating oils, plastic bags, garden hoses, automobiles, children's toys, modeling clay, glow sticks, cleaning products, and as inert ingredients in insecticides, raincoat, toothbrush, insect repellent	Early puberty in females (with early menses and breast development), infertility, endometriosis, reduces sperm count, interferes with thyroid function, attention and intellect deficit, liver cancer, diabetes, asthma exacerbation, birth defects, obesity, cardiovascular diseases (heart attacks & strokes)

PVC (polyvinylchloride)	Dust	e-waste, plastics, cable	Produces dioxins on burn, reduces immunity
Other Organic pollutants			
CFCs (Chlorofluorocarbons) (banned in 1987)	Air	Leakage from AC and refrigerators	Ozone depletion in stratosphere, greenhouse effect (global warming)
DECA (Decabromodiphenyl Ether)	Air	Flame retardant used in electronics, furniture and carpet	Memory loss, hearing deficit, decreased sperm count
Formaldehydes (e.g. DMDM hydantoin, diazolidinyl urea, Quaternium-15, bronopol, imidazoledinyl urea, formalin, formic aldehyde, merthaldehede, methanal)	Air	Indoor cooking with biomass, nail polish, shampoo, lotion, eyelash glue, moisturizer, eye shadow, mascara	Leukemia, greenhouse effect, asthma exacerbation, developmental toxicity
PAH (Polycyclic Aromatic Hydrocarbons, e.g. benzopyrene)	Air	Incomplete burning of biomass	Lung cancer, skin cancer
Pesticides	Water, food	Agriculture	Suicide poison, sterility with DBCP, preterm births from DDT, Parkinson's disease, convulsions, cognitive development, birth defects, childhood leukemia, endocrine disruption, cancer (by DDT, aldrin, eldrin, dieldrin, heptachlor, mirex, toxafen, fonofos, terbufos, malthion, permithrin, lindanem chloradane, glyphosate, atrazine, captain), suppresses immunity, asthma
Plastics	Soil, water	Plastic products	Eaten by animals resulting into blockage of digestive system, affects immune system, reduces photosynthesis in algae, blocks drainage
Sodium lauryl sulfate	Water	Toothpaste	Mouth (aphthous) ulcers

Triclosan	Water	Antibacterial soap, toothpaste, deodorant, face and body wash, cosmetics, mouthwash, fabrics, plastics	Antibiotic resistance in bacteria, endocrine disruption and inhibits photosynthesis in algae, disrupts thyroid function
Others			
Asbestos (silicate fibers)	Air	Housing insulation, roofing, tiles, dry wall, toys	Mesothelioma (lung cancer), asbestosis
Fertilizers	Water	Agriculture	Excessive algae growth from nitrates and phosphates, soil acidification from nitrate leaching, contributes to ozone and nitrogen oxides, excess nitrate in water causes blue baby syndrome & cancer
Perchloric acid	Air, water	Fireworks	Hypothyroid, lung cancer
Light		Artificial lights	Disturbs circadian cycle, sleep disturbance, affects nocturnal animals
Micro-organisms (e.g. bacteria, viruses, protozoa)	Water, food, air	Fecal material, sewage	Typhoid, cholera, diarrhea, hepatitis-A, polio, dysentery, eye infection
Microwaves		Mobile phone, radio-tower and wireless network	Glioma (brain cancer)
Noise	Air	Vehicles, loudspeakers, radio, TV, AC, public gathering, fire cracker, railways, airport	Sleep disturbance, high blood pressure, stroke, heart disease, reduces work performance, hearing loss
Radioactivity		Nuclear plant	Gene mutation, impairs reproduction, cancers (bladder, lung, ovary, stomach, skin, thyroid, leukemia)
Thermal	Water	Industries	Decreases oxygen in water, affects aquatic lives

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Introduction to the Author

Dr. Kishor Mistry was a faculty member at Biochemistry Department, MS University of Baroda. He went to USA with determination of returning to India for social work. In USA he studied MD in family medicine and came back to India after 21 years of stay. He is serving a slum population in Vadodara by providing healthcare.

His wife, Dr. Varsha Shah was also a faculty at Biochemistry Department, MS University of Baroda. She became a teacher in USA and after coming back to India she is serving slum children by providing educational support.

This social work is carried out through the Koshish-Milap trust (www.koshish-milap.org).

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Plastic can stay in the environment for 500 years.



95% of plastic used in packing ends up in garbage.

Do you Know ?



Every year we discard plastic that can encircle our earth four times.



Half of the ocean garbage comes from discarded plastic.



Every year 1.3 million ton of plastic garbage ends up in ocean.



Avoid using disposable plastic items.



Try to find a better alternate to plastic.



Carry your own glass, cup and bottle during travel.

Photo & Content - Source : Bhumi Putra, Dt. 1-6-2018





Ground Water, Ekalbarā, Dist. Vadodara
Source : P.S.S.

In 2012 the pollution caused 1000 deaths per hour everyday worldwide, which is one out of every eight deaths. Pollution has been linked with increased in heart attack, stroke, cancer, diabetes, asthma, Chronic Obstructive Pulmonary Disease, reproductive dysfunction, impaired IQ, etc.

Major sources of pollution are man-made chemicals and fossil fuel use. Out of about 1.4 lakh man-made chemicals only 7% are studied properly. So far scientists have identified 248 chemicals as cancer agents and 1000 chemicals as hormone function disruptors. Fossil fuel is a major contributor to air pollution and global warming.

Since our body is maintained by continuous exchanges of surrounding air, water and soil; someday the pollution reaches our body, plants and animals. The toxic chemicals are detected in human blood, baby growing inside womb, breast milk, food, drinking water and in distant Polar Regions.

Eleven out of the world's 20 most air polluted cities are in India. Air pollution is attributed to 2-3 years of shorter life span in India. In India about 70% of surface water and ground water reserves have been contaminated.

Pollution is also linked to 25 times faster global warming and the 100 times quicker extinction of plants and animal species compared to natural process. The uncontrolled pollution can make our life unsustainable or even can threaten the very existence.

This booklet is compiled on the basis of available evidences about pollution and health to raise awareness.