WORLD ENVIRONMENT DAY
JUNE 2019

On the Theme of

"Air Pollution"

Celebrated by

PAKISTAN ENGINEERING CONGRESS

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(4th Floor) Pakistan Engineering Congress Building,
97-A/D-1, Liberty Market Gulberg III, Lahore 54660
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ON BEHALF OF PAKISTAN ENGINEERING CONGRESS

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Immediate Past President / Convener Symposium Committee

Published by:

Engr. Najam Waheed
Secretary PEC

Price Rs.500/-
Members Free

ISBN: 978-969-603-041-6

Can be had at:

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LAHORE AMBIENT AIR POLLUTION: MAIN ROOT CAUSES AND IMPACTS ON PUBLIC HEALTH – A DETAILED REVIEW

Dr. Eng. A. Yasar[1], M. Iftikhar[1], B. K. Bakht[1], M. N. Anwar[1], Dr. A.B, Tabinda[1], M. Shabbir[1]

Abstract

Air pollution is one of the most critical environmental issue in the developing world. Greenhouse gases significantly contributed in the elevated global temperature. The emissions from the combustion of fossil fuels proved to be a major reason behind deteriorated environment of the metropolitan cities of the developing countries. The case of Lahore is no exception. It is a second most populous city of Pakistan which houses 11.1 million individuals. The study in 2015 showed that the polluted compound in the air such as particulate matter 2.5 ($PM_{2.5}$) was nine times more than the standards of WHO. The considerable sources of $PM_{2.5}$ are transportation related emissions, coal-fired power plants, household solid fuel burning, industrial emissions and open biomass burning. The crowded urban cities are demanding rapid urbanization fueled by massive infrastructure investment and followed by enormous environmental degradation. This situation give rise to inadequate public transport system which is a reason of higher rate of car ownerships increasing at 17% per annum.

The effects of the air pollution are very disastrous. The pollutants which cause fatal public health problems are (PM_{10}, $PM_{2.5}$), carbon monoxide (CO), nitrogen oxides (NOx), Sulphur dioxide (SO_2) and ozone (O_3). The major source of these pollutants are anthropogenic activities such as emissions from automobiles, industrial plants, brick kilns and stubble burning. Loss of the lung capacity, asthma, emphysema, lung cancer, asthma and reduced life span are the common health problems caused by air pollution. The smog episodes in urban cities are reason of variety of inflammatory diseases. There is a strong need to monitor ambient air quality in order to protect the human health and the environment in a region. The monitoring of air quality provides the information to formulate the air quality standards and objectives for various air pollutants in the air. This study was conducted to investigate the major causes of air pollution in order to provide the global scientific community and policy makers with the much-required scientific data to curb the emissions. This is a novel study since it just not identifies the sources but also tries to present a detailed – qualitative and quantitative - account of the associated impacts experienced – or expected to experience in future – by the citizens.

INTRODUCTION

Now a days, air pollution is identified as one of the major risks to the health of the living organisms. Interaction of humans with the air pollution of both types household and ambient increases the risk of individual human's exposure to the

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diseases as a result of the air pollution for example chronic bronchitis, lung cancer, different heart diseases, and stroke. In accounting of one of the latest studies, it was estimated that in 2013, almost 5.5 million deaths and most of these deaths were premature deaths or one out of every total ten deaths was somehow a result of the air pollution. Drastic health effects caused by air pollution are available globally since 1990s. In 1990s air pollution was a great risk to the human health ranking as the fourth lethal disease almost causing 4.8 million premature deaths in worldwide.

Human population is increasing at a massive scale and this air pollution is even more severe and dreadful in the region's growing at a very fast rate particularly urban areas, where more vehicular emissions are greatly contributing towards the air pollution and hence increasing the exposure towards the air pollution and its drastic effects. This does not mean that air pollution is only a problem in the urban regions, air pollution is also a great problem in the areas outside the cities. People in the villages and other under developing regions mostly use wood, charcoal, and cow dung, coal for heating and cooking purposes. Burning of coal, cow dung, wood etc as the fuel for cooking and heating contributes greatly towards the air pollution. It is also studied that the health risk due to the air pollution is more severe in the developing countries as compared to the developed states. According to the one study it was estimated that approximately 93% of the deaths and the fatal illnesses due to the air pollution occurred in the developing countries worldwide and approximately 90% population of these developing countries was exposed to the air pollution and its drastic effects. The ratio of the children's death (children under age of 5) due to air pollution and its lethal effects is approximately 60 times more in the low income countries as compared to the countries with high income proportion (Bank, W. 2016)

Various industries such as fabrics, chemicals, engineering, transportation, mining and construction etc. have put both an encouraging and damaging impact on the environment, human wellbeing and economic condition of a country. All these industries play a key role in a country's financial condition, lifestyle, employment opportunities and Gross Domestic Product (GDP). Moreover, ecosystem, economy and human health is adversely affected creating several problems like ozone depletion, soil erosion, depletion of natural resources and economic instability, intensification of pollution and rise in humans, animals and plants associated diseases. Many countries are concerned with the regulation of undesirable outcomes of construction industry but Pakistan, being a developing nation did not pay heed to the proper study and analysis of construction industry. Brick kilns are the major constituents of construction industry leading to rapid pollution. Many countries like China, India & Pakistan, have brick manufacturing as their fastest- growing industry. Emissions from brick kilns account for most of the air pollution and health issues in Pakistan.

Pakistan the 3rd largest bricks manufacturer in south Asia produces about 45 billion bricks. Pakistan's bricks sector is responsible for 1.5% of its GDP. The pollutants produced due to brick kilns using coal as fuel are Sulphur dioxide, carbon

monoxide, carbon dioxide, NOx and particulate matter. These emissions from the brick kilns lead to ozone depletion and acid rain. When these harmful gases released into the atmosphere encounter rain drops, they get converted into the weak acids. These weak acids have detrimental effects on the plant surfaces; leaves and stems, and on the skin of animals and humans. These gases also inflict harm to aquatic life by flowing with water into the rivers and other waterbodies. In addition, these hazardous chemicals also change the pH of soil. On the other hand, the disproportionate use of soil in bricks leads to soil degradation causing numerous environmental problems. Coal is the main fuel employed in brick kilns and for this purpose the use of excess wood gives rise to deforestation which in turn leads to several other environmental issues i.e. air pollution, health issues and climate shift etc.

Human health related issues are mainly due to the air pollution caused by emissions from the brick kilns. When these harmful gaseous emissions from brick kilns, are inhaled by human beings, they cause diseases such as cardiovascular problems, (CNS) central nervous system malfunctioning and different respiratory diseases. Few of these respiratory diseases are lung cancer, emphysema, chronic bronchitis, sputum, asthma, wheezing, cough and dyspnea. Other than respiratory problems, other health associated issues are also caused including ear, nose and throat problems and irritation of eyes. Thus, brick kilns have harmful impact both on the environment and human health. The significant and common emissions from brick kilns are Sulphur dioxide, carbon dioxide, carbon monoxide, nitrous oxides, fluoride compounds, particulate matter and carcinogenic dioxins and they are responsible for having adverse effects on the health of human beings. (M. W. Khan et al., 2019)

The damaging emissions from brick kilns are accredited to the consumption of low-quality fuel i.e. coal, secondhand motor oil and rubber tyres. Lack of emission control mechanisms and devices along with composition of these fuels results in the uncontrolled emission of enormous amount of pollutants into the environment. Such sources emitting number of pollutants into the ecosystem disturb the ambient air quality of that vicinity and cast direct and indirect threats to human health, plants and animals nearby. (Achakzai et al., 2017)

Airborne particles are considered as the indicators for the air quality as these have very drastic effects on the health of the humans. The particulates suspended in the air are more in the urban areas as compared to the rural comprising of the organic and inorganic contaminants. It was also studied that these particulate matters are the carriers of the toxic heavy metals. Particulate matter generally PM_{10} also have the capacity to carry heavy metals with it and these metals could be inhaled into the lungs by the humans thus causing drastic effects on the human health.

The sources of these particulate matters suspended in the air are both natural and human activity based. Natural sources include volcanic eruptions, winds, dust etc. Human activity-based sources are the emissions from the vehicles, industrial emissions, different combustion issues etc. These human based activities have

more drastic impacts on deteriorating the air quality as compared to the natural sources. Some of the major reasons for the anthropogenic increase in the particulate matter in the air are the rapid urbanization, drastic increase in the population which has also resulted in the increase in the traffic volume which has ultimately resulted in the increase in the vehicular emissions in the recent few years. In twenty years from 1991 to 2012 number of automobiles has increased from 2 to 10.6 million in Pakistan and the number of two stroke vehicles has increased more than ten times in this time duration in Pakistan (I. Ahmed. at al., 2019)

Main Root Causes:

Population growth and the economic development of the country could be easily recognized or indicated by the utilization of the fossil fuels by that nation. Both of these factors of population growth and economic development are the major factors in deteriorating the environment on the larger scale. Most of the ecological and other related issues in the urban cities and towns of the world are mostly due to the transportation sector which include different emissions from the vehicular engines. Utilization of the fossil fuels at a greater scale produce emissions which result in significant increase in the greenhouse gases which ultimately deteriorates the environment.

Transport sector is the most prominent source which deteriorates the environment at a very massive scale. In transport sector emissions are not only produced by the burning of the fuels in the engines of the vehicles but it also includes the emissions produced during the extraction, handling, purifying, manufacturing and transporting the fuel. According to one study 13.5% greenhouse emissions are produced from the transportation sector. Transportation factor mostly consumes the fossil fuels and most of the energy in the transportation sector is based on the non-renewable energy. Transportation sector is most important lifeline especially for the developing countries like Pakistan as transport sector needs to be very efficient, and reliable for the better social and economic communication as well. (Shirwani et al. 2019)

Environmental variation also chiefly depends on greenhouse gases significantly, CO_2 in the Earth's climate leading to global warming. Greenhouse Gas emissions include CH_4, NO_x, CO_2, O_3 and water vapors. The CO_2 outflows formed from anthropogenic activities are outcomes from the combustion of fossil fuel bringing about soil attrition, deforestation, animal husbandry, and farming etc. (Lin et al., 2017). Power sector was found to be responsible for GHG emissions in 2015. According to IEA (2017), the percentage proportion accounted for CO_2 90%, for N_2O 1%, for CH_4 9% and for other gases14%. Climate change affects weather patterns, household income, poverty, agricultural and forest products, local livings. (Rahut et al., 2017). Environmental variations immediately influence diverse sectors of Pakistan including water accessibility, harvest patterns, cattle, forests, biodiversity, coastal zones and many more. That is why, this is one of the most dangerous and complex environmental issues. According to Pakistan Energy

Yearbook (2016), energy mix was as; oil (27.5%), gas (40.9%), LPG (0.3%), coal (5.4%), hydropower (7.7%), nuclear energy (1.3%) and renewable energy 0.4 Mt

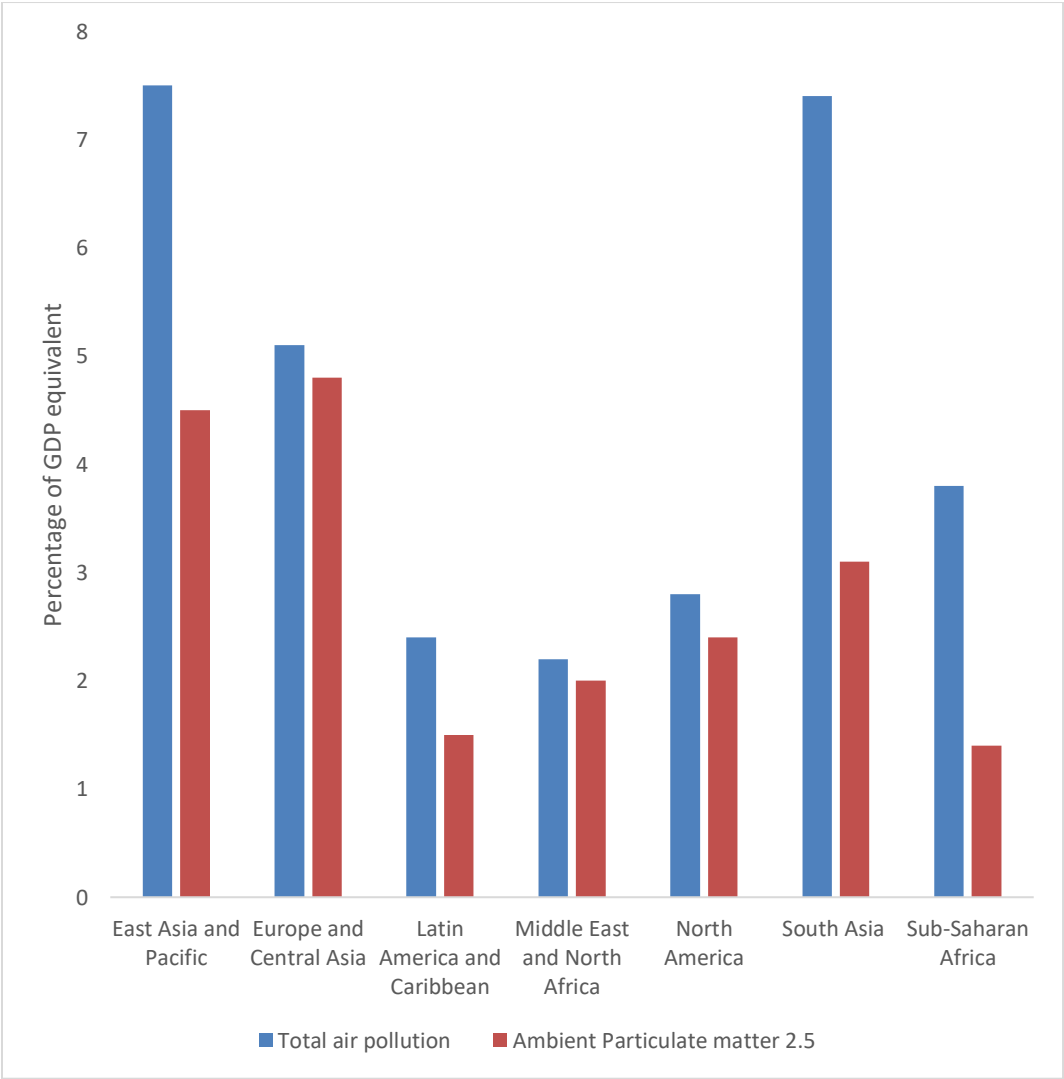
According to the report of World Health Organization (WHO) most health risk factor to the people now a days is air pollution. According to this report approximately 4.2 million people die globally due to the outdoor air pollution in 2016 and 91% of these deaths were caused in the low-income and middle-income countries. One of the main reasons for the poor air quality in these developing and poor countries is the use of the old technology and poor vehicles for the transport purposes which emit large amount of the harmful emissions and also consume large amount of the fuel. In perspective of Pakistan it was reported by the World Health Organization (WHO) that suspended particles has increased to a large level in Karachi, Pakistan which possess drastic risks to the human health. (World Health Organization, 2018)

Ambient Air Analysis of some parameters with monitoring stations at different areas of Lahore (Ashraf et al., 2018)

Location	Parameters	NO	NO_2	NO_x	SO_2	CO	VOC	O_3	PM_1	$PM_{2.5}$	W.S	Temp	Humidity
	Units	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	ppm	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	m/s	˚C	%
	PEQS	40	80	_	120	5	_	130	150	35	_		
Mall Road Lahore 2-3 Nov 2016 24 Hrs. Avg Lahore Smog		335	202	537	38	6	3	154	210	55	0.02	21	70
Mall Road Lahore 2-3 Nov 2015 24 Hrs. Avg Baseline Value		25	7	32	9	4	0.2	38	145	30	3	23	64
Gulberg Lahore 2-3 Nov 2016 24 Hrs. Avg Lahore Smog		270	191	461	70	6	2	148	165	40	0.02	21	70
Gulberg Lahore 2-3 Nov 2015 24 Hrs. Avg Baseline Value		26	10	36	12	4	0	40	126	27	2	22	66
Township Lahore 2-3 Nov 2016 24 Hrs. Avg Lahore Smog		338	226	564	78	6	3	132	191	51	0.01	21	70
Township Lahore 2-3 Nov 2015 24 Hrs. Avg Baseline Value		24	6	30	9	4	0	36	130	30	2	23	64

Welfare losses due to air pollution by region

Air pollution is causing its impacts since 1990 and approximately from 1990 to 2013 losses due to the air pollution have almost doubled including the increase of 40% in the loss of the labor income due to the air pollution impacts, even though the economy and the health status of many countries has increased enormously in the time period of twenty three years. On the other hand, in the developing and low-income countries death rate had increased due to the enormous increase in their population with the same less income sources and the air pollution. Globally in almost all the countries of the world, the proportion of the people affected by the air pollution has increased and it has resulted into greater number of the deaths other than the effect on their incomes (Bank, W. 2016).



The income status of regions effected by air pollution (Bank, W. 2016)

Air Pollution and Health Effects

Many studies have shown the drastic effects on the health of the living organisms in the past years because of the air pollution. Many different studies have been conducted which particularly examined the effects of the air pollution on the health for example effects or increase in the number of the cardiovascular patients or premature deaths due to the air pollution in many different parts of the world especially in America and the European countries. It was determined that the most common root cause of the death due to air pollution are the cardiovascular and respiratory diseases. This air pollution is having even more severe impacts on the health in the developing countries where there are no proper precautionary measures and the management to prevent the air pollution. There is still a need to make more scientific studies related to the air pollution and its impacts on the health in the developing countries (A. Phosri et al. 2019).

Reported diseases among patients	**Reported patients**	
	November-2015	**November-2016**
Dry Eyes	12	13
Irritation	20	21
Conjunctiva	42	42
Lacrimation	11	7
Lid Erosion	4	5
Cornea	7	8
Uveitis	3	4
Total	100	100

Percentage of reported eye related diseases among citizens of Lahore, based on data from 2 major hospitals. (Ashraf et al., 2018)

Air Pollution and Cancer in Children

In children there are many diseases and drastic health effects reported due to the short term and long term exposure to the air pollution in the over growing urban areas of different parts of the world. Cancer is one of the major diseases caused as a result to the exposure with the air pollution for a long term and at the end

causing the death of the children. Childhood cancer are more in white boys as compared to the white girls with the average ratio of 120-150 determinations of the cancer cases in per million boys as compare to the ratio of 110-140 determinations of the cancer cases in per million girls. This shows that the boys are less affected as compared to the males. Cancer also causes loss of death in the children:

- 4% children under age group of 5 years die due to the cancer because of the air pollution
- 13% children under age group of 5-15 years are died due to cancer because of the air pollution
- 15% children's death rate is the average death rate of the children under age group of 15 years die due to the cancer because of the air pollution

Some studies have also revealed that the increase in ratio in the childhood cancer is due to the increased exposure with the traffic and its harmful emissions. However, this could not be considered as the only solo reason for the childhood cancer and the very basic or root causing reason for the childhood cancer is unknown somehow, there are some factors which are confirmed to be associated with the childhood cancer these factors include environmental pollution particularly the air pollution, traffic emissions and radioactive rays or emissions. Furthermore, it has been studied that air pollution is one of the very basic and necessary reason for the increase in proportion of childhood cancer, this could be inferred as because the number of the childhood cases due to the alterations or mutations in the genetic material are very less so one of the other possible reason for the increasing childhood cancer is the air pollution (M. Seifi et al. 2019).

Air Pollution and Urbanization

Industrialization and the increasing urbanization have resulted into the massive increase in the environmental pollution and this pollution has decreased the well-being and the life quality of the humans. Environmental pollution is a very sensitive topic in relation with the health of the people but as it is the era of the development and the world is going towards the industrialization for the sake of the economic development and while making this development people are neglecting the environment and as a result the environmental pollution has increased at a massive scale and the impacts of the environmental pollution are now visible globally. Many people are unaware of the impacts of the environmental pollution and that is why they do not consider it important to make the development in the sustainable manner, industrialists only focus on the development but not on the sustainable development. Local people like the industrial development provides them with the job opportunities and reduces the poverty. This industrial development is good for the economic development and as far as the concerns of the public are concerned regarding the job but people should also make aware about the environment as it is the most important thing for the living and people should be seriously concerned regarding the environment and its protection. Population of china is increasing massively and it has also the fastest economy

development rate in the world from the last few years with the growth rate of 7% per capita income. This advance development has also resulted into the massive movement of the people from the rural areas towards the urban areas. According to one study in 2017, approximately 58.5% of the population of the China have migrated from the rural areas and now live in the urban areas. Analyzing the development and the migration of the people from the rural areas towards the urban areas for the development in China and comparing it with the development of the rest of the world has resulted into the increase emissions in the environmental and hence the environmental damage. This economic and industrial development has great contribution to the production in the world but on the other hand it has also drastically damaged the environment of the local region and as well as globally. As a consequence of this development and industrialization China is facing some of the most drastic health impacts due to the air pollution and China is having most polluted skies and the waterways (Y. Zeng et al. 2019).

One of the very basic cause of the air pollution is the migration of the people towards the urban areas and hence resulting into more emissions and environmental pollution. According to one study United Nations had issued a statement in 2014 that according to the survey approximately 50% of the world's population is living in the urban areas and this ratio would increase upto 70% by 2050. This fast-growing urban development and the migration of the people from the rural areas towards the urban areas has also drastically increased the environmental pollution particularly the air pollution and its problems in the developed areas. As the population of the urban areas is growing rapidly so there are fewer open spaces present in the urban areas and hence fewer natural ventilation sources for the movement of the air, in such scenario excessive vehicular emissions has played the role of oil in the burning fire and has decreased the air quality at a greater scale. This has also resulted into many health problems and severe diseases like cardiovascular problems, issues with the respiratory systems, asthma, lungs diseases, cancer and these diseases could be resulted as fatal diseases. In air pollution basic elements decreasing the components of the air quality are the particulate matter ($PM_{2.5}$ and PM_{10}) and the aerosol particles which are suspended in the air decreases it quality. These particulate matters are evidenced to be released from the vehicular emissions and the burning of the fuel such as coal, woods for the cooking and heating in houses, industries and other combustion sources (Paulina et al., 2019).

Air Pollution and Metallurgical Processes

In the developing states air pollution and its health impacts are one of the most emerging issues along with the goals of economic development. One of the basic components of the air pollution is the Sulphur dioxide (SO_2). It is the most damaging air pollutant decreasing the visibility of the air, contributes greatly towards the acid rain and also plays important role in causing the climate change, Thus Sulphur dioxide has negative impacts on the environment and the ecosystem. Sulphur dioxide particles can migrate several hundred kilometers towards the parts of the atmosphere irrespective of the location of their emergence

depending on the metrological conditions hence this pollutant can pollute the air quality both locally and globally. Sulphur dioxide could also be made oxidized by the radical of the OH and by O_3 and water in the gas and aqueous phase respectively (S.M. Serbula et al. 2017).

In Europe different policies regarding the air pollution have been implemented for the management of the environment and the implementation of the policies regarding the air quality has resulted into the noticeable and measurable decrease in the air pollution over last few years. This has increased their air quality. However, there are still some regions or areas in the Europe where the air quality status is not in accordance with the standards set for the good air quality suitable for the living organisms. This shows that the air pollution still has some major or minor impact on the environment, and the health of the living organisms particularly in the urban areas where the air quality is not in accordance with the standards (S.M. Serbula et al. 2017).

Particulate Matter (PM) is also one of the important air pollutant and are released into the environment directly or indirectly. It is also released directly in the atmosphere by many industries and smelters for example copper smelters working for the process of the pyro metallurgical also releases the high quantity of the Particulate Matter in the atmosphere along with the other pollutants like arsenic, lead, cadmium etc. These Arsenic emissions from the copper smelters working for the pyro metallurgical processes are considered to be three folds higher as compared to the natural emissions of the arsenic. It is also estimated that the Arsenic emissions from the copper smelters almost contributes to half of the anthropogenic pollution and the emissions of the Arsenic. The “International Agency for the Research on Cancer (IARC)” has also declared Arsenic and Cadmium as the carcinogenic components and they are associated with the cancer of the lungs, liver, kidney, prostate, bladder and skin (S.M. Serbula et al. 2017).

Conclusion

Local people do not care for the environment unless or until it is a severe problem for them. Control of the air pollution in the history of the England and the United States have shown that the local people consider the environment and the pollution as a major factor only when it causes direct impact on their health and well-being. Control of the environmental pollution and particularly air pollution is possible when the local people are aware of the importance of the environment and how it effects the lives and the health of the human beings and other living organisms. On the complete awareness of the local people regarding the air pollution and the severe damages it has caused to the environment and the health of the humans, Government is in the situation to take strict orders for the control of the air pollution. Air pollution is not a regional or a local issue it is basically a global problem and it is possible only to control the air pollution when there is complete awareness in the public and they are also willing to control the air pollution because pollutants in the air are emitted from the household level upto the industrial level of very large

scale so to control the air pollution working should be made from the very small scale at house hold level and upto the massive industries level (Y. Zeng et al. 2019).

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UNDERSTANDING THE RELATION BETWEEN POLLUTED WATER AND SOLID WASTE WITH AIR POLLUTION; ESTABLISHING A CASE FOR LAHORE

By

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Literature is scarce on identifying the correlation between polluted water and the ambient air surrounding it. However, there is evidence that emissions from wastewater can also exacerbate air pollution levels. Volatile Organic Compounds (VOCs), Nitrous Oxide and Methane emissions from industrial and municipal wastewater have been found in air surrounding wastewater drains. Lahore is home to almost 14 wastewater carrying drains that contribute more than 56 per cent of Ravi's total pollutants. This paper will discuss pathways of pollutants entering air from water and try to build an understanding on how pollution in wastewater drains of Lahore may also be adding to the air pollution. Similarly, municipal solid waste is generated in massive quantities in mega-cities such as Lahore. The solid waste collected in landfill sites also produces emissions that have negative health implications. This parley will also delve into how solid waste can be a source of added air pollution.

Introduction

The principle gaseous air pollutants and greenhouse gases in the environment are: Carbon monoxide, Lead, Nitrogen dioxide, Ozone, Particles, Sulphur dioxide, Carbon dioxide, Methane and Nitrous oxide etc. This paper will first take into consideration the definition and types of pathways and the chemical processes which introduce pollutants from water streams into air. A process in which Volatile Organic Compounds (VOCs) are removed from a site is called a pathway. The nature of the process can be chemical (when alcohol oxidizes in a wastewater treatment plant) or physical (when a solvent volatilizes from a surface). Pathways can constitute of a number of process like Volatilization, Decomposition, Oxidation/Reduction, Hydrolysis, Photochemical decomposition, Hydroxyl radical reaction etc.

Pollutant Pathways

Volatilization can be defined as a process in which the dissolved sample molecules escape to the gas phase. This primarily happens due to the molecular diffusion in non-agitated liquids. There are equations through which volatilization can be calculated in wastewater treatment plants and surface water structures. However, for landfill sites, the development of the model and the supporting data available is not sufficient as compared to that of the aqueous systems. At a soil-air interface, the rate of volatilization can be calculated by considering the

[1] *WWF - Pakistan*

concentration and properties of the escaping chemical, properties of the air at soil level and properties of soil.

Biological Decomposition can be defined as a process in which microbes break down organic compounds into simpler substances as a part of their metabolism. The rate at which decomposition occurs depends on the needs of the microbes and the composition of compound. Photochemical decomposition can be accomplished in two ways: when a substance or a chemical absorbs certain amount of light and react to it which is called direct pyrolysis or when the chemical or a substance reacts to the surrounding element which has absorbed light thus called indirect pyrolysis.

Hydrolysis means the breaking of a chemical bond and formation of new product due to the addition of water into an organic compound. This is basically the opposite of condensation. As far as ***oxidation/ reduction processes*** are concerned, the organic compounds present in aqueous systems can be oxidized through a number of oxidizing agents like oxygen, peroxy radicals, hydroxyl radicals etc. Usually, the hydroxyl radicals are present in very low concentrations but react very abruptly. The peroxy radicals are comparatively less reactive than hydroxyl radicals, however, they exist in greater concentrations. Another very reactive oxidizing entity is singlet oxygen, however, it tends to be very selective in its reactions. It particularly leans towards substituted olefins and dienes. If the conditions are anaerobic, reduction reactions may occur affecting organochlorines in particular. Hydroxyl radical reactions can occur if hydroxyl radical is added, hydrogen atom is removed or if both of these processes are completed. Since the hydroxyl radicals are electrophilic in nature, these are attracted to the molecules which have high electron density, thus joining together. The removal of hydrogen in an organic molecule is controlled by number of hydrogen reactions and the electronic configuration of the molecule resulting in the breakage of carbon-hydrogen bond (U.S. EPA, 1994).

Wastewater and Air Emissions

Lahore is one of the second-most populous cities of Pakistan with a population of 11.13 million (PBS, 2017). With rising population, water demands, and the subsequent wastewater generation also increases. For Lahore, the daily wastewater generation is estimated to be 231 liters/capita. The municipal and industrial wastewater of Lahore and the towns around it like Shahdara is discharged, untreated, into Ravi River through a system of 14-drainage channels. A rough estimate suggests that 6-municipal units dump almost 8 Million Cubic Meters (MCM) of untreated wastewater daily into Ravi River (PID, 2008). In addition, 0.70 MCM of wastewater from industries is discharged into the canals by 271 industrial units. These include chemical, pulp and paper processing, tanneries, textile, dairy, plastics, poultry, paint, pharmaceuticals, food processing, pesticides and leather. These 14 drains contribute to more than 56 per cent of Ravi's total pollution load. Hudiara Drain is ranked as the second worst source of pollution in Ravi River and joins it near Mohlanwal village (WWF, 2007). Industrial and

municipal wastewater from most of Lahore is carried to Hudiara Drain, via Minhala Drain, Charrar Drain, Ferozepur Road Drain and Sattu Katla Drain. Resultantly, Hudiara Drain has now been converted into a wastewater carrier (WWF Pakistan, 2014).

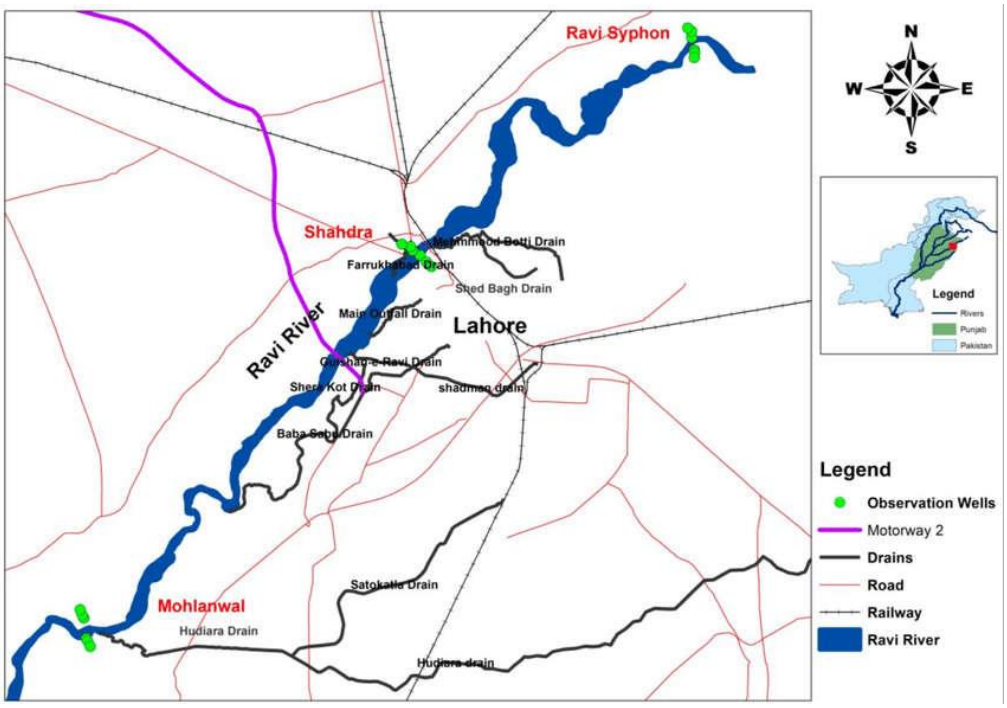


Figure 1: Map of Drains in Lahore

According to US-EPA, wastewater ranks at fifth number as a source of anthropogenic methane which was almost equal to 500 MtCO2e in 2010. Industrial and municipal wastewater treatments have shown to emit CH4, which is produced when organic matter goes under decomposition anaerobically in a wastewater treatment plant. N2O is also said to be emitted from wastewater treatment plants (U.S. EPA, 2019). Drainage channels, whether closed or open, also serve as a site for Volatile Organic Compounds (VOC) emissions. The transfer of VOCs will occur if there are substantial VOC discharges in the aqueous phase, the existence of enough drop structures which can increase the water-to-air mass transfer and finally if the headspace ventilation rates are high. If these three conditions are met, then emission "hot spots" can result in municipal sewers (Quigley & Corsi, 2012). Researchers have identified that the transfer of gases like CO2, NH3, CH4 etc. happen in an air-water interface which can potentially be used to predict the impact of wastewater on air pollution using Deacon's model. However, little data is available to support the application of this model on actual grounds (Denmead & Freney, 1992). There exists a considerable gap regarding research in this area. Emissions of nitrogen oxides and hydrocarbons react with sunlight to eventually form another secondary pollutant, ozone, at ground level. Ozone at this level

creates health concerns, unlike Figure-1: Map of drains in Lahore ozone in the upper atmosphere, which occurs naturally and protects life by filtering out ultraviolet radiation from the sun.

Since Lahore has 14-drainage channels delivering the wastewater of the whole city, it can be said that these drainage channels along their way emit Greenhouse Gases and VOCs. Particularly, areas immediately next to the wastewater discharge point of industries, around Hudiara drain and Ravi River can be said to have increased greenhouse gas emissions. However, different factors like weather, chemical transformations in the air, and transport of pollutants have to be considered as well in order to evaluate the true extent of air pollution (EEA, 2019). The question which is yet to be answered is that how much or at what rate these gases are emitted from drainage channels that might contribute to the air pollution of the city. Researches have been done for greenhouse gas emissions from wastewater treatment plants which showed that if primary treatment is applied, GHGs emit at a rate of 0.005 kg CO2- equivalent/m3 and if conventional activated sludge treatment with anaerobic digestion is applied then the emission rate is 0.26 kg CO2-equivalent/m3 treated (HD, HR, HL, & DM., 2005). However, literature is scarce on the estimation of greenhouse gas emission from open channels and not much focus has been made on the role of wastewater as a potential source of air pollution. There is a need to study and collect primary data for the drainage channels in Lahore, so that an estimate can be made regarding their share in polluting the air.



Figure 2: Lakhodair landfill site (Source-Urban Unit)

Solid Waste and Air Pollution

Lahore produces 0.65 kg per capita per day of solid waste (JICA and Pak-EPA, 2005). The total waste collected by formal and informal sector in Lahore is estimated to be almost 68% (Masood, Barlow, & Wilson, 2014). Most of it was previously dumped in an unlined, undeveloped landfill site at Mehmood Booti. However, it has been closed since it reached its full capacity. Now solid waste of the city is dumped at the recently constructed, engineered sanitary landfill at Lakhodair. Some waste is also being dumped at Saagian dumpsite and Bagrian/Tiba dumpsite, unofficially.

Solid waste dumping results in the production of landfill gas (LFG) when organic solids decompose in landfills. This gas mainly constitutes of an estimated 50 percent methane, 50 percent carbon dioxide (CO2) and a little percentage of non-methane Figure 2: Lakhodair landfill site (Source-Urban Unit) organic compounds. Methane is considered to be 28 to 36 times stronger than CO2 when it comes to trapping heat in the atmosphere (U.S. EPA, 2019). Studies done on communities residing near landfills have shown that if the population around the landfills is exposed to ammonia and hydrogen sulphide for a short term but at a high concentration, this may lead to various health impacts like headaches, nausea, vomiting, nose/eyes irritation, coughing, difficulties in breathing etc. Methane and carbon dioxide replace oxygen and result in nausea, fatigue, vomiting, lack of coordination etc. However, these effects of CO2 and CH4 have rarely been reported in conjunction with landfill sites (NY Department of Health, 2019).

Since Lakhodair landfill site is an engineered one, hence it can be argued that the greenhouse gas emissions will be comparatively less as compared to other open landfills in Lahore. This is because passive collection is being applied for gas (Urban Unit, 2019). A research done in 2015 on Global Warming Potential (GWP) of municipal solid waste of Ravi Town at Saggian dump site revealed that the collection and disposal of solid waste emitted at total of 45137.3 ton of CO2, 54956.5 ton of CH4 and 0.29 ton of N2O in the environment with a combined GWP of 273374.8 ton. (Munir, Baqar, Saeed, Zameer, & Shaikh, 2015). According to a study, for 1540 kilo tons per annum (kt/a) of municipal solid waste of Lahore a total of 119 kt/a of methane is produced (Naveed, Nawaz, Ramzan, & Zafar, n.d.). It is evident from the data above that nonengineered, open dumpsites in Lahore are a significant contributor to air pollution in Lahore

Conclusion

In conclusion, natural waster bodies of Lahore are being polluted with untreated domestic and industrial wastewater. There is some research that shows that wastewater contributes to air emission. However, data supporting this argument is very rudimentary. Also, lack of primary data on this topic is another shortfall. There is a need to find the hot spots for GHGs and VOCs emissions in the drainage channels of Lahore and point sources and non-point sources as well. These can be used as a starting point to evaluate the true extent of the problem. Moreover, studies have supported the argument that open and unplanned dumping of solid

waste in Lahore is also contributing to the air pollution of the city. The extent to which landfills are contributing to the total greenhouse gas emissions in Lahore is yet to be explored. Hence, this area needs research so that probable greenhouse gas emission spots can be identified and mitigation measures for these may be adopted.

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STAKEHOLDER ENGAGEMENT ON AIR QUALITY AND HEALTH IMPACTS

Tayeba Batool

Key Messages

- The challenges from poor air quality continue to increase, partially from the impact of carbon emissions impact on climate. Pakistan is one of the ten most affected countries in the world[1].
- Air pollution poses severe health hazards for a large segment of population world over. Harmful vehicular emissions, inefficient fuel burning, burning of solid and agricultural waste, and arid/ dust conditions are some of the key offenders that aggravate. Women and children are especially vulnerable because of constant interaction in indoor air quality.
- Children are the worst impacted, because they absorb more pollutants with each breath, at a stage when their brains and bodies are still under development. According to the World Health Organisation (WHO), almost 700,000 children under five die each year, because of air pollution, with millions more children's health adversely affected[2]
- Pakistan has made a few attempts to address air pollution exclusively, such as the Pakistan Clean Air Programme, but constitutional changes and lack of enforcement have hindered efforts.
- Improving air quality is a fundamental challenge identified under the Sustainable Development Goal 3.9.1 (Mortality rate attributed to household & ambient air pollution); SDG 11.6 (Reduce the adverse per capita environmental impact of cities, by paying special attention to air quality and municipal and other waste management). It also addresses SDG-7 (Sustainable Energy), SDG-9 (Industrialization), and SDG-13 (Combating climate change).

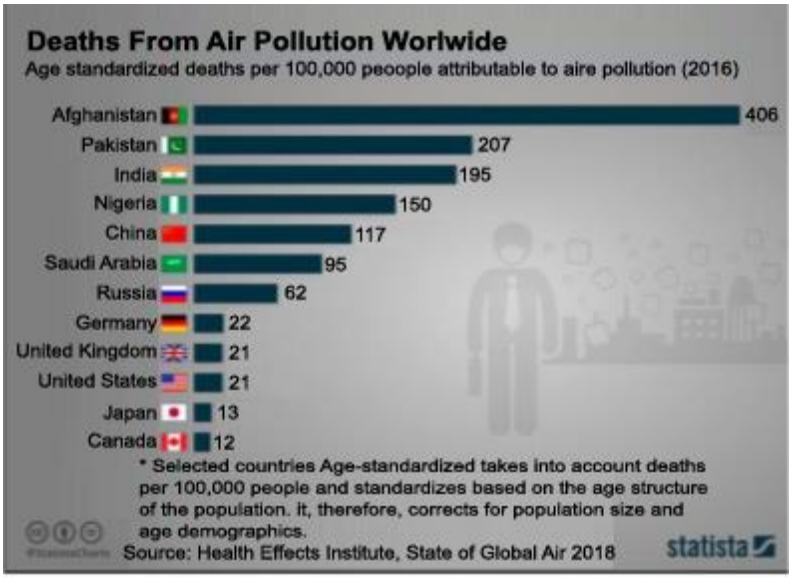
Objectives

This policy brief presents the linkages between air quality and health, and assess the challenges this connection brings for sustained development. It reviews emerging literature on the topic, and analyzes the current state of research, collaborative action, and policy related efforts at addressing air quality, particularly the Pakistan Clean Air Programme (PCAP). The subsequent sections also present insights from stakeholder engagement (civil society, policy makers, health experts, researchers), in the form of Roundtable consultations and parliamentarian sessions. The last section presents recommendations to advance action and dialogue on air quality.

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[1] AFP, (April 03, 3019), Pakistan among top 5 countries with highest mortality rate due to air pollution: study, Dawn News, https://www.dawn.com/news/1473651

[2] World Economic Forum. 2019. Our poisonous air is harming our children's brains. https://www.weforum.org/agenda/2019/03/our-poisonous-air-is-harming-our-children-s-brains



Source: World Economic Forum

Introduction & Background

According to the "State of Global Air" report, published by US-based Health Effects Institute and the University of British Columbia, air pollution is the fifth leading cause of early death worldwide, behind malaria, road accidents, malnutrition, and alcohol[3]. Pakistan is one of the top five countries with the highest number of deaths, resulting from air pollution. Within Pakistan, urban areas are hit harder, because of the higher levels of pollutants.

Major air pollutants includes Sulphur Dioxide, Oxides of Nitrogen, Carbon Dioxide and certain Particulate Matters. Types of Particulate Matter (PM) which are harmful and also less known publicly include PM10 and PM 2.5. PM10 is coarser, and causes irritation when it passes through the nasal passage, attaching itself to the mucosa. PM 2.5 is most problematic because it enters the airways inside the human body, whereby the smaller particles enter the bloodstream, and affect the lungs and cardiovascular system. These particles can also affect the brain through the circulatory system. Air pollution has also been linked to cancer and diabetes[4].

The health impacts from air pollution are widespread. Microscopic air pollutants penetrate deep into the human respiratory system, whereby they enter the blood stream and circulate throughout the body. One third of the deaths from stroke, lung cancer and heart diseases are directly or indirectly attributed to air pollution[5].

The risks for children are even worse. Children take in more air per unit of body weight than adults. Fine particulate matter are tiny pollution particles in air, which

[3] *Health Effects Institute. 2019. State of Global Air 2019, www.stateofglobalair.org.*
[4] *Australian Government. National Pollutant Inventory. http://www.npi.gov.au/resource/particulate-matter-pm10-and-pm25*
[5] *World Health Organization. https://www.who.int/air-pollution/*

are thinner than a single human hair. When they pass through the lungs to the brain, they can harm membranes, the body's natural defense system against toxic substances. Additionally, the same dose of toxic chemicals will harm a developing brain more than an adult.

In 2016, the WHO estimated that 600,000 children died from lower respiratory infections caused by polluted air. Reports suggest that more than 93% of the world's 1.8 billion children, including 630 million under the age of five, are exposed to harmful air pollutants[6]. In low- and middle-income countries around the world, 98% of all children under five are exposed to PM (Particulate Matter) 2.5 levels, which is above WHO air quality guidelines[7].

Methodology & Findings

This policy brief consolidates findings and insights from the Roundtable Discussion on Air Quality and Health hosted by LEAD Pakistan, and participation in the seminar organized by Air Quality Asia[8]. As part of its research, LEAD Pakistan undertook an analysis of the Pakistan Clean Air Programme and held prior meetings to engage former policy makers and health experts/consultants, and discuss the current landscape of evidence on air quality and health.

Roundtable Discussion on Air Quality and Health

In March 2019, Lead Pakistan hosted a roundtable discussion on "Air Quality & Health" to discuss possible strategic engagements and research collaborations on the topic. The discussion solicited insights on integrating health dimensions of air quality, especially for Pakistan, in context of research, data, and policy action. The event brought together relevant stakeholders from climate change and environment, health and population sector, health professionals and practitioners, and academia, to generate an informed analysis.

Dr. James Schauer, an expert and national advisor to the US government, presented an overview of the current scientific and technological inquiries on air quality, and suggested policy action for the society. As Director of the Wisconsin State Laboratory of Hygiene[9], Dr. Shauer has pioneered efforts to use chemical analysis methods to understand the chemical composition of atmospheric particulate matter, and the application of this data to understand the sources and health impacts of particulate matter. His work provides a scientific foundation to develop strategies and polices to improve air quality, especially in developing and highly polluted countries around the world.

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[6] World Economic Forum. 2019. Our poisonous air is harming our children's brains. https://www.weforum.org/agenda/2019/03/our-poisonous-air-is-harming-our-children-s-brains.

[7] World Health Organization. October 29, 2018. More than 90% of the world's children breathe toxic air every day. https://www.who.int/news-room/detail/29-10-2018-more-than-90-of-the-world%E2%80%99s-children-breathe-toxic-air-every-day-air-pollution-is-destroying-our-health.

[8] Air Quality Asia is "an international air quality advocacy group building on a successful parliamentary action model with the vision to secure a breathable future for Asia"; https://www.airqualityasia.org/

[9] A public and environmental health laboratory for the State of Wisconsin; operates as part of the University of Wisconsin-Madison.

Parliamentarians' Session

A seminar organized hosted by Air Quality Asia at the Parliament of Pakistan, in March 2019, gathered MNAs and Senators from six committees, including the Speaker of the National Assembly and Prime Minister's Advisor on Climate Change. Panels included critical issues pertaining to health impact of air pollution, its economic cost, building sustainable transport systems, state of renewable energy sector in Pakistan, and Clean Air Models from China, Mexico, New York, and California.

The United States of America (US) and China have made drastic strides in controlling air pollution, and their lessons and policies can provide valuable insights. Another key point highlighted climate injustice, and the need for stronger representation at the international forum. Although Pakistan's carbon print was low, it is subjected to the same costs as the rest of the world to reduce carbon emissions.

The discussion also highlighted multiple other, often overlooked, modalities arising from air pollution. Children might miss school days because of high exposure/bad quality days, or because of overall decreased immunity. The poorest segment of the society is most exposed, and least equipped to mitigate the risks. Their livelihoods are also intricately linked with finding the cheapest (and in most cases, the most pollution causing) fuels for their machines, vehicular and/or household needs. Poor air quality also affects agricultural yield and crop nutrition, which further burdens the population at large.

Addressing air quality is also an integral component for Pakistan to achieve the Sustainable Development Goals (SDGs) 2030, particularly to reduce the number of deaths and illnesses from hazardous chemicals and air, (3.9.1) and to reduce the adverse per capita environmental impact of cities (11.6). Air quality and health is also increasingly becoming an international agenda. In May 2015, the World Health Assembly resolution "Addressing the health impacts of air pollution", adopted unanimously by the 194 Member States, aimed to further strengthen efforts and international cooperation to address air pollution[10]. In the World Health Organization's First Conference on Air Quality and Health, commitments included the establishment of a "new multi-stakeholder Global Energy-Health Platform of Action to achieve power of health workers to be agents of change."[11]

Equipping health workers to be agents of change, equipping them with the capacity and tools to educate their patients and decision-makers about the health effects of air pollution, and to have their say in shaping mitigation policies.

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[10] https://www.who.int/gho/publications/mdgs-sdgs/MDGs-SDGs2015_chapter6_snapshot_air_pollution.pdf; Key strategic priorities for the future include: developing new energy efficient and affordable technologies such as induction stoves that can reduce household air pollution and related health risks; strengthening health sector capacity to contribute to multisectoral policy-making that benefits health and air quality; and improving the monitoring of air quality and identification of pollution sources, including through satellite remote sensing, portable monitors, data mining and crowd sourcing.

[11] https://www.who.int/airpollution/events/conference/en/

Scaling up WHO's own Air Pollution programme, globally, regionally and in countries, including through establishment of a Trust Fund with other partners on climate, environment and health, which could access climate and environment finance directly.

Strengthening institutional mechanisms, including exploration of an air quality convention.

Pakistan Clean Air Programme (PCAP)

Historically, the Pakistan Clean Air Programme was the first of its kind initiative to identify major sources of air pollution, establish roles and responsibility for other relevant ministries and departments, and recommend short, medium and long-term measures to improve air quality.[12] Initiated by the Ministry of Environment[13] (which has now been devolved to the provinces), with support from the Japanese International Cooperation Agency (JICA), recognized four major sources of air pollution to be addressed, namely vehicular emissions, industrial emissions, solid waste burning and trans-boundary pollution.

Based on data gathered from the Economic Survey of Pakistan, the number of vehicular emissions continues to increase. Using the number of motor vehicles on the road as the indicator, the increase has been more than double, with almost 163 percent more vehicles in 2018 than in 2006. Similarly, the increasing amount of waste generation and lack of waste processing facilities also implies a significant increase in waste burning.

	2005-06	2017-18	%Change
Motor Vehicles on the Road (Millions)	7.1	18.7	163

Source: Economic Survey of Pakistan

The PCAP suggested several measures to be enforced in the short, medium and long term, targeting reduction in each of the four sources identified, with the collaboration of other ministries such as Ministry of Petroleum and Natural Resources, Ministry of Industries and Production, Provincial and Federal Environment Protection Agencies, and Forest Departments.

This included banning/phasing out of two-stroke and diesel public service vehicles, installing continuous air monitoring stations, raising fuel standards (including adopting EURO IV standards) and awareness on the same, vehicle inspection systems, fuel adulteration management, waste management, and promoting pollution control technologies (including catalytic converters, exhaust recirculation devices, PM arresters).

[12] Pakistan EPA (2006a). Pakistan Clean Air Programme (PCAP).

[13] Now Climate Change Division; Portfolio of Environment was devolved to the provinces after the 18th Amendment to the Constitution of Pakistan 1973.

City	2004		2018		Increase (%)
	Population (Million)	Solid waste generation (Tons per day)	Population (Millions)	Solid waste generation (Tons per day)	
Karachi	10.8	6632	20.5	9440	98.6
Lahore	5.14	5200*	10.0	6510	98.7
Faisalabad	2.3	902	7.5	4883	94.6
Rawalpindi	1.41	800**	5.9	3841	95.2
Hyderabad	1.3	756	5.5	3581	95.3
Gujranwala	1.3	615	4.8	3125	94.9
Peshawar	1.15	564	2.9	1888	96.7
Quetta	0.65	247	0.6	326	98.7

Source: Ministry of Environment Biref for 2004 Data & Export. Gov (citing Project Procurement International, Pakistan) for 2018 Data (*2008 Data **2012 Data)

However, the implementation of PCAP has faced several challenges on an institutional level. The dissolution of environment as a provincial portfolio limited the center's power on planning and enforcement. Air quality monitoring is insufficient. In 2007, Air Monitoring stations were established in Karachi, Lahore, Peshawar, Quetta and Islamabad, five in total, under the Environment Monitoring System by EPA and JICA. By 2018, there were seven fixed and three mobile Ambient Air Quality Stations (AAQS) in Islamabad, Lahore and Karachi. However, findings suggest that several of them are non-functional or inaccurate.

Air quality has continued to aggravate all over the country, with citizens voicing concerns through legal action as well. In 2013, based on one of these cases, the Lahore High Court appointed a Lahore Clean Air Commission, to combat smog and formulate a Smog Policy for Punjab, which identifies the root causes and prescribes a plan to protect and safeguard the life and health of the people of Punjab. The Smog Commission comprised of representatives across different provincial departments, including Environment, Health, Specialized Health Care & Medical Education, along with advocates, scientists and business community, and released their findings in 2018.[14] The commission arrived at several recommendations on 4-stroke rickshaw engines, public transport, and fuel and emission standards as per Euro II, Euro III, and Euro IV.

[14] *http://www.supremecourt.gov.pk/web/page.asp?id=2745*

Provincial EPAs[15], which are the mandated authority to handle environment and air quality management, are slowly gaining momentum on the issue of clean air. Punjab EPA drafted its first Punjab Clean Air Program in 2018-19. In 2014, Sindh EPA issued the Sindh Environmental Protection Act, with monitoring on vehicle emissions report.[16] The Khyber Pakhtunkhwa Environmental Protection Act[17] addresses installation of electrostatic precipitators (EP) for control of dust pollution in cement units, surveys and design for dust control in stone crusher units, and pollution from brick kilns.

However, there is no central monitoring mechanisms and a dire paucity of data to set targets and indicators of progress. Furthermore, without the cooperation and buy-in of associated stakeholders, the implementation of these actions will face massive challenges.

Recommendations

- Establish a forum focused on health and air quality, which can also be mandated to mainstream health indicators and targets in policies addressing air quality, and vice-versa (ensure air quality standards are mainstreamed in health policies and frameworks). Additionally, this forum can
- identify research linkage and analysis for air quality and health, and enhance awareness and literacy on climate change/air quality and health for the public.
- Strengthen air quality monitoring, technologies and systems to ensure installation of air quality monitors for reliable, accurate, and accessible data. Establish more stringent vehicle and industrial emission inspection systems to limit the pollutants being released.
- Strengthen health data gathering and monitoring. Inadequate data, arising from the lack of baseline indicators for health, lack of disaggregated statistics across public and private hospitals, or lack of enforcement on data collection, severely limits analysis and action planning. Introducing automatic systems, or standard reporting templates are a few options to explore. Additional research is also needed on how to mitigate or address immunity to counter diseases incurred because of air pollution.
- Integrate efforts between provinces and ministries (especially environment, health, climate change, industries, agriculture, and social welfare) for effective enforcement of policies (including implementation of clean air

[15] Among other functions, they implement Rules and Regulations of the Pakistan Environmental Protection Act (PEPA) 1997 and prepare additional legislation as per the needs of the province. They also have the responsibility to prepare and implement provincial standards, develop provincial systems for the implementation of pollution charges, conduct research & development for viable environmental technologies, and engage local governments in the implementation of PEPA 1997.

[16] http://epasindh.gov.pk/Vehicular%20Emission%20Reports%20Monthly/april%2018.pdf

[17] http://epa.kp.gov.pk/page/air_pollution#sthash.FuMFlvWs.dpuf

programs, data collection, air quality monitoring). Policies have to be developed at community, provincial and federal level, and have to be inclusive of all related sectors, such as agriculture, industries and livelihoods. This will also enable Pakistan to move closer towards its commitments to the SDGs outlined earlier.

- Develop necessary skills and technical expertise to negotiate international commitments, to ensure climate justice and sustainable action.

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AJ&K AMBIENT AIR QUALITY – STATUS AND DEVELOPMENT STRATEGIES[1]

Dr Abdul Majeed[2]

Abstract

In AJ&K main sources of air pollution are human activities in particular vehicular emissions, wood combustion for energy, cooking and other domestic activities. The vehicles emit a wide variety of pollutants, principally carbon monoxide (CO), oxides of nitrogen (NOx), oxides of Sulphur (SOx) and Volatile Organic Compounds (VOCs). These emissions have an adverse impact on the air quality and health of human beings, particularly those who are directly exposed to this pollution. Fortunately in AJ&K the problem currently is not that severe because of low level of industrialization, good forest cover and watersheds, and lower volume of vehicular traffic as compared to most areas of Pakistan. However, rapid developments in improving road network, energy and industrial expansion in AJ&K are causing problems of air pollution. Though legislative measures have been taken and standards are in place, the implementation of rules and regulations is a grey area that needs attention.

Measures such as conversion of vehicles to no lead gasoline and low sulfur diesel have been implemented but remain insufficient to prevent deterioration in ambient air quality in the urban areas due to increasing vehicle numbers and their hazardous emissions. Indoor air pollution is a major cause of widespread chronic bronchitis and other respiratory infections in rural households and poor urban households that depend on biomass for cooking and heating particularly in winters. To maintain air quality within acceptable limits, the study suggests various strategies grouped under the following development strategic objectives:

1. Improve Air Quality Monitoring and Forecasting System;
2. Establish functional data base of information on air quality with easy access by public
3. Raise general public awareness on clean air and environment to help promote the concept of clean production in industries and fuel efficient technologies in the industrial, transport and domestic sectors; and
4. Integrate environmental considerations in the Planning Process

1. Introduction

Ambient air refers to any unconfined portion of the atmosphere or outdoor air. It is a mixture of the gases such as Nitrogen (78%), Oxygen (21%), Carbon dioxide

[1] *The paper is extracted from a study funded by AJ&K Environmental Protection Agency (EPA) and was undertaken by International Union for Conservation of Nature (IUCN) Pakistan using DPSIR technique. The draft report of the study is yet to be approved by the Government of AJ&K.*

[2] *Water, Energy and Climate Change Adviser , IUCN Pakistan*

(0.03%), and a small amount of Argon and other gases. Air Pollution occurs if there is a change in the composition of the ambient air caused by smoke, dust, gases, fumes, aerosols and odorous substances. Thus, in general terms, it may be defined as the presence of one or more contaminants like dust, mist, smoke and color in the atmosphere that are injurious to human beings, plants and animals.

It is a well-known fact that outdoor environment directly impacts human health. It is therefore important that the condition of the outdoor environment be improved to ensure better health status of people and decrease the number of illnesses. On the level of society it is important to adopt environmental management measures – managing the utilization of land, spatial planning of the environment used or to be used by humans, monitoring, assessment and management of risks, etc. The level of implementation of these measures and the allowance for the results in the adoption of decisions will determine the impact on each person's health.

According to WHO Ambient (outdoor) air pollution is a major cause of death and disease globally. The health effects range from increased hospital admissions and emergency room visits, to increased risk of premature death. An estimated 3 million premature deaths globally are linked to ambient air pollution, mainly from heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, and acute respiratory infections in children.

Studies have shown that poor air quality can also adversely affect the natural environment. Ecological damage may occur when air pollutants come into direct contact with vegetation or when animals inhale them. Pollutants can also settle out of the air onto land and water bodies. From the soil, they can wash into waterways, or be taken-up by plants and animals. Poor air quality can also affect our climate.

These effects of poor air quality on human health and the environment can, in turn, have negative economic impacts in terms of hospitalization and medical treatments, premature deaths, and lost work days. Damage to soils, vegetation, and waterways may reduce the productivity of our agriculture and forestry industries.

The primary source of air pollution is the combustion of fossil fuels in vehicles, industries, power plants, and the burning of municipal solid waste. However, in AJ&K main sources are human activities in particular vehicular emissions, wood combustions and other domestic activities including burning of wastes in open air. People of AJ&K live in areas where urban smog, particle pollution, and toxic pollutants which can pose serious health concerns are still not very evident.

2. Causes of Air Pollution in AJ&K

The main causes of pollution of air in AJ&K are described as under[3]:

1. **Emissions from industries and manufacturing activities:** Manufacturing industries, garbage burnings in open air are responsible

[3] *Government of AJ&K, EPA, State of Environment Report, 2018 (Draft), IUCN Pakistan*

for emitting high levels of carbon monoxide, organic compounds, and chemicals into the air.

2. **Burning Fossil Fuels:** Transportation has become a key part of everyday life in AJ&K. Cars and heavy duty trucks, and airplanes all burn lots of fossil fuels to work. Emissions from automobile engines contain both primary and secondary pollutants. This is a major cause of pollution and one that is very difficult to manage. This is because people rely heavily on vehicles and engines for transporting people, goods and services. Fumes from car exhausts contain dangerous gases such as carbon monoxide, oxides of nitrogen, hydrocarbons and particulates. On their own, they cause great harm to people who breathe them. Additionally, they react with environmental gases to create further toxic gases.
3. **Household and Farming Chemicals**: Crop dusting, fumigating homes, household cleaning products or painting supplies, over the counter insect/pest killers, fertilizer dust emit harmful chemicals into the air and cause pollution. In many cases. These are common practices in most of AJK areas.
4. **Garbage Burning in Open Air:** This is very common cause of pollution in developing and under-developed countries and AJ&K is no exception. Proper garbage disposal systems are not operational in AJ&K. Landfill sites are not properly located and garage burning is often resorted to by the cleaning staff. This adds to pollution of the ambient air with toxic chemicals, smell and particulate matter.
5. **Indoor Air Pollution**: This includes smoking and using synthetic building materials, smells from household care and furnishing chemicals etc. The pollutants may include pollen, tobacco smoke pesticides, radon, asbestos and carbon monoxide trapped inside the buildings. The Government has strictly banned smoking in all public buildings.

3. Current Status of Ambient Air Quality

Air pollution contributes to acidification and global climate change, which have an impact on crop productivity, forest growth, biodiversity, cultural monuments and many aspects of the national economy. The primary source of air pollution is the combustion of fossil fuels in vehicles, industries, power plants, and the burning of municipal solid waste. In AJ&K main sources of pollution in air are human activities in particular vehicular emissions, wood combustion for energy and cooking and other domestic activities. High levels of air pollutants cause all kinds of respiratory problems and irritation of the eyes. Long-term exposure to air pollution can cause cancer and damage to the immune, neurological and reproductive systems.

No systematic study has been done to monitor and quantify the ambient air quality due to various sources. Results of a study conducted in 2010 on ambient air quality show that the levels of pollution of NO_x and SO_2 are within the WHO and US EPA

limits and the NEQS. Overall CO_2 level in AJ&K is lower than the NEQS values. Noise levels measured were within the NEQS limits. Ozone concentrations measured were also within the limits. Volatile Organic Compounds (VOCs) measured in this study were also on the lower side with only a few spike values. Bio-aerosols were also on a very lower side as compared to the studies conducted in other parts of the country.

However, the ambient air in AJ&K, particularly in urban areas is generally of poor quality due to high emissions from both stationery and mobile sources. These include generators, leakages from gas transmission lines, vehicles, and burning of wood, and trash, etc. The vehicular emission comprise of a wide variety of pollutants, principally carbon monoxide (CO), oxides of nitrogen (NO_x), oxides of Sulphur and VOCs (Volatile Organic Compounds).

4. State of the Environment of Ambient Air

A DPSIR (Drivers Pressure State Impact Response) analysis of the state of the environment of ambient air in AJ&K is as follows:

4.1 The Drivers

Rapid population growth and unplanned urbanization in AJ&K together with increase in automobiles are exacerbating the urban pollution. The main drivers of air pollution in AJ&K are identified as:

1. Burning Fossil Fuels: Emissions from automobile engines contain both primary and secondary pollutants and contain dangerous gases such as carbon monoxide, oxides of nitrogen, hydrocarbons and particulates. Another source of emissions from burning fossil fuel is the widespread use of small diesel electric generators in commercial and residential areas due to frequent and prolonged power outages.

2. Emissions from Industries and Brick Kilns: Industrial facilities, particularly those consuming fossil fuels, emit significant amounts of air pollutants. The industrial base of AJ&K is not well developed, however, a wide range of small scale to medium-scale industries, including brick kilns, plastic molding, steel re-rolling, food and beverages, leather and shoe, textile, etc. contribute substantially to urban air pollution through their use of “waste” fuels, including old tires, paper, wood, coal, and textile waste.

3. Garbage Burning in Open Air: This is very common cause of pollution in developing and under-developed countries and AJ&K is no exception. Proper garbage disposal systems are not operational in AJ&K, which leads to the burning of garbage in open air.

4. Household and Farming Chemicals: All kinds of fertilizers, pesticides and insecticides, fumigating agents, household cleaning products, paints emit harmful chemicals into the air and cause pollution. Use of these products is growing and has become a common practice in most

urban and rural areas of AJ&K mainly for promoting agriculture in the State, but also for maintaining houses and other structures.

5. Indoor Air Pollution: Indoor pollution results from smoking and using synthetic building materials and furnishing chemicals etc. The pollutants may include tobacco smoke pesticides, radon, asbestos and carbon monoxide trapped inside the buildings.

4.2 The Pressures

The drivers identified above develop a number of pressures on the environment, which are described hereunder.

1. **Air Pollution:** Some air pollution is visible, like suspended dust and smoke particles, while many of the greenhouse gas emission from industry and transport are invisible. The air pollution impairs the air quality and quality of life. There is high air pollution in most urban areas of AJ&K.
2. **Hotter and Drier Summers**: Greenhouse gases are a major cause of global warming, and AJ&K has been experiencing hotter and drier summer. In addition, there are many extreme heat events during the summer. Conversely, the winters are usually milder with occasional cold events.
3. **Haze**: Haze and smog hanging over cities from suspended particulate matter is the most familiar and obvious form of air pollution. This is caused when sunlight encounters tiny pollution particles in the air. Haze obscures the clarity, colour, texture, and form of what we see. In AJ&K, incidence of haze in areas close to urban centers is quite common which is indicative of presence of heavy amounts of particulate matter in air caused by burning of wood, garbage in open areas and nearby brick kilns.

4.3 The State

Fortunately, Aazd Jammu & Kashmir because of its high natural green cover, and relatively smaller urban footprint, the ambient air is relatively cleaner than in most of the cities of Pakistan. However, there are signs of deteriorating air quality near the industries and particularly stone crushing plants. The last study on assessing air quality was conducted over 7-years back but that was rather limited to a few parameters only. Since then the things have changed rapidly and no updated information is available on the status of ambient air quality. Based on the foregoing and scanty data that is available, observations and discussions with public and private sector stakeholders, the overall state of environment of the Ambient Air can be termed as “Good” though with a declining trend.

State of Environment – Ambient Air

State				
Excellent	**Good**	**Moderate**	**Poor**	**Bad**
		☑		
Trend				
Improving	**Stable & Improving**	**Stable**	**Stable and declining**	**Declining**
				↘

4.4 The Impacts

The likely impacts on the air quality in future, if no action is taken to address the issues and bring about an overall improvement, are described in the following sections.

1. **Human Health:** Air pollution can harm human health when it accumulates in the air in high enough concentrations. People exposed to high enough levels of certain air pollutants may experience: irritation in the eyes, nose, and throat, wheezing, coughing, chest tightness, and breathing difficulties, worsening of existing lung and heart problems, such as asthma, increased risk of heart attack. In addition, long-term exposure to air pollution can cause cancer and damage to the immune, neurological, reproductive, and respiratory systems. In extreme cases, it can even cause death.
2. **Biodiversity:** At present there is little or no noticeable impact on biodiversity. There has not been any investigation of impacts of air pollution in AJ&K on biodiversity. However, emissions of nitrogen oxides from cars, trucks, and other sources may contribute to the addition of nitrogen entering aquatic ecosystems which may lead to Eutrophication. Studies have shown that air toxics are contributing to birth defects, reproductive failure, and disease in animals. Persistent toxic air pollutants (those that break down slowly in the environment) are of particular concern in aquatic ecosystems. These pollutants accumulate in sediments and may bio-magnify in tissues of animals at the top of the food chain to concentrations many times higher than in the water or air. Ground-level ozone can lead to reductions in productivity of crop and trees, survival of tree seedlings, and increased susceptibility of plant to disease, pests and other environmental stresses.

4.5 The Response

Barring urban centers like Muzaffarabad and Mirpur, air quality in AJ&K currently does not face serious challenges of pollution as a whole. However, the rapid development activity in the infrastructure and energy sectors is posing some problems at the micro level which, if left unchecked, might become a serious problem that would necessitate proper response at different levels. AJ&K is

fortunate in having a good green cover over most landscapes and in towns/cities, which has prevented widespread deterioration of air quality. The response of the State is through the State Environmental Protection Agency.

Though legislative measures have been taken and standards are in place, the implementation of rules and regulations is a grey area that needs attention. Lack of proper monitoring of air quality is a serious handicap. On ground, the response still has to see the light of the day.

5. Development Strategies

Measures such as conversion of vehicles to no lead gasoline and low sulfur diesel have been implemented but remain insufficient to prevent deterioration in ambient air quality in the urban areas due to increasing vehicle numbers and their hazardous emissions. Indoor air pollution is a major cause of widespread chronic bronchitis and other respiratory infections in rural households and poor urban households that depend on biomass for cooking and heating particularly in winters.

5.1 Strategic Objectives:

1. Improve Air Quality Monitoring and Forecasting System;
2. Establish functional data base of information on air quality with easy access by public;
3. Raise general public awareness on clean air and environment to help promote the concept of clean production in industries and fuel efficient technologies in the industrial, transport and domestic sectors; and
4. Integrate environmental considerations in the Planning Process

5.2 Strategies to Achieve Objectives

Objective 1:

1. Establish a well-designed monitoring network with upgraded PM_{10}[4] and $PM_{2.5}$ monitoring equipment and capability to cover the whole of AJ&K;
2. Establish mobile air quality monitoring laboratories in Muzaffarabad and Mirpur for monitoring air ambient quality and to respond to specific pollution events or complaints respectively in northern and southern parts;
3. Facilitate the development of a joint industry-funded monitoring station in industrial affluent areas like Mirpur;
4. Identify areas of potential high exposure to population due to air toxics and conduct monitoring programs where necessary;
5. Develop an Air Pollution Potential Atlas for the State of AJ&K identifying areas likely to have poor air dispersion to facilitate better air quality management;

[4] *Particulate Matter. Figures in subscript show the sized in Micron.*

6. Develop and implement a smoke monitoring plan in various urban centers; and
7. Introduce new technologies in brick kilns.

Objective 2:

1. Gather data on the main sources and types of air pollutants and the trends in the type of home heating systems used and estimate emissions of PM_{10} and $PM_{2.5}$ from domestic and small industrial sources and agriculture related activities.
2. Establish a database of pollutants and their temporal trends in various parts of AJ&K. The database should have: (a) GIS based interactive maps, (b) website that is regularly updated with real-time data.

Objective 3:

1. Develop and run long term program of mass awareness for general public including gender, industrialists, public transporters, and brick kiln owners;
2. Conduct market research to monitor trends towards less polluting alternatives and barriers to conversion to alternative forms of domestic cooking and heating;
3. Undertake a study on providing incentives to help promote and adopt improved technologies for heating, cooking and baking clay bricks. This would include subsidies/tax free rates for new efficient technologies.

Objective 4:

1. Sensitize and build the capacity of technical and management staff of all concerned departments on Integrated Air Quality Management (IAQM) through sensitization and capacity building events.
2. Prepare guidance material to assist in integrating air quality considerations into the development and implementation of planning schemes in the industrial and transport sectors.

ADDRESSING THE PAKISTAN AIR POLLUTION CRISIS: ACADEMIA-INDUSTRY-GOVERNMENT ROLES

Asad U. Khan[1] and Nasir M. Ahmad[2]

Abstract

This article highlights the air pollutions in Pakistan. The cause of the air pollution, its impact on human populations and some suggestion to overcome are issues are described. The role of government, academia and industry is briefly proposed to tackle the issue.

1. Introduction:

Pakistan ranked very high in terms of air quality as shown below in Figure 1. In addition most of the major city in Pakistan facing unhealthy air as reported recent and shown in following report.

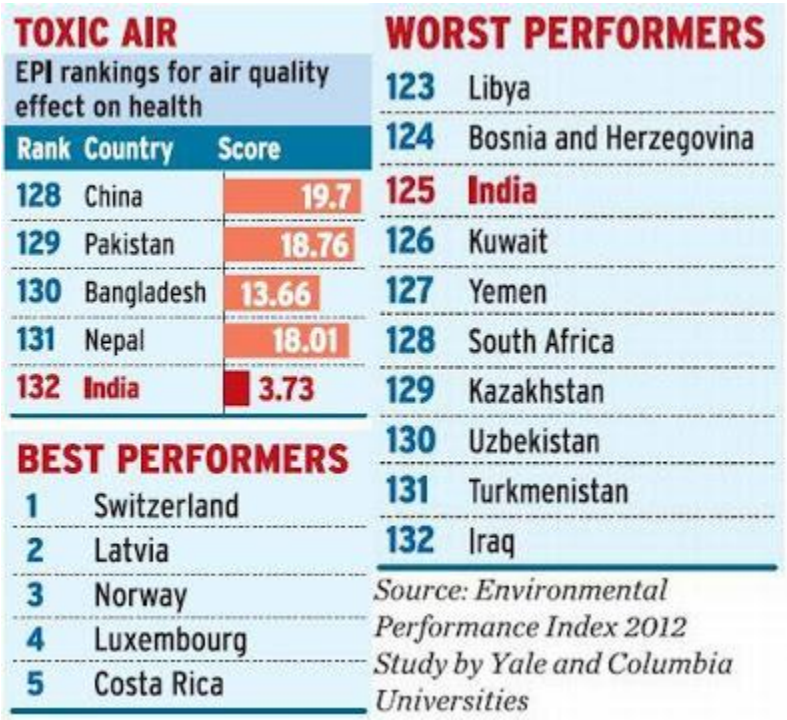


Figure 1: Environmental Performance Index 2012 of various countries.

[1] *Department of Chemical Engineering, COMSATS University Islamabad, Lahore Campus, Defence Road, Lahore 54000, Pakistan*
[2] *School of Chemical and Materials Engineering (SCME), National University of Sciences and Technology (NUST), H-12 Sector, Islamabad 44000, Pakistan*

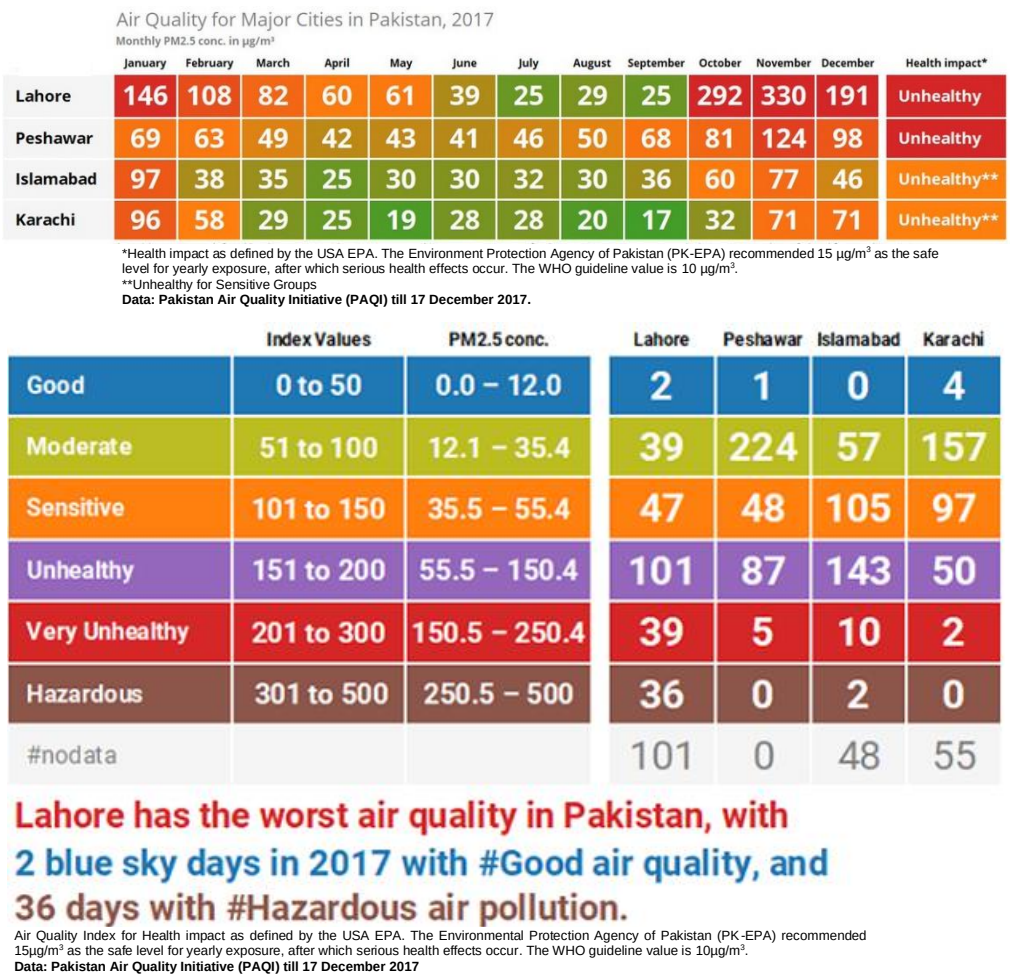


Figure 2: Air quality index analyses of various major cities in Pakistan.

Above figures, clearly indicated that air contamination is major challenge for the whole society in Pakistan that require urgent attention and cooperation between government, academia and industry.

Air contamination is one in everything about ecological issues developing swiftly in Pakistan because of urbanization and production. The standard of air is weakening due to generation of real air poisons released by a large number of vehicles and furthermore the ignition of natural mixes in processing plants and enterprises. In consequences of urbanization and assembling, air poisons, for example, suspended particulate issues, unpredictable natural mixes, carbon monoxide gas, oxide, sulfur oxide, gas, lead, and diverse genuine metals are extensively made in urban areas of Pakistan. All this require great degree of attention to overcome this challenge. Some of the ongoing studies indicated the generation of highly non- desirable large amounts of suspended particulate matter (SPM) in urban areas. For instance, in Lahore, Rawalpindi and Karachi, the level

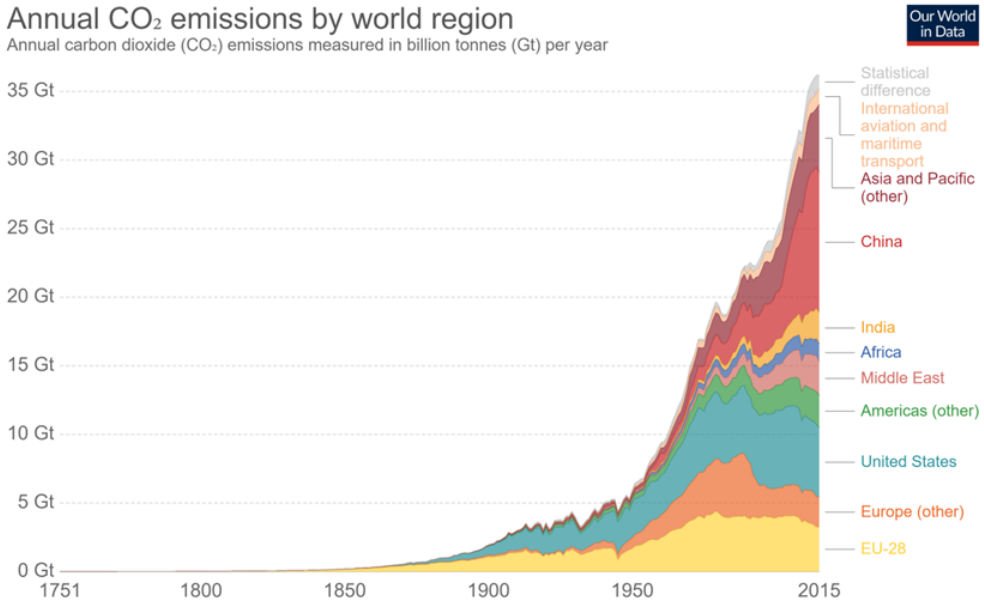
of CO, NOx, and afterward were found in high fixation (Ahmed, 2009). Because of vehicle and vitality area contributes about one 1/2 the NO, basic part of CO, and with respect to one 1/2 natural compound outflows.

These and other toxic gases are produced on account of ignition of non-renewable energy sources. Thus there is a need to find optimum solution in present power age, that are fundamental for the advancement. In any case, significant considerations should be paid towards the property of framework and furthermore to mitigate the developing contamination. Generally, these air poisons would affect the general's wellbeing. in accordance with the Organization for Economic Cooperation and Development (OECD) report, "contamination can wind up most compelling motivation behind unexpected passing, executing. Measurable 3.6 million people every year by 2050. Urban contamination is prepared to turn into the most significant ecological explanation for unexpected passing inside the returning decades, reordering even such mass executioners as poor sanitation and a nonattendance of crisp drinking water". In reality, consistent exposures to high convergence of SPM and various gases may antagonistically affect wellbeing and welfare of people in urban zones of Pakistan because there is direct relationship of metabolic procedure maladies with level of SPM (suspended particulate matter) and different gases inside the nearby air.

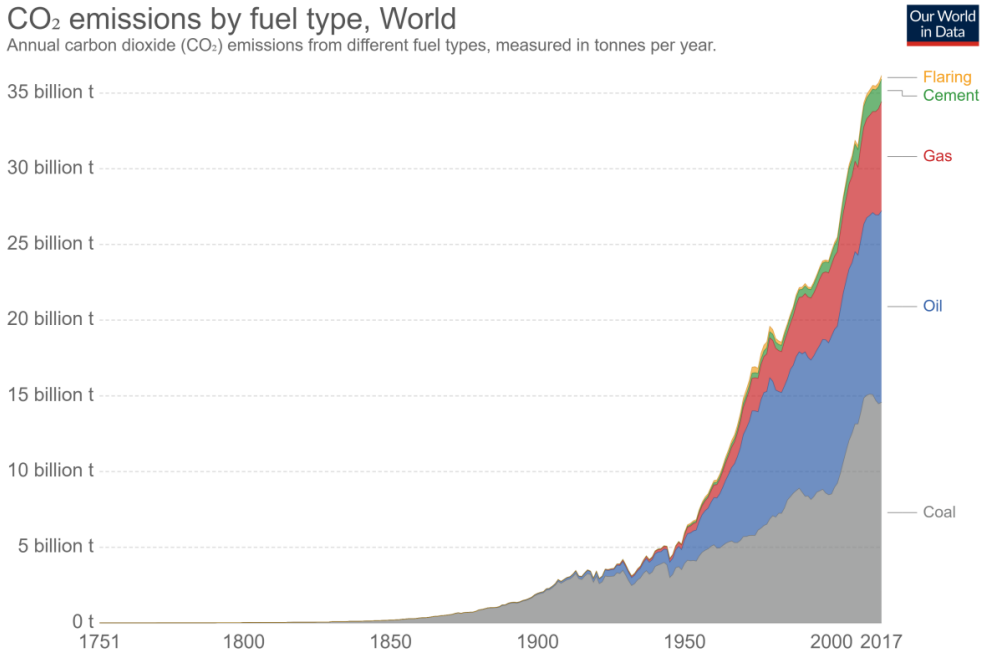
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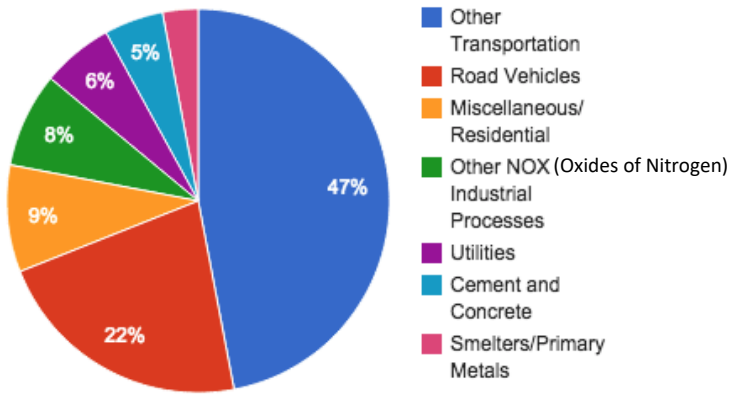
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Source: Carbon Dioxide Information Analysis Center (CDIAC)
Note: Emissions data have been converted from units of carbon to carbon dioxide (CO_2) using a conversion factor of 3.67. regions denoted "other: are given as regional totals minus emissions from the EU-28, USA, China and India. Here, we have rephrased the general term "bunker (fuels)" as "international aviation and maritime transport" for clarity.



Source: Global Carbon Project (CGP); CDIAC OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/



2. Causes and Role of Government, Academics & Industry:

The degrees of gases like carbon monoxide gas (CO), sulfur dioxide (SO_2), ozone (O_3) and hydrocarbons are among the major constituents of air pollution in Pakistan. All these lead to spread of suspended solid particulate in air. Some data for various cities in Pakistan about average suspended matter is given in Table 1:

Table 1: Average Suspended matter (PM2.5)

Sr.	City	Level µg/m3
1.	Islamabad	73
2.	Lahore	121.83
3.	Karachi	53.20
4.	Peshawar	70.10
5.	Quetta	47.1
6.	Safe Limit	35.0

For examples, Oxides of (NOx) concentration are constantly increasing in major cities throughout day time namely due to increasing number of CNG operated vehicles. Formation of secondary pollutants like sulphates and photo-chemical air pollution are also a quite common some of contaminants. The level of pollution in Pakistan's two largest cities, Karachi and Lahore, is estimated to be twenty times beyond World Health Organization (WHO) standards, thus is continued to rise. Similarly, Islamabad, the capital, is constantly smothered by a thick cloud of air pollution that hides views of the Margalla Hills that tower over the city's tree-lined streets.

As industrial sector become large, factories have emitted a lot more unhealthful effluents into the air. Also, as in different developing countries, the amount of

vehicles in Pakistan has big in recent years--from 680,000 in 1980 to 5.8 million in 2018. This is despite the fact that the amount of automobiles (1 per 143 people) in Pakistan remains well below that of the U.S. National Conservation Strategy Report claims that the typical Pakistani vehicle emits twentyfive times the maximum amount greenhouse gas as compared to this average U.S. vehicle. As well as twenty times among hydrocarbons and over 3.5 times chemical element oxides in grams per km.

With few controls on conveyance emissions and tiny social control, reports show that automobile exhaust accounts for ninetieth of the pollutants in Pakistan's air. The govt. has begun to require notice of the degrading air quality within the capital that adversely affects the health of some sixteen million individuals. A recent promotion placed by the govt. in an exceedingly newspaper warned, "Take care of your tune-ups before the poison within the air takes care of you."

The poor fuel quality is additionally found to be guilty for the country's serious pollution issues. Fuel consumption rose by 400% in Pakistan from 1980 to 2015. Approximately, 550 metric tons p.a. of lead emissions are generated by vehicles in Pakistan burning poor-quality fuel, with the ensuing pollution adding regarding over $500 million per year in connected health care prices.

Various grades of gasoline sold-out contain 0.35 gm/liter of lead--in comparison, leaded gas in different countries typically contains no over 0.15 gm/liter. It is report that the matter of pollution may for the most part be solved if the government able to tighten its fuel quality standards. However, the government's Clean Fuel Initiative was for the most part ineffective, and currently the likelihood of exploitation of different fuels for vehicles. In line with the most recent statistics, over 275 CNG stations are operational and over 275,000 cars regenerate to CNG, creating Pakistan third largest CNG shopper within the world. Use of CNG in vehicles is being able to cut back pressure on crude imports, to cut back carbon emissions and improve the surroundings.

By considering high concentration of air pollutants, it would be aforementioned that major contributors of pollution in Pakistan are automobiles besides industries and factories as a result of air pollutants are considerably made from motor vehicles due to sizable amount of motor vehicles running within the country. With few controls on conveyance emissions and tiny social control, reports show that automobile exhaust accounts for ninetieth of the pollutants in Pakistan’s air (Ahmed, 2009). The report shows that impure air in developing countries like Pakistan is due to overwhelming gases made largely by vehicles, factories, and also the burning of power plants. Thus, the government of Pakistan ought to pay special attention towards the development of air quality that's being contaminated by pollution. The government need to take certain effective steps so as to shield system from the bottom layer gas, warming, and health issues caused by high concentration of air pollutants; otherwise poor air quality are going to hamper the environmental development of the country. Furthermore, government, industry and

academics needs to work together to develop policy and make legislation to cut toxic emission, so our future generation can live in healthy air.

3. Steps to Improve Air Quality Through Combined Approach:

According to the World Bank Report, the impure air could be a cause for 21,751 premature deaths once a year and also the increasing variety of metabolic process diseases (estimated 707 million cases of respiratory symptoms within the country).

Due to formation of air pollution, haze and dense fog (suspended stuff aid formation of fog), visibility in our cities remains terribly poor and someday scenario becomes therefore crucial that air and road traveling needs to be suspended that adversely impacts on the national monetary resource.

The following approaches are going to be adopted to manage conveyance emissions within the country:

a) Social control of Euro-II Emission Standards for brand spanking new Vehicles

Ministry of Environment in consultation with vehicle makers and Ministry of Industry has notified adoption of Euro-II Emission Standards (Pak-II) effective from first July, 2009 for hydrocarbon vehicles and first July 2012 for diesel vehicles. Ministry of Environment can guarantee compliance of Pak-II Emission Standards.

b) Fuel Re-formulation (unleaded and low Sulphur)

Ministry of crude and Ministry of surroundings collectively developed a program on clean fuels in 1995. Within the first instant gas was introduced throughout the country. Later, the sulphur contents in diesel fuel were reduced from 1% to 0.6%. Additional reduction in sulphur content needs serious investment to put in desulphurization plants in refineries. Ministry of Petroleum is trying to create out there Euro-II compliant sulphur diesel (0.05%) by year 2012.

d) Putting in Vehicle Inspection/Emission Testing System

The automobile Examination and Emission Testing Centers (MVE&ETC;) are going to be established within the country untidily of automobile Examiner, automobile Registration and Environmental Protection Agencies. every MVE&ETC; can comprise of 3-4 lane testing facilities. All automobiles classes viz. industrial and personal are going to be sporadically tested for fitness and emission. 2 and 3 wheelers, that comprise the biggest variety of vehicles within the cities, will be enclosed for a lot of rigorous tests. Examination of buses and trucks would force a lot of rigorous inspection and frequent inspection drills. When the vehicle is passed it will become responsibility of owner to stay it within the condition when it passed the examination.

Pakistan Clean Air Program is going to be enforced that specialize in the following:

- Rising fuel quality
- Implementation of Euro-II Standards

- Introduction of CNG Buses
- Promotion of twin fuel injection system technology in existing diesel vehicles (LPG+ Diesel and CNG+ Diesel)
- Encouraging institution of auto inspection/emission testing centers privately sector (Isb: 2; LHR: 4; KHI: 6 PWR: 2; QTA: 1
- Checking roadside vehicles and in institution (ISB: 50,000; Punjab: 200,000; Sindh: 250,000; Peshawar: 25,000; Quetta: 10,000)
- Urban plantation in ten cities
- Institution of six Air observance Stations in ISB: 1; KHI: a pair of; LHR: 2, PWR:1

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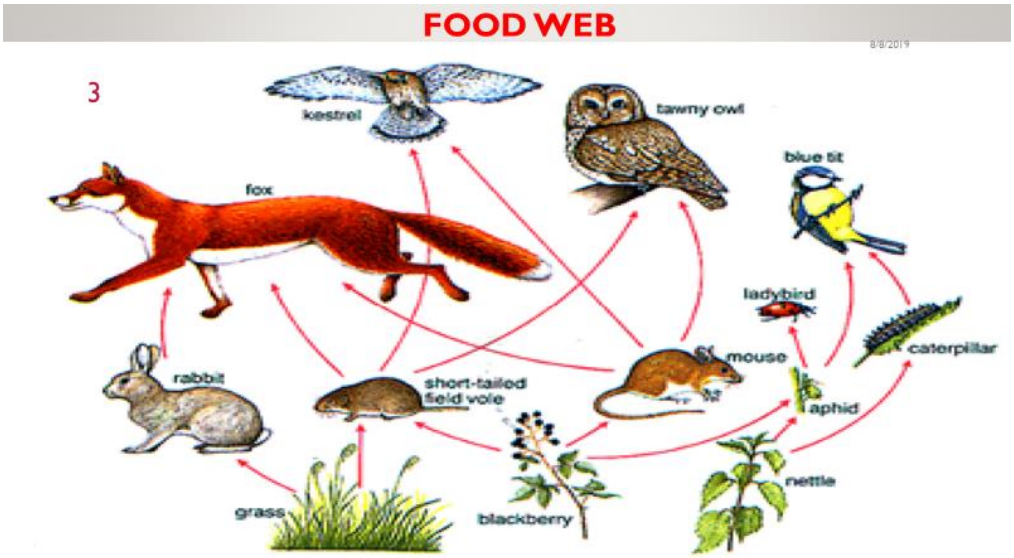
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THE ROLE OF FORESTS IN CARBON SEQUESTRATION TO COUNTER AIR POLLUTION

Abdul Aleem Chaudhry Ph. D.

*The theme of **World Environment Day-2019** is "**Air Pollution**" upon purity of which safety of health and life is dependent. World Environment Day is being celebrated with the slogan "***Beat air pollution".**

Environmental pollution is any discharge of material or energy into water, land, or air that causes or may cause acute (short-term) or chronic (long-term) detriment to the Earth's ecological balance or that lowers the quality of life. **Pollutants** may cause primary damage, with direct identifiable impact on the environment, or secondary damage in the form of minor perturbations in the delicate balance of the **biological food web** that are detectable only over long time periods.



Air pollution is defined as the substances and the energy forms in the atmosphere, not present in normal atmospheric composition, to reach the atmosphere, or be present but in much lower concentrations. This is caused by the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or air pollution may cause damage to the natural environment or built environment, into the atmosphere.

More than 3,000 substances that are not part of the atmospheric composition, falling in the atmosphere can be considered **air pollutants**. Some substances that are normally present in the atmosphere in a certain concentration can be considered pollutants because their concentration is much higher than usual concentration. Also, certain substances that are normally present in certain layers of the atmosphere (e.g. ozone in the stratosphere), once arrived in the troposphere is pollutant. Some gases, such as oxides of nitrogen may have beneficial effect on

vegetation, after hydration may affect the leaf fertilizer. The air pollutants factors can be **chemical** (chemicals), **mechanics** (particles in suspension) **physical** (ionizing radiation) and **acoustic** (noise).

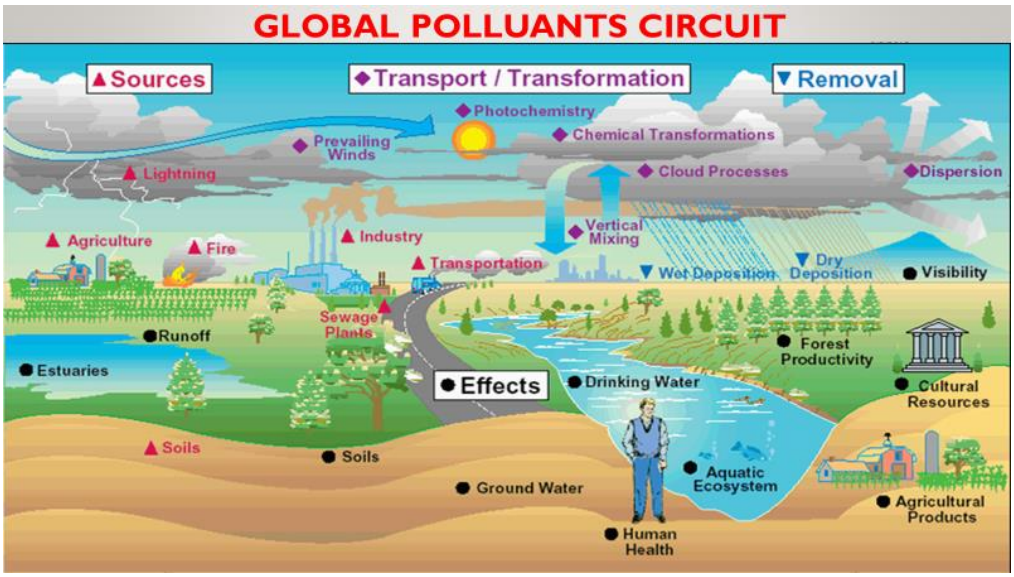


Pollutants describe a global circuit; they are produced by different sources, are transported and transformed into atmosphere, some of them being removed, another part is reaching the earth having different effects on different biocoenosis of ecosystems. An analysis done at the global level revealed a diversification of pollutants agents and sources of air pollution. This diversification and increasing concentrations are in strict correlation with industrialization and the increasing of amounts use as fossil energy (non-renewable sources). **At the beginning**, the pollution was felt in **urban areas** and the forms of relief that **favored the accumulation of pollutants and long stay** (depressions, closed valleys, etc.). Currently, air pollution has become a larger area, sometimes to **disperse across multiple continents**. Air pollution can be analyzed on three spatial scales viz,. **global pollution, regional pollution and local pollutants**.

Global pollution is the cumulative effect of various sources, the entire surface of the globe, manifested by global effects e.g. the stratospheric ozone depletion; greenhouse effect - emission of greenhouse gases (CO_2, methane, CFCs, etc.) and the formation of aerosols (pollutant clouds which are formed by suspended particles and chemical compounds).

Regional pollution is originated by vehicles, manufacturing plants, and coal-burning facilities emit chemicals that cause air **pollution**. Some of these chemicals, when combined with sunlight and high temperatures, react in the atmosphere to form ozone, the primary ingredient in urban air **pollution**. Local air pollution--including that produced by individual sources, such as automobiles that has spread out to encompass areas of many thousands of square kilometers. Meteorological conditions and landforms can greatly influence air-pollution concentrations at any given place, especially locally and regionally. For example, cities located in bowls or valleys over which atmospheric inversions form and act

as imperfect lids are especially likely to suffer from incidences of **severe smog**. Oxides of sulfur and nitrogen carried long distances by the atmosphere and then precipitated in solution as acid rain, can cause serious damage to vegetation, waterways, and buildings.



Local pollutants: (smog): a multi-source, widespread air pollution that occurs in the air of cities. **Smog**, a contraction of the words smoke and fog, has been caused throughout recorded history by water condensing on smoke particles, usually from burning coal.

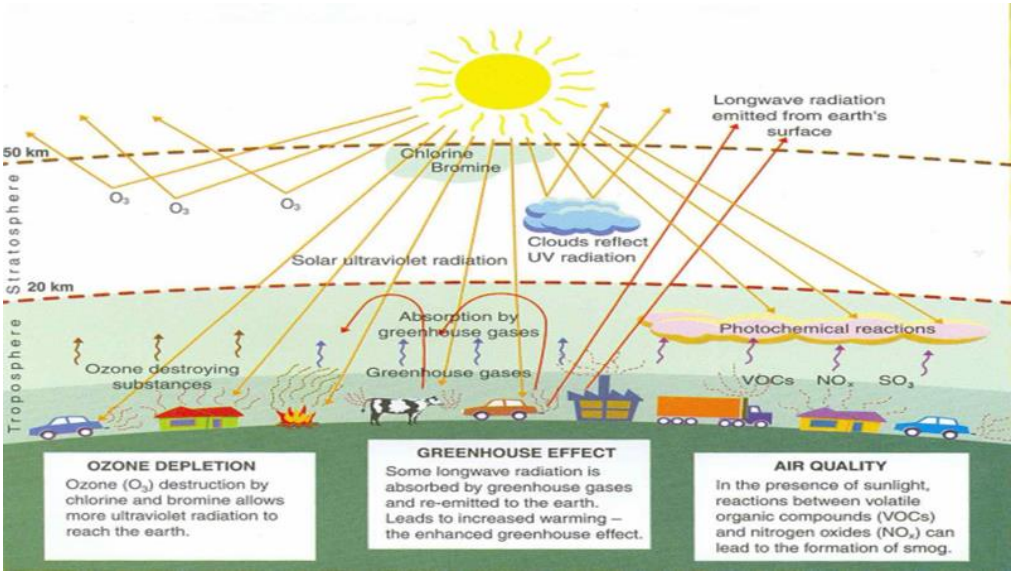
Effects of pollutants can be Acidifying agents including Sulphur dioxide (SO_2), Nitrogen oxides (NOx) ammonia (NH_3), Fluoride and Cl_2, Hydrogen chloride (HCl) – and Oxidizing agents - carbon monoxide (CO), PAN (peroxyacetylnitrate-$CH_3CO.O_2.NO_2$), and Ozone (O_3).

Sources of pollutants can be **Air pollution:** from **natural and anthropic sources**; these sources generate pollutants with different effects at global level or on individuals of plants and animals.

Pollutants may enter into the system through **Natural processes viz.,** volcanoes, which produce sulfur, chlorine, and ash particulates; **Wildfires** producing smoke and carbon monoxide; **Cattle and other animals that** emit methane as part of their digestive process; even **pine trees** emit **volatile organic compounds** (VOCs); **Anthropic sources** including industrial plants, power plants and vehicles with internal combustion engines that produce nitrogen oxides, VOCs, carbon monoxide, carbon dioxide, sulfur dioxide (CO, CO_2, NO, NO_2, N_2O, NH_4) and particulates; in most **mega-cities**, **cars** are the main source of these pollutants; **Stoves**, incinerators, and **farmers burning their crop waste** produce carbon monoxide, carbon dioxide, as well as particulates; other human-made sources

include **aerosol sprays** and **leaky refrigerators**, as well as **fumes** from paint, varnish, and other solvents.

Air pollution doesn't stay in one place. **Winds and weather** play an important part in the transport of pollution locally,



Details of pollutants sources, as given above, are given below:

Sources of pollutants

Natural sources: Sulfur, chlorine, and ash particulates, smoke and carbon monoxide methane volatile organic compounds (VOCs) Aerosol from deforestation and burning: **CO, CO_2**, NO, NO_2, N_2O, NH_4

Origin: Volcanoes, wildfires, cattle and other animals, pine trees

Effects: acid rain, smog, respiratory irritant, increased respiratory diseases, damage cell membranes of plants

Anthropogenic sources

Sources: industry and conventional energies (the mining industry, the energy industry based on fossil fuels - coal, oil, natural gas, central heating, chemical and metallurgical industry, engineering internal combustion machinery industry, industrial waste, noises, etc.);

Origin: agriculture (the vegetation fire, denitrification in soils excessively fertilized, paddy field, intensive husbandry, deforestation, etc.) transportation (motor vehicle pollution, noises, etc.)

Effects: urbanization (sewage plans, authorized landfill site, etc.)

Source: Carbon monoxide, carbon dioxide, sulphur dioxide, nitrogen oxides, fluorides and substances with fluorine, chlorine (Cl_2), bromine (Br_2) and iodine (I_2), small dust particles, VOC, methane, ammonia and radioactive radiation

Origin: *Industry*: the mining industry, oil and natural gas extraction, the energy industry based on fossil fuels - coal, oil, natural gas, the production of brick, tile, enamel frit, ceramics, and glass; the manufacture of aluminum and steel; and the production of hydrofluoric acid, phosphate chemicals and fertilizers. central heating, chemical and metallurgical industry, engineering internal combustion machinery industry, industrial waste, noises

Effect: respiratory irritant, acid rain, smog, increased respiratory diseases, formation of secondary pollutants (PAN, O_3),

- **Source**: ***Agriculture***: CO, CO_2, NO, NO_2, NH_3, CH_4, SO_2, oxides of heavy metals, H_2SO_4, SPM, HC, VOC, background aerosols: sea salt oxidation of sulphur containing gases, same organics, nitrous oxide (N_2O) pesticides
- **Origin:** Aerosols from transport and constructions NOx, CO, HCl, Lead and other heavy metals, SPM, Domestic aerosols CFC, HC, FC, H_2S, CH_4 CO_2, The motor vehicle pollution, noises, sewage plants, authorized landfill site
- **Effects:** Domestic aerosols CFC, HC, FC, H_2S, CH_4 CO_2, effect on soil fertilizer, Respiratory diseases, toxic effects on living cells, greenhouse gas effect, toxic effects, carcinogenic proprieties, accumulation in tissues, blocking of different processes, stratospheric ozone depletion.

Countering Air Pollution

To counter Air pollution various measures have been suggested that include:

- Conserve energy - at home, at work, everywhere.
- Look for the ENERGY STAR label when buying home or office equipment.
- Carpool, use public transportation, bike, or walk whenever possible.
- Follow gasoline refueling instructions for efficient vapor recovery, being careful not to spill fuel and always tightening your gas cap securely.
- Consider purchasing portable gasoline containers labeled “spill-proof,” where available.
- Keep car, boat, and other engines properly tuned.
- Be sure your tires are properly inflated.
- Use environmentally safe paints and cleaning products whenever possible.
- Mulch or compost leaves and yard waste.
- Consider using gas logs instead of wood.

***On Days when High Ozone Levels are Expected, take these Extra Steps to Reduce Pollution*:**

- Choose a cleaner commute - share a ride to work or use public transportation.
- Combine errands and reduce trips. Walk to errands when possible.

- Avoid excessive idling of your automobile.
- Refuel your car in the evening when its cooler.
- Conserve electricity and set air conditioners no lower than 78 degrees.
- Defer lawn and gardening chores that use gasoline-powered equipment, or wait until evening.

***On Days when High Particle Levels are Expected, take these Extra Steps to Reduce Pollution*:**

- Reduce the number of trips you take in your car.
- Reduce or eliminate fireplace and wood stove use.
- Avoid burning leaves, trash, and other materials.
- Avoid using gas-powered lawn and garden equipment.

Take the following steps to minimize your exposure to air pollution and protection your health:

- Information on the health effects of ozone, and
- Information on the health effects of particles (PDF) (2 pp, 65 K, about PDF)

Carbon Dioxide CO_2 in the Carbon Cycle

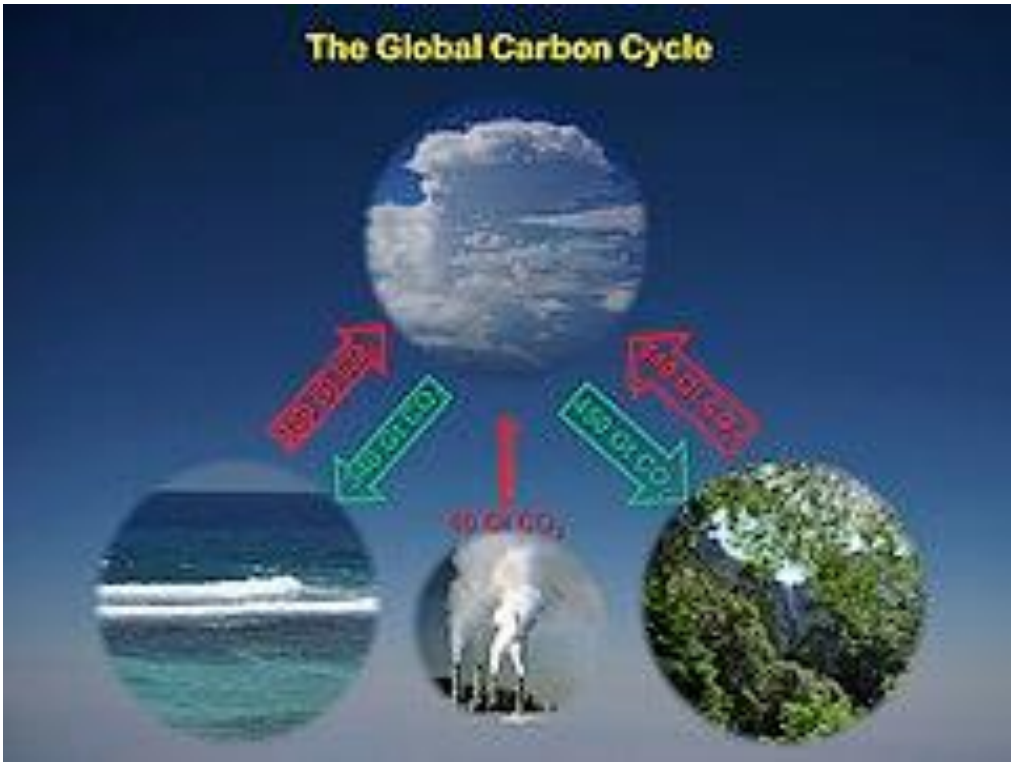
The **carbon cycle** is the biogeochemical cycle by which carbon is exchanged among the biosphere, pedosphere, geosphere, hydrosphere, and atmosphere of the Earth. Carbon is the main component of biological compounds as well as a major component of many minerals such as limestone. Along with the nitrogen cycle and the water cycle, the carbon cycle comprises a sequence of events that are key to make Earth capable of sustaining life. It describes the movement of carbon as it is recycled and reused throughout the biosphere, as well as long-term processes of carbon sequestration to and release from carbon sinks.

Atmosphere

The oceans and land have continued to absorb about half of all carbon dioxide emissions into the atmosphere, even as anthropogenic emissions have risen dramatically in recent decades. It remains unclear if carbon absorption will continue at this rate.

Epiphytes on electric wires. This kind of plant takes both CO2 and water from the atmosphere for living and growing.

Carbon in the Earth's atmosphere exists in two main forms: **carbon dioxide** and **methane**. Both of these gases absorb and retain heat in the atmosphere and are partially responsible for the **greenhouse effect**. Methane produces a larger greenhouse effect per volume as compared to carbon dioxide, but it exists in much lower concentrations and is more short-lived than carbon dioxide, making **carbon dioxide the more important greenhouse gas of the two**.


The Global Carbon Cycle



Carbon dioxide is removed from the atmosphere primarily through **photosynthesis** and enters the terrestrial and oceanic biospheres. Carbon dioxide also dissolves directly from the atmosphere into bodies of water (ocean, lakes, etc.), as well as dissolving in precipitation as raindrops fall through the atmosphere. When dissolved in water, carbon dioxide reacts with water molecules and forms carbonic acid, which contributes to ocean acidity. It can then be absorbed by rocks through weathering. It also can acidify other surfaces it touches or be washed into the ocean.[9]

Human activities over the past two centuries have significantly increased the amount of carbon in the atmosphere, mainly in the form of carbon dioxide, both by modifying ecosystems' ability to extract carbon dioxide from the atmosphere and by emitting it directly, e.g., by burning fossil fuels and manufacturing concrete.

In the extremely far future (i.e, 2-3 billion years), the rate at which carbon dioxide is absorbed into the soil via the carbonate–silicate cycle will likely increase due to expected changes in the sun as it ages. The expected increased luminosity of the Sun will likely speed up the rate of surface weathering. This will eventually cause most of the carbon dioxide in the atmosphere to be squelched into the Earth's crust as carbonate. Though volcanoes will continue to pump carbon dioxide into the atmosphere in the short term, it will not be enough to keep the carbon dioxide level stable in the long term. Once the carbon dioxide level falls below 50 parts per million, C_3 photosynthesis will no longer be possible. This is expected to occur about 600 million years from now.

Once the oceans on the Earth evaporate in about 1.1 billion years from now, plate tectonics will very likely stop due to the lack of water to lubricate them. The lack of volcanoes pumping out carbon dioxide will cause the carbon cycle to end between 1 billion and 2 billion years into the future.

Terrestrial biosphere



A portable soil respiration system measuring soil CO_2 flux

International Union of Forestry Research Organization **Terrestrial biosphere**

The **terrestrial biosphere** includes the organic carbon in all land-living organisms, both alive and dead, as well as carbon stored in soils. **About 500 gigatons of carbon are stored above ground in plants and other living organisms**, while soil holds approximately 1,500 gigatons of carbon. Most carbon in the terrestrial biosphere is **organic carbon**, while about a third of soil carbon is stored in inorganic forms, such as calcium carbonate. Organic carbon is a major component of all organisms living on earth. Autotrophs extract it from the air in the form of carbon dioxide, converting it into organic carbon, while heterotrophs receive carbon by consuming other organisms.

Because carbon uptake in the terrestrial biosphere is dependent on biotic factors, it follows a diurnal and seasonal cycle. In CO_2 measurements, this feature is apparent in the Keeling curve. It is strongest in the northern hemisphere because this hemisphere has more land mass than the southern hemisphere and thus more room for ecosystems to absorb and emit carbon.

Carbon leaves the terrestrial biosphere in several ways and on different time scales. The combustion or respiration of organic carbon releases it rapidly into the atmosphere. It can also be exported into the ocean through rivers or remain sequestered in soils in the form of inert carbon. Carbon stored in soil can remain there for up to thousands of years before being washed into rivers by erosion or released into the atmosphere through soil respiration. Between 1989 and 2008 soil respiration increased by about 0.1% per year. In 2008, the global total of CO_2 released by soil respiration was roughly 98 billion tons, about 10 times more carbon than humans are now putting into the atmosphere each year by burning fossil fuel (this does not represent a net transfer of carbon from soil to atmosphere, as the respiration is largely offset by inputs to soil carbon). There are a few plausible explanations for this trend, but the most likely explanation is that increasing temperatures have increased rates of decomposition of soil organic matter, which has increased the flow of CO_2. The length of carbon sequestering in soil is dependent on local climatic conditions and thus changes in the course of climate change.

Oceans

The ocean can be conceptually divided into a surface layer within which water makes frequent (daily to annual) contact with the atmosphere, and a deep layer below the typical mixed layer depth of a few hundred meters or less, within which the time between consecutive contacts may be centuries. The dissolved inorganic carbon (DIC) in the surface layer is exchanged rapidly with the atmosphere, maintaining equilibrium. Partly because its concentration of DIC is about 15% higher but mainly due to its larger volume, the deep ocean contains far more carbon—it's the largest pool of actively cycled carbon in the world, containing 50 times more than the atmosphere—but the timescale to reach equilibrium with the atmosphere is hundreds of years: the exchange of carbon between the two layers, driven by thermohaline circulation, is slow.

Carbon enters the ocean mainly through the dissolution of atmospheric carbon dioxide, a small fraction of which is converted into carbonate. It can also enter the ocean through rivers as dissolved organic carbon. It is converted by organisms into organic carbon through photosynthesis and can either be exchanged throughout the food chain or precipitated into the ocean's deeper, more carbon-rich layers as dead soft tissue or in shells as calcium carbonate. It circulates in this layer for long periods of time before either being deposited as sediment or, eventually, returned to the surface waters through thermohaline circulation. Oceans are basic (~pH 8.2), hence CO_2 acidification shifts the pH of the ocean towards neutral.

Oceanic absorption of CO_2 is one of the most important forms of carbon sequestering **limiting** the human-caused rise of carbon dioxide in the atmosphere. However, this process is limited by a number of factors. CO_2 absorption makes water more acidic, which affects ocean biosystems. The projected rate of increasing oceanic acidity could slow the biological precipitation of calcium carbonates, thus decreasing the ocean's capacity to absorb carbon dioxide.

Geosphere

The geologic component of the carbon cycle operates slowly in comparison to the other parts of the global carbon cycle. It is one of the most important determinants of the amount of carbon in the atmosphere, and thus of global temperatures.

Most of the earth's carbon is stored inertly in the earth's lithosphere. Much of the carbon stored in the earth's mantle was stored there when the earth formed. Some of it was deposited in the form of organic carbon from the biosphere of the carbon stored in the geosphere, about 80% is limestone and its derivatives, which form from the sedimentation of calcium carbonate stored in the shells of marine organisms. The remaining 20% is stored as kerogens formed through the sedimentation and burial of terrestrial organisms under high heat and pressure. Organic carbon stored in the geosphere can remain there for millions of years.

Carbon can leave the geosphere in several ways. Carbon dioxide is released during the metamorphism of carbonate rocks when they are subducted into the earth's mantle. This carbon dioxide can be released into the atmosphere and ocean through volcanoes and hotspots. It can also be removed by humans through the direct extraction of kerogens in the form of fossil fuels. After extraction, fossil fuels are burned to release energy, thus emitting the carbon they store into the atmosphere

Deep carbon cycle

Although deep carbon cycling is not as well-understood as carbon movement through the atmosphere, terrestrial biosphere, ocean, and geosphere, it is nonetheless an incredibly important process. The deep carbon cycle is intimately connected to the movement of carbon in the Earth's surface and atmosphere. If the process did not exist, carbon would remain in the atmosphere, where it would accumulate to extremely high levels over long periods of time. Therefore, by

allowing carbon to return to the Earth, the deep carbon cycle plays a critical role in maintaining the terrestrial conditions necessary for life to exist.

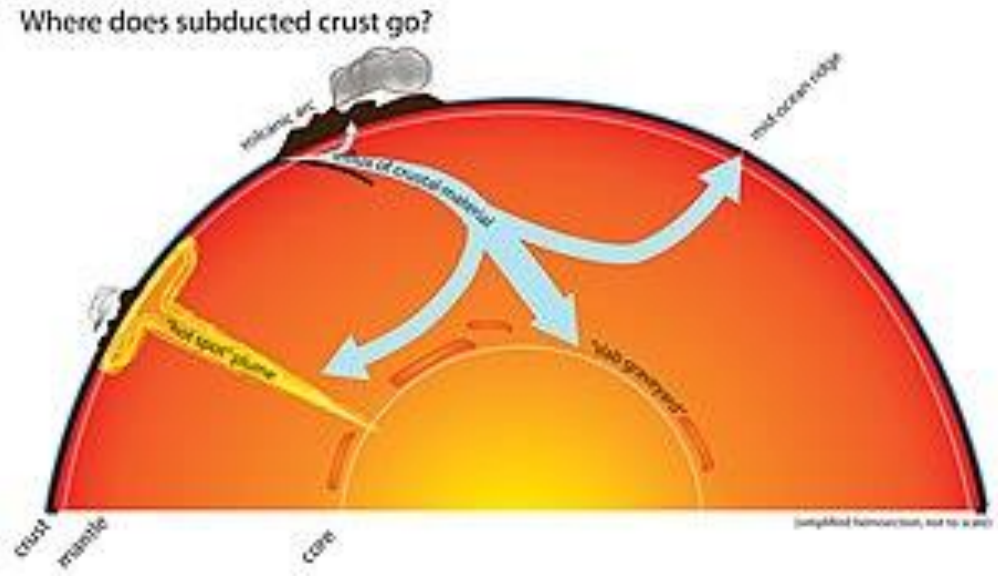


Figure depicting the movement of oceanic plates—which carry carbon compounds—through the mantle

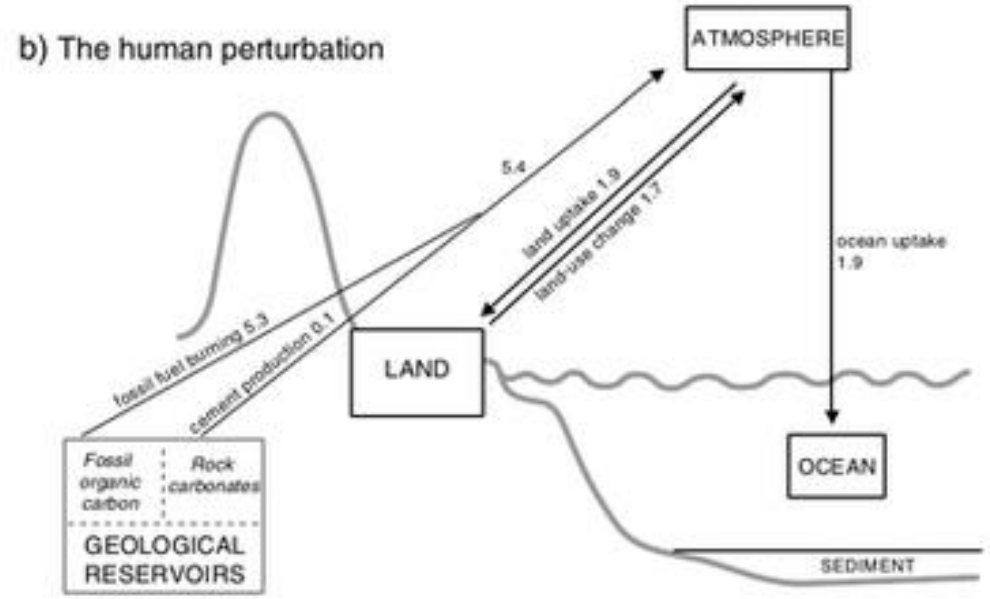
Furthermore, the process is also significant simply due to the massive quantities of carbon it transports through the planet. In fact, studying the composition of basaltic magma and measuring carbon dioxide flux out of volcanoes reveals that the amount of carbon in the mantle is actually greater than that on the Earth's surface by a factor of one thousand. Drilling down and physically observing deep-Earth carbon processes is evidently extremely difficult, as the lower mantle and core extend from 660 to 2,891km and 2,891 to 6,371km deep into the Earth respectively. Accordingly, not much is conclusively known regarding the role of carbon in the deep Earth. Nonetheless, several pieces of evidence—many of which come from laboratory simulations of deep Earth conditions—have indicated mechanisms for the element's movement down into the lower mantle, as well as the forms that carbon takes at the extreme temperatures and pressures of said layer. Furthermore, techniques like seismology have led to a greater understanding of the potential presence of carbon in the Earth's core.

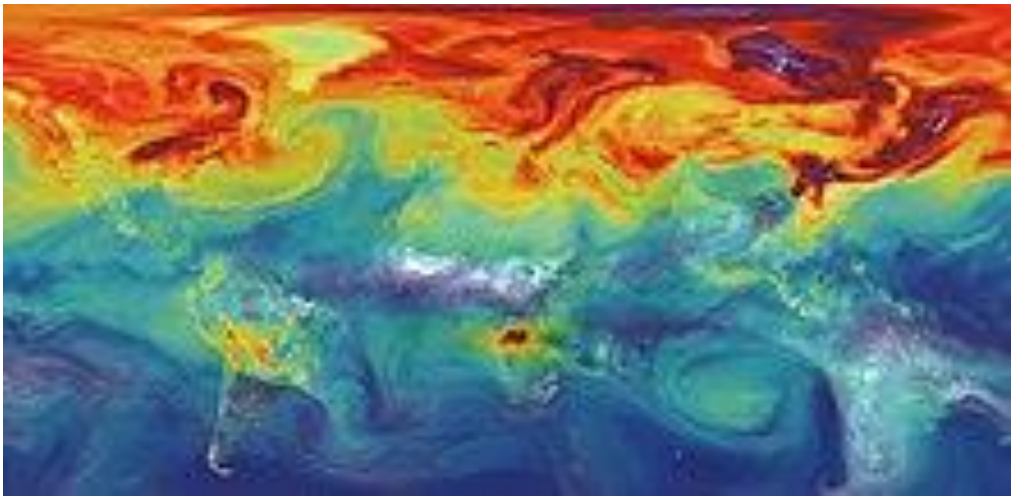
Human influence

Human activity since the industrial era has changed the balance in the natural carbon cycle. Units are in gigatons.

Since the industrial revolution, human activity has modified the carbon cycle by changing its components' functions and directly adding carbon to the atmosphere.

The largest human impact on the carbon cycle is through direct emissions from burning fossil fuels, which transfers carbon from the geosphere into the atmosphere. The rest of this increase is caused mostly by changes in land-use, particularly deforestation.





CO_2 in Earth's atmosphere: If half of global-warming emissions are not absorbed. (NASA computer simulation).

Another direct human impact on the carbon cycle is the chemical process of calcination of limestone for clinker production, which releases CO_2. Clinker is an industrial precursor of cement.

Humans also influence the carbon cycle indirectly by changing the terrestrial and oceanic biosphere. Over the past several centuries, direct and indirect human-caused land use and land cover change (LUCC) has led to the **loss of biodiversity**, which lowers ecosystems' resilience to environmental stresses and decreases their ability to remove carbon from the atmosphere. More directly, it often leads to the release of carbon from terrestrial ecosystems into the atmosphere. **Deforestation** for agricultural purposes removes forests, which hold large amounts of carbon, and replaces them, generally with agricultural or urban areas. Both of these replacement land cover types store comparatively small amounts of carbon so that the net product of the process is that more carbon stays in the atmosphere.

Other human-caused changes to the environment change ecosystems' productivity and their ability to remove carbon from the atmosphere. ***Air pollution, for example, damages plants and soils, while many agricultural and land use practices lead to higher erosion rates, washing carbon out of soils and decreasing plant productivity***.

Humans also affect the oceanic carbon cycle. Current trends in climate change lead to higher ocean temperatures, thus modifying ecosystems. Also, acid rain and polluted runoff from agriculture and industry change the ocean's chemical composition. Such changes can have dramatic effects on highly sensitive ecosystems such as coral reefs, thus limiting the ocean's ability to absorb carbon from the atmosphere on a regional scale and reducing oceanic biodiversity globally.

Arctic methane emissions indirectly caused by anthropogenic global warming also affect the carbon cycle and contribute to **further warming in what is known as climate change feedback**.

On 12 November 2015, NASA scientists reported that human-made carbon dioxide (CO_2) continues to increase, reaching levels not seen in hundreds of thousands of years: currently, the rate carbon dioxide released by the burning of fossil fuels is about double the net uptake by vegetation and the ocean.

Pakistan wants to reduce 20 percent of its 2030 projected Green House Gas (GHG) emissions, amounting to 1603 million tons of carbon dioxide equivalent subject to the availability of international grants to meet the total abatement cost for the indicated 20 percent reduction amounting to about US$ 40 billion at current prices (May 30, 2018).

According to government sources, Pakistan submitted its Intended Nationally Determined Contribution (Pak-INDC), under Article 2 of the Paris Agreement, to the United Nations Framework Convention on Climate Change (UNFCC). Under the INDC, Pakistan’s adaptation needs range between U$ 7 to U$ 14 billion/annum during this period.



According to a preliminary projection, the GHG emissions levels for Pakistan are expected to increase many times in the coming decades. An important path to low-carbon development is carbon capture and storage (CCS), which focuses on securing and storing carbon dioxide emissions before these are released into the atmosphere. Although this technology is still in its early stages, countries are committed to implementing variations of it with both bilateral and multilateral cooperation underway.

This cooperation is particularly important because implementing CCS on a large scale can be expensive and offers few obvious economic benefits. One of the major multilateral efforts in this area is the Carbon Sequestration Leadership Forum (CSLF), which supports joint efforts to develop cost-effective carbon sequestration technology. Furthermore, renewable and nuclear energy can be of critical importance in diminishing reliance on fossil fuels and developing low-carbon communities.

Expectations for nuclear power as an alternative source of energy are especially high among big emitters such as India, China, and the US, as well as in a number of developing countries that lack the necessary infrastructure to meet their growing energy needs. Currently, the International Atomic Energy Agency (IAEA) assists countries in determining whether nuclear energy is a feasible option, the agency assists with energy planning and developing relevant infrastructure, such as drafting nuclear legislation and establishing independent and effective safety regulators. There has also been significant international action on renewable energy.

The International Renewable Energy Agency (IRENA), founded in January 2009, is the first international forum for specifically promoting the use of renewable energy. The United Nations Environment Program (UNEP) has launched several

initiatives, including the Global Bio-energy Partnership (GBEP), to support the deployment of biomass and bio-fuels and the Solar and Wind Energy Resource Assessment (SWERA), which seeks to make renewable energy data widely available. Despite these promising international efforts, only about 25 percent of the world's energy is produced through renewable and alternative sources (including hydroelectric, biomass, and nuclear).

However, investments in these areas continues to increase and more and more countries are setting policy targets for using renewable energy. Policy reform might include steps like energy market reform or reduction of tariff barriers to low-carbon technology transfer. International institutions have begun to promote domestic policy shifts through measures like technical assistance provided by organizations like the UNEP and UNDP, discussions on tariff reductions for environmentally friendly technologies through the WTO, and processes aimed at phasing out fossil fuel subsidies spurred through the G20.

Climate change is a geographic problem and reducing the risks caused by climate change is an immense challenge. Pakistan is consistently ranked by multiple climate change vulnerability indices as being one of the most vulnerable to the impacts of climate change due to drought, floods, heat waves, and glacial lake outburst floods in the past few decades.

The government is cognizant of this issue and is taking strategic adaptation measures at the policy management and operational level to minimize the global warming effects. Further efforts to overcome the challenges of climate change are made through enacting legislation, setting standards and developing and implementing policies for a secure and lively environment. The existing and proposed measures being taken by the government would help to address the climate change issues effectively.

PAKISTAN can earn huge sums in foreign currency if they create carbon credit certificates and sell them in the international open market.

A carbon credit (also called a carbon offset) is a permit that allows the holder's entity to emit one tons of carbon dioxide. These certificates are awarded to companies that have reduced their greenhouse gases below their emission quota – i.e., below one ton of carbon dioxide.

Just imagine how much foreign exchange Pakistan could have earned if it hadn't delayed its wind-energy projects. These projects were a good opportunity to earn for the country. The price of a carbon credit now is around $ 2 which used to be $10 last year.

Pakistan has around 12 projects in various sectors like fertilizer, cement, power generation, etc. that have qualified for selling carbon credits.

No study has been carried out to establish how much greenhouse gases are emitted in Pakistan; but it's estimated that the size of CO2 emissions that can be converted into carbon credits, stands at around 43 million tons. Thus the country

stands to gain from the carbon credits initiative. To date only the private sector has come forward to earn carbon credits while many public sector projects can qualify for the same.

Pakistan's Carbon Emissions to Grow by 4 Times in 15 Years

Pakistan lags behind its coverage of climate change issues. We are a growing economic power but the emissions are set to soar too and not many people are aware of what kind of consequences climate change could have on our environment.



To add salt to wound, our neighbors and even countries like Bangladesh, Sri Lanka have a good understanding and are well aware of climate change and of its impact. We, as a vulnerable country, should also need to conduct such awareness campaigns for climate change.

Pakistan might not be contributing to a large amount of Greenhouse Gas (GHG) emissions but it is still among the top ten most climate-affected countries of the world. The Climate Change Bill passed in 2016 also states:

> Pakistan's per capita emissions of greenhouse gases today is one of the lowest in the world. Yet it ranks amongst the top ten countries most affected by climate change during the last twenty years.

We have not only faced floods, droughts or even the 2015 Karachi heat wave but also other impacts such as glacier melting, rising temperatures, rising sea level just to name a few.

Our carbon emissions have also grown by 123% between 1994 and 2015. Not to mention that the Prime Minister has set the goal for Pakistan to become one of the top 20 economies of the world by 2025 which no doubt means that development will have to take place and to achieve this economic growth, there's going to be a focus on energy and transport. The estimated carbon growth is expected to be

from 405 metric tons to 1,603 metric tons in just 15 years. That is carbon emissions rising 4 times which is huge number.

However, during a survey done in 2013, Pakistan actually had lower carbon emissions than both India and China but higher than Bangladesh

Clean Development Mechanism

The Clean Development Mechanism (CDM), is one among the three flexible Kyoto Protocol mechanisms facilitated implementation of Green House Gas (GHG) emission reductions in developing countries. Such GHG emissions are procured by the developed countries to meet their emission reduction targets under the Kyoto Protocol.

The concept of the CDM is sketched in Article 12 of the Kyoto protocol (UNFCCC 1997). The CDM was created to assist non- ANNEX I Parties in achieving sustainable development, transfer of sustainable technologies and contributing to the ultimate objective of the Climate Convention while enabling ratifying Annex-I[1] parties to use Certified Emission Reductions (CERs) from project activities in non-Annex-I countries- including Pakistan- in order to contribute towards their compliance of national greenhouse gas emission reduction targets during the first commitment period (2008- 2012). Under the CDM, ratifying parties Annex-I parties are allowed to implement projects that reduce emissions in non- Annex-I Parties or absorb carbon through afforestation or reforestation activities. In return, ratifying Annex-I parties receive CERs while the project activity assists the host country in their development process and climate change mitigation. As GHG abatement costs in developing countries are expected to be much lower than in industrialized countries the CDM gives the Annex-I country the opportunity to achieve their abatement targets at lower costs while providing sustainable development projects with a mitigation potential to the host country.

The CDM was conceived in order to assist countries with a binding emission reduction target in achieving partial compliance with their country target by carrying out project activities aimed at reducing emissions in the developing countries like Pakistan that yet do not have such obligations.

The underlying idea of the mechanism is to take advantage of cost- efficient mitigation options everywhere in the world; in other words, to achieve the same environmental benefits at lower costs, with so- called least- cost abatement measures. The Protocol hence intends to support industrialized countries in reducing their costs of compliance.

In order to preserve a high probability of keeping global temperature increase below 2-degrees Centigrade, current climate science suggests that atmospheric

[1] *Non-ANNEX I Parties in achieving sustainable development, transfer of sustainable technologies and contributing to the ultimate objective of the Climate Convention while enabling ratifying Annex I parties to use Certified Emission Reductions (CERs) from project activities in non-Annex I countries including Pakistan, in order to contribute towards their compliance of national greenhouse gas emission reduction targets during the first commitment period (2008-2012)*

CO_2 concentrations need to peak below 450ppm. This requires global emissions to peak in this decade and decline to roughly 80% below 1990 levels by the year 2050. Such dramatic emissions reductions require a sharp move away from fossil fuel, significant improvements in energy efficiency and substantial re-organization of our current economic system. This transition can only be achieved by far-reaching national and international climate policies.

Opportunities of Earning Carbon Credits in Alternative and Renewable Energy Projects in Pakistan

Carbon offsetting is an increasingly popular means of taking action. By paying someone else to reduce GHG emissions elsewhere, the purchaser of a carbon offset aims to compensate for – or "offset" – their own emissions. Individuals seek to offset their travel emissions and companies claim "climate neutrality" by buying large quantities of carbon offsets to "neutralize" their carbon footprint or that of their products.

Carbon offset markets exist both under compliance schemes and as voluntary programs. Compliance markets are created and regulated by mandatory regional, national, and international carbon reduction regimes, such as the Kyoto Protocol and the European Union's Emissions Trading Scheme. Voluntary offset markets function outside of the compliance markets and enable companies and individuals to purchase carbon offsets on a voluntary basis.

In Pakistan, alternative and renewable energy (ARE) projects have definite prospects for development as carbon offsetting initiatives. Being clean source of energy, the ARE projects are best suited for CDM and can earn CERs. The Government of Pakistan (GoP) has taken up a broad spectrum of initiatives for the development of AREs in the country and seeks projects to address the CDM pertaining to sustainable development and should apply to CDM Executive Board as per the guidelines of UNFCCC for get CERs and earn carbon revenues.

To accelerate and streamline activities related to the REs, the Government of Pakistan has authorized Alternative Energy Development Board (AEDB) to act as a focal body of the federal government with mandate of one window facility for ARE development in the country. The GoP approved Policy for Development of Renewable Energy for Power Generation, 2006, in which it specified constitution of Joint Management Committee (JMC) for sale and management of CERs earn through renewable energy projects. The JMC comprise of power purchaser, power producer and AEDB.

Status of Registration of Alternative and Renewable Energy Projects with CDM (2017)

CDM (Clean Development Mechanism) is one of the instruments that developers of the Alternative and Renewable Energy (ARE) Projects pursue and earn financial returns by getting their projects registered with CDM Executive Board and selling the accrued Certified Emission Reduction certificates in the international carbon market.

The sponsors of ARE projects in Pakistan also have been looking at this option. 18 RE projects have been registered for 1.3 million CERs annually, and 29 RE projects are in process of registration for 1.6 million CERs annually. Current Market price of one CER is below USD 1; however, it is expected to increase as the developed countries are going to re-affirm their commitments to take target to reduce emissions in COP-21 (to be held in Paris in Oct 2015). To avail max benefits from new market situations, the investors are endeavoring to register their projects with CDM. The details of the ARE projects who have started process for CDM registration are as follows:

Projects Registered with CDM				
Sr. No.	**RE Resource**	**No. of Registered Projects**	**Cumulative Capacity of Registered Projects (MW)**	**No. of Approved CERs**
1	Wind Power	8	405.9	709287
2	Biomass/Waste to Energy	8	190	550000
3	Small / Mini / Micro Hydro	1	15	76000
4	Solar Power	1	50	33000
Projects In Process of Registered with CDM				
Sr. No.	**RE Resource**	**No. of Projects**	**Cumulative Capacity of Registered Projects (MW)**	**No. of Claimed CERs**
1	Wind Power	10	528	929280
2	Biomass/Waste to Energy	4	88	254737
3	Small / Mini / Micro Hydro	12	116.8	591787
4	Solar Power	3	125	82500

1. **Wind Power**

Till to date 18 wind power projects are in advanced stage of CDM registration process. 8 projects of 50 MW each have been registered with CDM Executive Board. Aggregate number of approved CERs from these projects is 709,287. Significant factor about these projects is that these are registered by the end of 2012 which allows them to sell their CERs in European Union market.

2. **Solar Power**

M/s DACC Power Generation (Pvt.) Ltd. has got registered Program of Activities (PoA) for Solar Power Projects in Pakistan. The PoA was registered on 24/12/2012

has the lifetime from 01/08/2012 to 31/07/2040. First project of the PoA was registered on 24/12/2012 with approved CERs number 32,070 having crediting period between 24/12/2012-23/12/2012. The PoA allows upcoming solar power projects to get integrated with it and earn the benefits like prompt registration and inclusion in the list of projects registered by 2012. The sponsors of solar power projects are encouraged to start CDM process and are being offered to register their projects with solar PoA of DACC.

3. **Small / Mini / Micro Hydro**

Agha Khan Rural Support Programme got registered their CDM project for community Based Renewable Energy Development in the Northern Areas and Chitral (NAC), Pakistan (103 Micro Hydro Turbine sites with 15 MW capacity). The approved number of CERs for the project are 76,017. The project was registered for crediting period between 01/01/08 – 21/12/13

4. **Biomass/Waste to Energy**

08 projects have so far been registered with CDM Executive Board for various biomass / waste to energy applications which include generation of electricity from bagasse and biomass, composting of solid waste and replacing conventional fuel with biomass. A total of 553,825 CERs have been approved for these projects.

There are a number of ARE projects that are pursuing development of projects under CDM. They are at preliminary stages of completing procedural requirements in this regard.

Checklist of Investors to initiate developing clean energy project

CDM screening methodology for ARE project developers

Step 1: Clarification of scale of the project activity
Step 2: Clarification of design of project activity
Step 3: Selection of UNFCCC Methodology
Step 4: Assessment of CERs potential
Step 5: Clarification of Crediting periods
Step 6: Clarification of potential for recovery of transaction costs
Step 7: Sustainability Check
Step 8: Additionality Check
Step 9: Management decision to go ahead or not
Step 10: If management decides for go ahead then issue Prior Consideration Note to Climate Change Division and onward communication to CDM-Executive Board.

Why does atmospheric carbon dioxide matter?

Carbon dioxide is a greenhouse gas, meaning that it traps the heat of the sun. For this reason, an increase in atmospheric carbon dioxide means an increase in global temperatures. The amount of carbon dioxide in the atmosphere varies naturally. The amount of atmospheric carbon has increased as a result of human

activity, as fossil carbon – that is, oil, coal and natural gas – has been burned to produce energy. We have released carbon dioxide that would otherwise have remained stored forever. In so doing, we have facilitated global warming.

How do we know this? The amount of atmospheric carbon dioxide is measured continuously. Carbon dioxide contents from hundreds, thousands and even millions of years ago have been estimated based on seabed sediments and plant fossils.

The size of the carbon sinks that forests create varies by season and year. Trees serve as carbon sinks during the growing season. If the autumn is warm, the forests are a source of carbon: the soil decomposes, but the growth has already stopped for the year.

The availability of the light, heat and water needed by trees varies, which is why forests store different amounts of carbon in different years. A warm, sufficiently rainy summer spurs forest growth, and the carbon sink is considerable. During a dry summer, growth and the carbon sink are more modest.

During an intense growth period, trees store more carbon than older forests, where growth is slower. Above all, old forests serve as carbon storage. Active forest management has increased the size of Finnish carbon sinks, as Finnish forests on average are younger and grow better than before, as well as increasing the amount of carbon storage, as there are more trees in the forests than a hundred years ago, for example. The trees are sturdier and grow more densely.

At the same time, forests have been used as a source of raw material, and wood has been processed to manufacture various products. These products have been used to replace products containing fossil carbon and reduce fossil carbon dioxide emissions. This phenomenon is known as the substitution effect.

Forests as Store house of Carbon

The World's Largest **Carbon Storehouse**. **Carbon** sinks are **forests**, oceans, or other natural locations that have the ability to absorb **carbon** from the atmosphere. The peat contains slowly decaying plants, or vegetation, that have been accumulating for over 10,000 years.

With regard to forests, the term "**carbon sink**" means that a forest stores more carbon dioxide than it releases into the atmosphere. But why is all of Europe so interested in this basic biological phenomenon at the moment Carbon dioxide is a vital gas. It is necessary for photosynthesis: plants use sunlight to turn water and carbon dioxide into oxygen and a sugar called glucose. Trees turn glucose into other substances, such as cellulose. Trees take in carbon dioxide from the air and store it as carbon.

Carbon dioxide is created when carbon-containing substances are burned or when they decompose in other ways. Breathing also generates carbon dioxide. According to a popular saying, "Forests are the lungs of the earth". This is actually

incorrect, as forests produce oxygen, whereas the lungs generate carbon dioxide. Nevertheless, plants that produce oxygen are vital to life.

As trees grow, they store carbon in their trunks, branches, roots and leaves. Plant litter stores carbon in the soil. Carbon is released back into the air as carbon dioxide when wood and plant litter decompose. When wood is being used, the carbon is stored or released, depending on what is being made from the wood. A wooden house provides long-term carbon storage, whereas a piece of firewood or a newspaper stores carbon only for a short period of time. Wooden products can be burned to produce energy or recycled. Pulp processes also generate wood-based energy as a by-product. The Finnish forests are a carbon sink, as their growth stores more carbon than is released through their use and natural drain. Finland's growing forest assets have been helping to reduce the amount of carbon dioxide in the atmosphere for decades.

Forests Absorb Carbon Dioxide

Carbon dioxide (CO2) in the atmosphere is necessary for plants and trees to grow. Forests play a specific and important role in the global carbon cycle by absorbing carbon dioxide during photosynthesis, storing carbon above- and below ground, and producing oxygen as a by-product of photosynthesis. In the presence of increased greenhouse gases in the atmosphere, forests become even more vital by removing CO2 from the atmosphere to mitigate the effects of climate change on the environment.

In photosynthesis atmospheric CO2 is converted into sugar and cellulose and stored in the tree's wood, leaves and roots. Trees and wood are 50% carbon by weight, so growing trees in a forest accumulates carbon.

Forests have a major **role** to play in the protection of the global carbon cycle. They represent an important sink for atmospheric carbon dioxide, and conversion of **forests** to other land uses is one of the causes of the increase in atmospheric carbon dioxide concentrations.

Carbon Cycles, Sequestration, and Storage

- The role of **terrestrial ecosystems** in the **mitigation of climate change** is an important component of the Intergovernmental Panel on Climate Change (**IPCC**) Fourth Assessment.
- Foresters are aware that C sequestration in trees and soils represents only an intermediate solution, because
- sequestration potential is limited both in time and amount. However, it is nevertheless appealing to consider that
- the biosphere might immediately **absorb CO_2** at low costs perhaps as a by-product of regular forest management. This issue of International Union of Forestry Research Organizations (IUFRO) e-notes on role of forests on

carbon sequestration summarizes existing scientific information on potential C sequestration through active forest management.

- **The forest carbon** (C) pool can actively be influenced by **adapted forms of forest management** that increase forest productivity and, thereby, increase the C input to the soil, and by decreasing soil disturbances, thereby avoiding high rates of decomposition of soil organic matter (SOM). This e-note gives an overview on the known or expected effect of **silvicultural treatments** and **decisions** that lead to **additional C sequestration**.
- Vision is that of promoting "**science-based sustainable management** of the world's forest resources for **economic, environmental and social benefits**."

IUFRO believes that public policy decisions supported by sound science produce better decisions engendering greater public support and more societal benefit. Forests play a major role in the natural global carbon cycle by capturing C from the atmosphere through photosynthesis, converting that photosynthate to forest biomass, and emitting C back into the atmosphere during respiration and decomposition.

Forests and climate change

- **Forests help stabilize the climate.** They regulate ecosystems, protect biodiversity, play an integral part in the carbon cycle, support livelihoods, and can help drive sustainable growth.
- To maximize the climate benefits of forests, we must **keep more** forest landscapes intact, **manage them more sustainably**, and **restore more** of those landscapes which have been lost.
- Halting the loss and degradation of natural systems and promoting their restoration have the **potential to contribute over one-third of the total climate change mitigation** scientists say is required by 2030.
- **Restoring 350 million hectares** of degraded land in line with the Bonn Challenge could sequester up to **1.7 giga tons of carbon dioxide equivalent annually**.
    - Forests are a stabilizing force for the climate. They regulate ecosystems, protect biodiversity, play an integral part in the carbon cycle, support livelihoods, and supply goods and services that can drive sustainable growth.
    - Forests' role in climate change is two-fold. They act as both a cause and a solution for greenhouse gas emissions. Around 25% of global emissions come from the land sector, the second largest source of greenhouse gas emissions after the energy sector. About half of these (5-10 $GtCO_2e$ annually) comes from deforestation and forest degradation.

- Forests are also one of the most important solutions to addressing the effects of climate change. Approximately 2.6 billion tons of carbon dioxide, one-third of the CO_2 released from burning fossil fuels, is absorbed by forests every year. Estimates show that nearly two billion hectares of degraded land across the world – an area the size of South America – offer opportunities for restoration. Increasing and maintaining forests is, therefore, an essential solution to climate change.



Urban trees

Urban trees are the first to be noticed while considering to counter air pollution as

- **Urban trees** play multiple roles when it comes to local air pollution. While trees in general help reduce air pollution, including absorbing the greenhouse gas carbon dioxide, some species contribute to local smog by emitting volatile organic carbons (VOCs). Planting locations of individual trees and species selection make a difference in the overall pollution balance.
- **Many urban trees** help clear the air pollution, although some are better at it than others. Trees remove some of the gases in the air, including ozone, carbon monoxide, and nitrogen dioxide, by absorbing them through their stomata and on their leaf surfaces. **All trees collect carbon dioxide, which was designated as a pollutant** because of its contribution to climate change. Trees also intercept sulfur dioxide and the fine airborne particles so troubling to asthmatics.
- **Large trees** remove far more pollutants than small trees. A 30-inch-diameter tree removes about 70 times more air pollution a year than a 3-inch-diameter tree, assuming both are healthy.

- **The vegetation** plays an important positive role in atmospheric purification and air pollutants reduction.
- **The primary producers** represented by plants are an important component in biogeochemical cycles. The vegetation made exchanges with a part of the atmospheric gases by photosynthesis, respiration processes, and the final stage of litter decomposition which leads to mineralization.
- **The plants** play an important role in reducing atmospheric CO_2 content, by photosynthesis. This reduction of atmospheric CO_2 content has an important role in reducing of greenhouse gases, participating in reducing greenhouse effect and its consequences on climatic changes. The carbon stored in plants is the result of balance between carbon fixed by photosynthesis and carbon released in the atmosphere by respiration.
- **As the structure of vegetation** is more complex, the **carbon stock in plants biomass** is higher and the **period of sto**rage is longer.
- The most efficient type of vegetation in storing carbon in terms of carbon stored in plants alive is the **temperate-continental forest**; and
- in terms of carbon stored in dead organic matter are **peat lands**.
- **Trees** (also) planted to reduce the intensity of ionizing radiation and noise in different **urban and industrial areas**. The existence of vegetation in an area creates a **microclimate** where the **temperature differentials** between day and night are buffered.
- **This prevents** the occurrence of warmer temperatures which stimulate the production of volatile pollutants into the atmosphere.

Planting Trees Cannot, however, Replace Cutting Carbon Dioxide Emissions, Scientists Say



A study (December 12, 2017) argues that a singular focus on planting trees will not help in keeping global warming to well below two degrees Celsius above the pre-industrial levels. To ensure that global temperature remains under this safe limit, the signatories to the Paris Climate Accord will need to undertake aggressive mitigation measures to reduce emission of greenhouse gases.

The study titled "The limits to global-warming mitigation by terrestrial carbon removal" has been published in *Earth's Future*, a journal of the American Geophysical Union.

In a report issued by the Potsdam Institute for Climate Impact Research (PIK), Germany, Lena Boysen, the lead author of the study, has been quoted as saying, "If we continue burning coal and oil the way we do today, the amount of greenhouse gas we need to take out of the atmosphere in order to stabilize the climate will in due time be too huge to manage."

Pakistan's Need to Adapt to Climate Change

Plants suck carbon dioxide out of the atmosphere, but this low-tech terrestrial carbon dioxide removal method, the study argues, will need to be combined with high-tech carbon storage mechanisms to ensure that global temperatures stay within permissible limits.

The study analyzed the feasibility of a negative emissions approach using biomass plantations and of carbon dioxide removal using global dynamic vegetation computer simulations. Based on their results, they calculate that the number of trees that will need to be planted will be so large that they will eliminate most natural ecosystems around the world or reduce food production to dangerously low levels. The study estimates that more than a quarter of land used for agriculture

at present will have to be converted into biomass plantations. This will place global food security at risk.

“Even if we were able to use productive plants such as poplar trees or switchgrass and store 50 percent of the carbon contained in their biomass,” says Boysen in the PIK report, “the business-as-usual scenario of continued, unconstrained fossil fuel use will cause devastating environmental consequences.”

However, the study says that growing biomass in well-selected places with increased irrigation or fertilization can support climate policies of rapid and strong emission cuts to achieve climate stabilization below two degrees Celsius. “As scientists, we are looking at all possible futures, not just the positive ones,” says Wolfgang Lucht, a co-author of the study. “What happens in the worst case, a widespread disruption and failure of mitigation policies? Will plants allow us to still stabilize climate in emergency mode? The answer is: no. There is no alternative for successful mitigation. Plants can potentially play a limited – but important – role if managed well.”

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Air Quality: Issues & Challenges

Ahmad Rafay Alam

Air Quality

- Air quality is a public health issue
  - Air pollution is a public health emergency
- Take steps to clean the air around you
  - Filters/purifiers/masks
- Air quality decision involve the energy, transport, agriculture and urban development sectors
- Consistently lobby government.
  - It's either CPEC or your lungs

What is SMOG?

(Smoke + Fog)

Chronology

- **Nov 2016: First Smog**
  - LHC takes notice
- **Nov 2017: Second Smog**
  - Smog Policy 2017
  - SHEAP
  - Smog Commission
- **Nov 2018: Third Smog**
  - SC takes notice
  - Report of Smog Commission
  - Punjab Action Plan

Smog Commission Action Plan

- Low Sulphur fuels
- Adoption of Euro II Standards
- Installation of catalytic converters
- Controlling of crop and waste burning
- Building capacity to monitor and forecast
- Controlling fugitive dust
- Tree plantations
- Planned urban development
- Greening of industrial processes

Smog Commission Report

(1) Deliberations and recommendations

(a) Voluntary actions to reduce burning of agricultural residue

The Sustainable Rice Global Initiative is an association of rice businesses that have set environmental standards. These standards include a restriction on burning of crop residue for farmers that sell to the member companies. Many rice exporters from Pakistan are now supplying to these companies, and will increasingly be under scrutiny to stop burning of residue. The Mars Company of UK sells its rice with the brand of Uncle Ben's rice, and 16,000 tons of rice are imported from Pakistan each year.

WWF, which is working with the Sustainable Rice Organization, offered to assist in coordinating with the Pakistani rice exporters to voluntarily start reducing the burning of crop residue, which in October, November is mainly rice stubble. The participants stated that the Punjab Agriculture Department should also be actively involved in this initiative.

Short-Term Action: Arrange a workshop of rice exporters to adopt the principles of the Sustainable Rice Global Initiative which does not allow burning of rice stubble by source farmers.

Medium Term: Encourage appropriate farming methods, agricultural technology that discourages farmers from burning rice stubble, such as the "Happy Seeder"

Smog Policy 2017

(1) Deliberations and recommendations

(a) Voluntary actions to reduce burning of agricultural residue

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9	Controlling burning of municipal waste and crop residue	Burning of municipal waste and crop residue, which cause formation of dust clouds due to dry meteorological conditions, to be controlled. System of disposal of municipal waste to be put in place. Agriculture Department to carry out vigorous campaign for educating farmers on fertility losses suffered due to burning of crop residues and at the same time introduce alternative technologies for quick and environmentally safe disposal of crop residue such as converting it into mulch.	• Local Government Department • Agriculture Department

Sources of Air Quality

EXECUTIVE SUMMARY

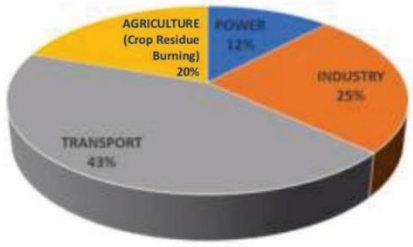
emissions from these sectors would also be occurring during the twelve months. Assuming that energy sector activities operate uniformly in a year, the total emissions are disaggregated into per month emissions. This gives the realistic comparison of sectoral air pollutant emissions and share in Punjab.

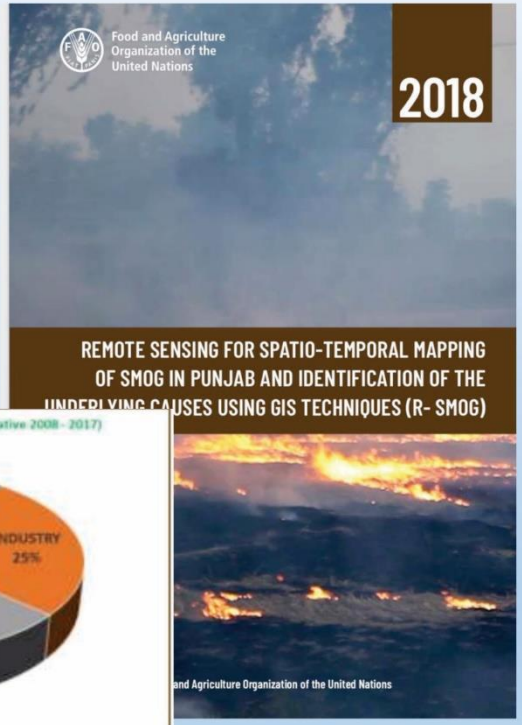
Sectoral emission Inventory for Punjab shows that the major portion of total air pollutant emissions are coming from the transport sector (269 GG) and it holds 43% share in all sectors (power, industry, transport, and crop residue burning - CRB). The second key sector responsible for air pollutant emissions in Punjab is industry whose share is 25% and amounts 154 GG. The sector at number three is agriculture (mainly considering rice residue burning). It accounts for 20% (121 GG) of total air pollutant emissions with respect to other sectors. The emissions from residue burning of other crops have not been estimated due to the fact that since smog usually happens in October and November and these two months only involves burning of rice residue. The last sector is a power which amounts 74 GG and contributes 12% in total emissions. Collectively, the main sectors responsible for air pollutant emissions in Punjab are power, industry, and transport which together hold 80% contribution in air pollutant emissions and aids in the formation of photochemical smog in Punjab. The contribution of Agriculture sector (crop residue burning) is significant to the seasonal smog phenomenon in Punjab,

2. In order to control air pollutant emissions f
transport, options available include changes i
and fuel quality better inspection and mainte
vehicles is discussed. Long run recommendat
investment in public transport to reduce aggr
consumption, shift to cleaner fuels and renew

3. For reducing crop residue burning, some of
measures could include:

Sectoral air pollutant share in Punjab - OCT. NOV. - (Cumulative 2008 - 2017)





PEQS for Ambient Air

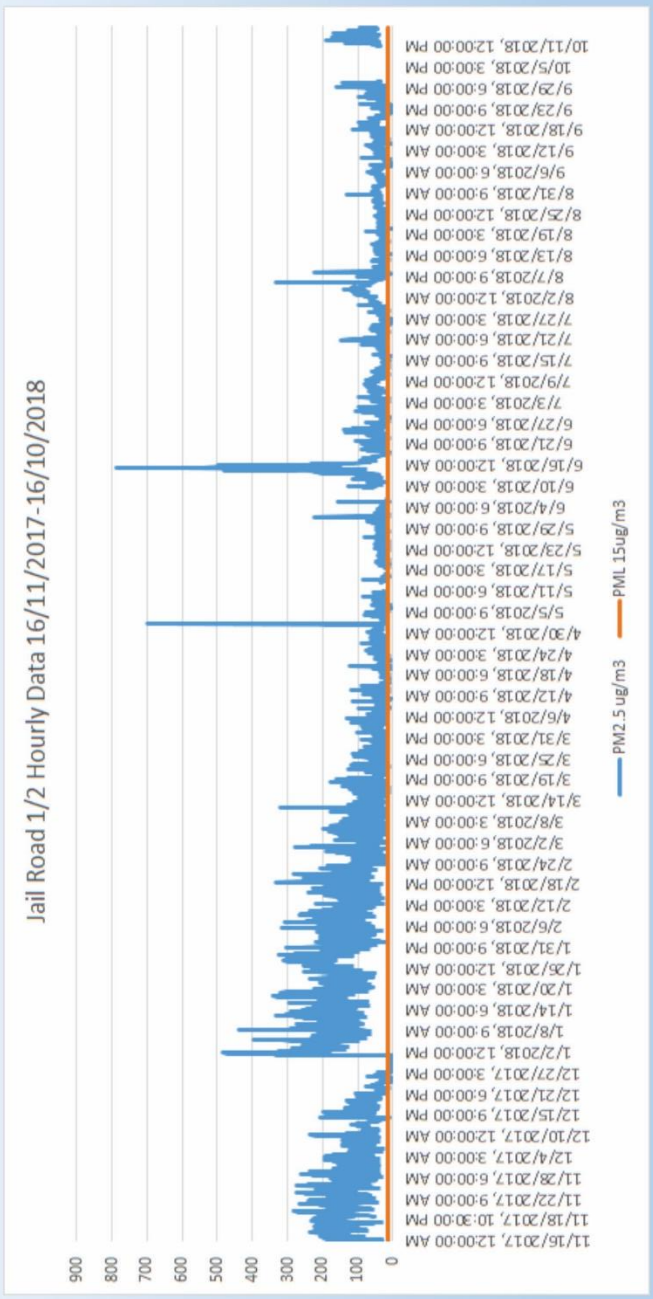
Government of the Punjab
Environment Protection Department

NOTIFICATION: No. SO(G)/EPD/7-26/2013. – In exercise of the powers conferred under clause (c) of sub-section (1) of section 4 of the Punjab Environmental Protection Act, 1997 (XXXIV of 1997), Environmental Protection Council has approved the following as the Punjab Environmental Quality Standards for Ambient Air:

Punjab Environmental Quality Standards for Ambient Air

Pollutant	Time-weighted average	Concentration in Ambient Air	Method of measurement
Sulfur Dioxide (SO_2)	Annual Average*	80 µg/m³	Ultraviolet Fluorescence method
	24 hours**	120 µg/m³	
Oxides of Nitrogen as (NO)	Annual Average*	40 µg/m³	Gas Phase Chemiluminescence
	24 hours**	40 µg/m³	
Oxides of Nitrogen as (NO_2)	Annual Average*	40 µg/m³	Gas Phase Chemiluminescence
	24 hours**	80 µg/m³	

Respirable Particulate Matter $PM_{2.5}$	Annual Average*	15µg/m³
	24 hours**	35µg/m³


Jail Road 1/2 Hourly Data 16/11/2017-16/10/2018
PM2.5 ug/m3
PML 15ug/m3
0
100
200
300
400
500
600
700
800
900
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9/29/2018, 6:00:00 PM
10/5/2018, 3:00:00 PM
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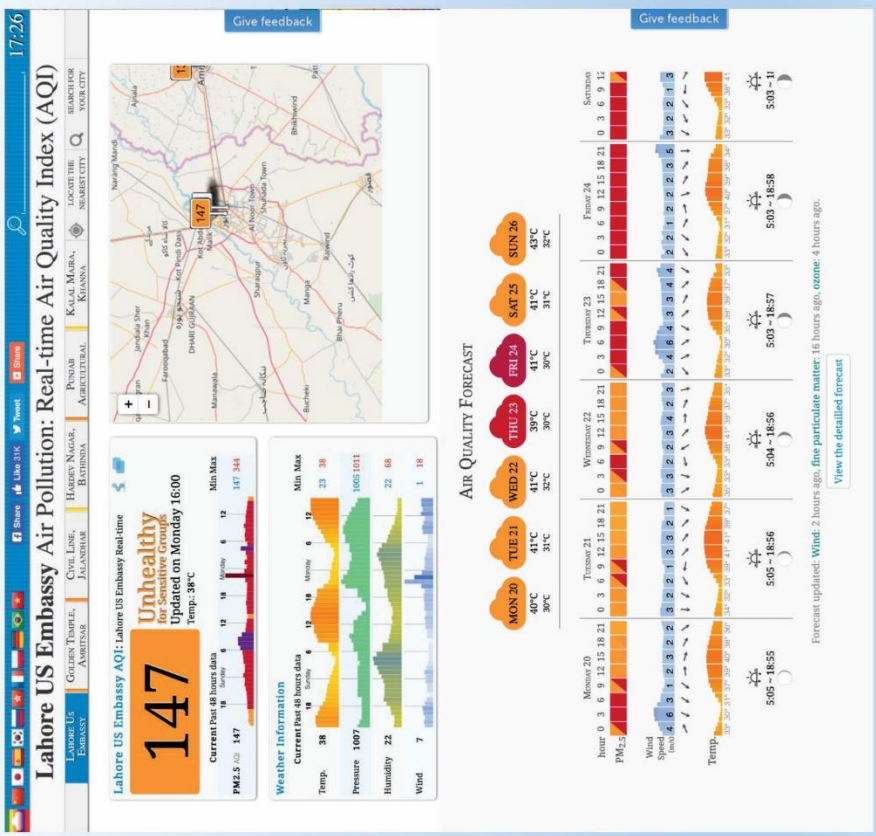
Air Quality Index

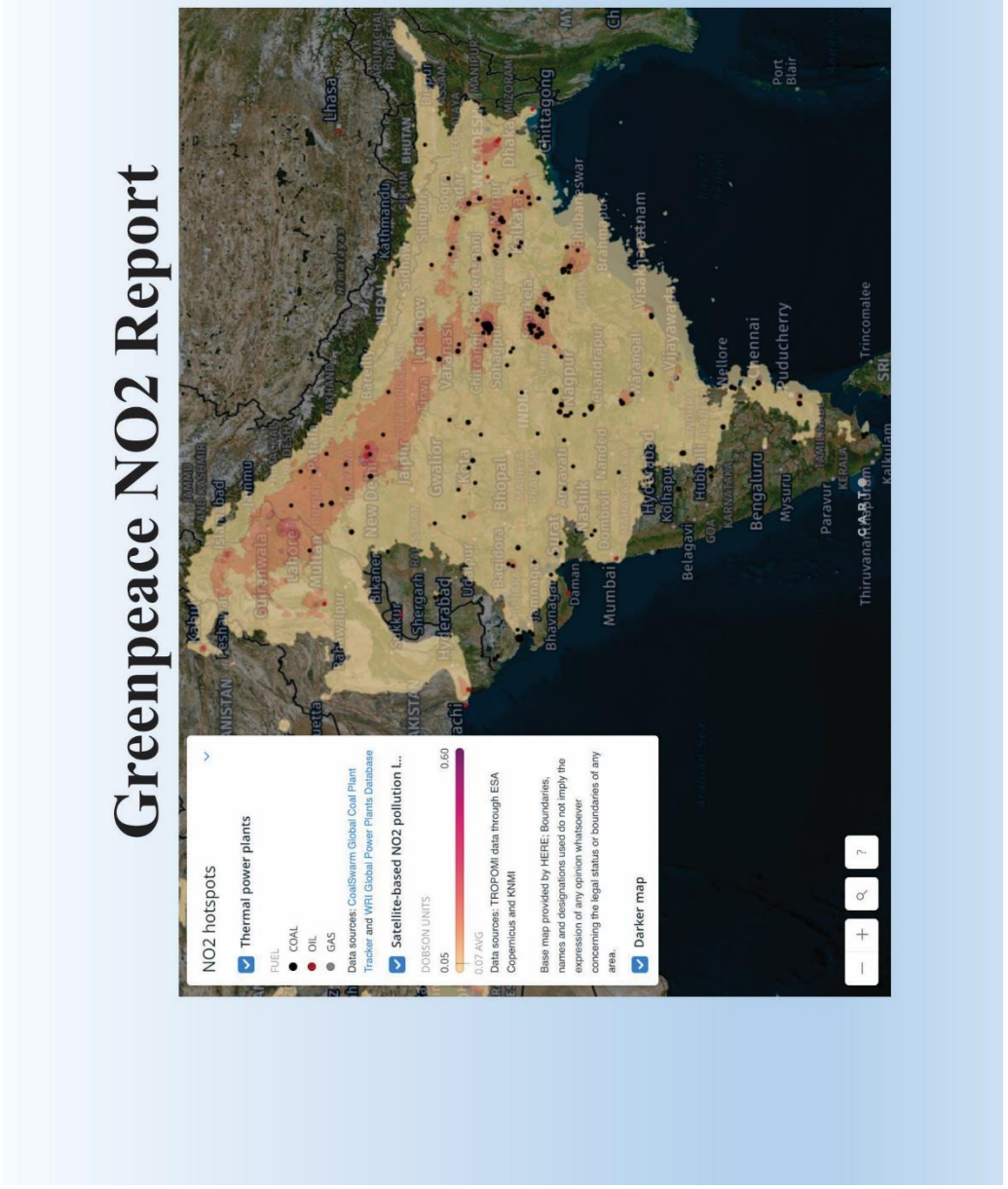
Air Quality Index will be calculated based upon 24 hourly/8 hourly average concentration of those ambient air quality criteria pollutants' concentrations whose measured values are available through Ambient Air Quality Monitoring Stations (AQMSs) namely PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO and O_3. The basis of Ambient Air Quality Index (AQI) are limit values defined in Punjab Environmental Quality Standards for Ambient Air. Beyond limit interpretations have been proposed keeping in view the regional practice of assigning Air Quality Indices based on multiplication factors in proportion to standard limits and individual tolerance levels. Intermediate values for Air Quality Index for specific pollutant will be computed by interpolation.

PM_{10}[1]	$PM_{2.5}$[2]	SO_2[3]	NO_2[3]	O_3[3]	CO[4]	Air Quality Index	Indicator Color	Overall Description
0-150	0-35	0-120	0-80	0-130	0-5	0-100	Green	**Good**– Minimal Impact
151-200	36-70	121-240	80-160	131-260	5-10	101-200	Light Green	**Satisfactory**– May cause minor breathing discomfort to sensitive people.
201-250	71-105	241-360	161-320	261-450	11-25	200-300	Yellow	**Moderately Polluted**– May cause breathing discomfort to people with lung disease such as asthma, and discomfort to people with heart disease, children and older adults.
251-350	106-140	361-700	321-560	451-550	26-40	301-400	Orange	**Poor**– May cause breathing discomfort to people on prolonged exposure, and discomfort to people with heart disease.
351-430	141-300	701-1600	561-800	551-1900	41-50	401-500	Red	**Very Poor**– May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases.
430 +	300 +	1600 +	800 +	1900 +	50 +	500+	Maroon	**Severe**– May cause respiratory impact even on healthy people, and serious health impacts on people with lung/heart disease. The health impacts may be experienced even during light physical activity.

…tement (for PM2.5)

Level			
0 - 50	Good	Air quality is considered satisfactory, and air pollution poses little or no risk	None
51 -100	Moderate	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.	Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion.
101-150	Unhealthy for Sensitive Groups	Members of sensitive groups may experience health effects. The general public is not likely to be affected.	Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion.
151-200	Unhealthy	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects	Active children and adults, and people with respiratory disease, such as asthma, should avoid prolonged outdoor exertion; everyone else, especially children, should limit prolonged outdoor exertion
201-300	Very Unhealthy	Health warnings of emergency conditions. The entire population is more likely to be affected.	Active children and adults, and people with respiratory disease, such as asthma, should avoid all outdoor exertion; everyone else, especially children, should limit outdoor exertion.
300+	Hazardous	Health alert: everyone may experience more serious health effects	Everyone should avoid all outdoor exertion


Lahore US Embassy Air Pollution: Real-time Air Quality Index (AQI)
Lahore US Embassy AQI: Lahore US Embassy Real-time
147
Unhealthy
for Sensitive Groups
Updated on Monday 16:00
Temp.: 38°C
Weather Information
Give feedback
Air Quality Forecast
MON 20
TUE 21
WED 22
THU 23
FRI 24
SAT 25
SUN 26
Forecast updated: Wind: 2 hours ago, fine particulate matter: 16 hours ago, ozone: 4 hours ago.
View the detailed forecast


Greenpeace NO2 Report
NO2 hotspots
Thermal power plants
FUEL
COAL
OIL
GAS
Data sources: CoalSwarm Global Coal Plant Tracker and WRI Global Power Plants Database
Satellite-based NO2 pollution l...
DOBSON UNITS
0.05
0.60
0.07 AVG
Data sources: TROPOMI data through ESA Copernicus and KNMI
Base map provided by HERE; Boundaries, names and designations used do not imply the expression of any opinion whatsoever concerning the legal status or boundaries of any area.
Darker map
Lhasa
Kathmandu
Chittagong
Port Blair
Mumbai
Bengaluru
Mysuru
Chennai
Puducherry
Nellore
Trincomalee
Thiruvananthapuram
Kakkulam
Paravur
Belagavi
Kolhapur
Nagpur
Bhopal
Gwalior
Jaipur
Lucknow
Varanasi
Visakhapatnam
Vijayawada
Hyderabad
Sharjah
Bhavnagar
Surat
Nashik
Daman
Aurangabad
Nanded
Bhiwandi
Solapur
Gulbarga
Ujjain
Indore
Jabalpur
Raipur
Sambalpur
Rourkela
Bhubaneswar
Brahmapur
Warangal
Ajmer
Bikaner
Jodhpur
Udaipur
Ahmedabad
Vadodara
Rajkot
Jamnagar
Bhuj
Kota
Agra
Meerut
Delhi
Chandigarh
Amritsar
Ludhiana
Jalandhar
Lahore
Multan
Faisalabad
Gujranwala
Rawalpindi
Peshawar
Islamabad
Karachi
Hyderabad
Sukkur
Quetta
Dhaka
Sylhet
Rajshahi
Khulna
Barisal
Rangpur
Siliguri
Guwahati
Shillong
Imphal
Aizawl
Agartala
Kohima
Itanagar
Dibrugarh
Jorhat
Tezpur
Kaziranga
Thimphu
Paro
Kathmandu
Pokhara
Biratnagar
Nepalgunj
Dharamsala
Shimla
Manali
Srinagar
Leh
Jammu
Kargil
Gilgit
Skardu
Mansarovar
Kailash
Yarlung Tsangpo
Brahmaputra
Ganges
Indus
Narmada
Godavari
Krishna
Kaveri
Tapti
Mahanadi
Brahmani
Subarnarekha
Damodar
Sabarmati
Mahi
Luni
Chambal
Betwa
Ken
Son
Tungabhadra
Bhima
Pranhita
Wardha
Penganga
Manjira
Musi
Palar
Ponnaiyar
Vaigai
Periyar
Bharathapuzha
Chalakudy
Kallada
Pamba
Meenachil
Achankovil
Vembanad
Kochi
Kozhikode
Kannur
Mangalore
Udupi
Karwar
Panaji
Ratnagiri
Alibag
Thane
Navi Mumbai
Pune
Satara
Sangli
Kolhapur
Ahmednagar
Aurangabad
Jalna
Parbhani
Latur
Osmanabad
Beed
Nanded
Yavatmal
Akola
Amravati
Buldhana
Washim
Hingoli
Nizamabad
Karimnagar
Warangal
Khammam
Nalgonda
Mahbubnagar
Rangareddy
Medak
Sangareddy
Vikarabad
Kurnool
Nandyal
Anantapur
Kadapa
Tirupati
Chittoor
Nellore
Ongole
Guntur
Vijayawada
Eluru
Kakinada
Rajahmundry
Visakhapatnam
Vizianagaram
Srikakulam
Berhampur
Cuttack
Bhubaneswar
Puri
Sambalpur
Jharsuguda
Rourkela
Sundargarh
Angul
Talcher
Dhenkanal
Keonjhar
Baripada
Balasore
Bhadrak
Kendrapara
Jagatsinghpur
Paradip
Haldia
Kolkata
Howrah
Hooghly
Durgapur
Asansol
Burdwan
Bardhaman
Midnapore
Kharagpur
Purulia
Bankura
Birbhum
Murshidabad
Nadia
Malda
Dinajpur
Jalpaiguri
Cooch Behar
Darjeeling
Kalimpong
Gangtok
Namchi
Pelling
Tawang
Bomdila
Ziro
Pasighat
Tezu
Roing
Along
Daporijo
Aalo
Yingkiong
Mechuka
Kimin
Seppa
Pakke Kessang
Bameng
Dirang
Tenga
Shergaon
Rupa
Jang
Tuting
Yonggyap
Mayudia
Kibithoo
Walong
Hayuliang
Chowkham
Namsai
Tinsukia
Dibrugarh
Sivasagar
Jorhat
Golaghat
Kaziranga
Nagaon
Tezpur
Mangaldai
Barpeta
Nalbari
Rangia
Goalpara
Dhubri
Kokrajhar
Bongaigaon
Guwahati
Shillong
Tura
Williamnagar
Nongpoh
Jowai
Nongstoin
Mawlai
Cherrapunji
Dawki
Mawsynram
Imphal
Moreh
Ukhrul
Tamenglong
Churachandpur
Kangpokpi
Thoubal
Bishnupur
Aizawl
Lunglei
Champhai
Serchhip
Kolasib
Mamit
Saiha
Agartala
Udaipur
Kailashahar
Dharmanagar
Kumarghat
Belonia
Sabroom
Kohima
Dimapur
Mokokchung
Wokha
Zunheboto
Tuensang
Mon
Longleng
Kiphire
Phek
Tseminyu
Peren
Jalukie
Tamlu
Khonsa
Changlang
Miao
Namsai
Roing
Tezu
Pasighat
Aalo
Daporijo
Along
Yingkiong
Mechuka
Kimin
Seppa
Pakke Kessang
Bameng
Dirang
Tenga
Shergaon
Rupa
Jang
Tuting
Yonggyap
Mayudia
Kibithoo
Walong
Hayuliang
Chowkham
Namsai
Tinsukia
Dibrugarh
Sivasagar
Jorhat
Golaghat
Kaziranga
Nagaon
Tezpur
Mangaldai
Barpeta
Nalbari
Rangia
Goalpara
Dhubri
Kokrajhar
Bongaigaon
Guwahati
Shillong
Tura
Williamnagar
Nongpoh
Jowai
Nongstoin
Mawlai
Cherrapunji
Dawki
Mawsynram
Imphal
Moreh
Ukhrul
Tamenglong
Churachandpur
Kangpokpi
Thoubal
Bishnupur
Aizawl
Lunglei
Champhai
Serchhip
Kolasib
Mamit
Saiha
Agartala
Udaipur
Kailashahar
Dharmanagar
Kumarghat
Belonia
Sabroom
Kohima
Dimapur
Mokokchung
Wokha
Zunheboto
Tuensang
Mon
Longleng
Kiphire
Phek
Tseminyu
Peren
Jalukie
Tamlu
Khonsa
Changlang
Miao


Moving the Debate Forward
NO2 hotspots
Islamabad
Rawalpindi
Gujranwala
Lahore
Faisalabad
Jhang City
Sargodha
Peshawar
Kohat
Mianwali
Sahiwal
Gujrat
Jhelum
Chakwal
Attock
Mandhar
Budhai
Nowshera
Hafizabad
Kamoke
Murdike
Kasur
Chiniot
Jaranwala
Kot Rajput
Dera Ismail Khan
Bhakkar
Lakki
Bannu
Tangmarg

Climate change: Warming threatens Himalayan glaciers

By Matt McGrath
Environment correspondent

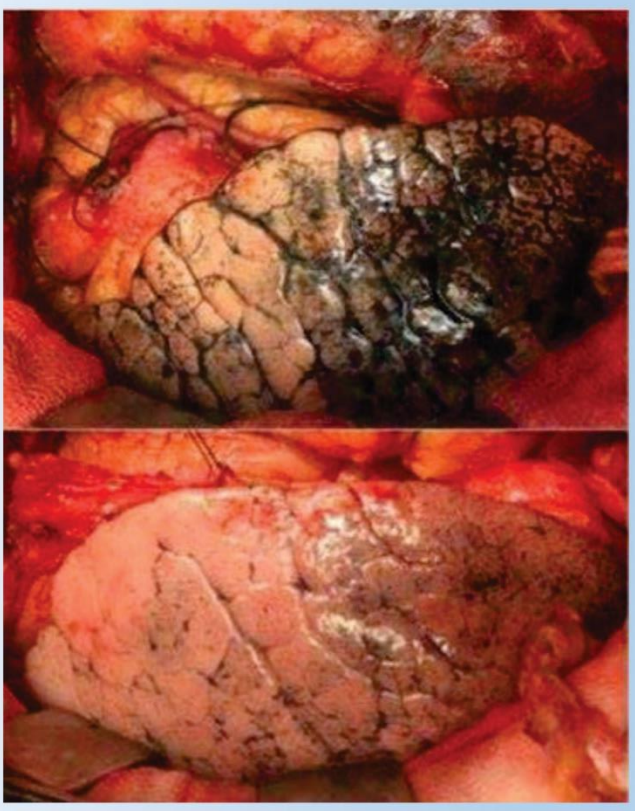
4 February 2019 Share



Climate change poses a growing threat to the glaciers found in the Hindu Kush and Himalayan mountain ranges, according to a new report.

The study found that if CO2 emissions are not cut rapidly, two thirds of these giant ice fields could disappear.

How Bad is it?



The number of children presenting with hyperactive airway disease to Pediatric Pulmonology OPD has grossly increased over the last 10 years (Figure 3). As per a verbal information taken from a popular pharmacy chain of Lahore, the sale of domestic nebulizers has increased 6-7 folds over the last 5 years. Similarly the use of bronchodilators, nebulizing prescriptions, cough syrups has also grossly increased.

NO. OF PATIENTS WITH ASTHMA PRESENTING TO PEDIATRIC PULMONOLOGY DEPARTMENT, (Figure 3)

NO. OF ADMISSIONS WITH PNEUMONIA IN CH& ICH IN 2018 (Figure 6)

In short, respiratory illnesses are constantly on the rise with increase in pollution in Lahore and they contribute to about 25% indoor admissions in medical units of CH& ICH every year. (Figure 8)

Govt ponders over electric cars to fight pollution

The Newspaper's Staff Reporter | Updated May 18, 2019



Islamabad: Prime Minister Imran Khan chairs the meeting.—PPI

ISLAMABAD: Prime Minister Imran Khan on Friday chaired a meeting on climate change and decided to introduce electric cars by setting up electric car plants for the first time in the country.

PM considering proposal to allow low-grade petrol for motorcycles

Khaleeq Kiani | Updated May 21, 2019



The government is considering introducing special low-grade petrol for motorbikes in the country, apparently as a solution to allow obsolete refineries to continue operations and provide a cheaper option to the owners of two-wheelers as oil prices increase. — APP/File

Listing of Papers Presented at Various World Environment Day(s), Commemorated by Pakistan Engineering Congress

Sr. No.	Title of Paper	Name of Author
	2007 – Climate Change:	
1.	Engineering options for Managing and Mitigating Climate Change	Safia Shafiq
2.	An overview of Glacier Depletion in Tibetan	Rehmatullah Jilani
3.	Plateau Climate Change and Sustainable Development	Dr. Qamar-uz-Zaman Chaudhry
4.	Glaciers- The Barometer of Climate Change	Rakhshan Roohi Arshad Ashraf Rozina Naz
5.	Climate Change and Tree-limit status: A case study based on comparison between an optimistic scenario for European mountains and a pessimistic on for Pakistan	Amin U Khan
6.	Adapting to Risks of Climate Change	Shafqat Masood
7.	Impact of Temperature Gradient With Time & Its Variation With reference To Change Of state	Engr. Shaukat Ali Awan
	2008 – Kick the Habit, Towards a Low Carbon Economy:	
8.	Clean Development Mechanism	Muhammad Ashraf
9.	Hydel Power Generation: A Low Carbon Prospect For Prosperous Pakistan	Dr. Allah Baksh Sufi, A. Dastgir and Zahid ul Haq
10.	Re-Utilization of Solid Waste Carbon Saves Economy	Muhammad Khalid Iqbal, Tahira Shafiq & Khursheed Ahmad
11.	Low Carbon Economy – A Pakistan Perspective	Muhammad Daniel Saeed Pirzada
12.	Isotipic and Chemical Characterization of Coal from Selective areas of Pakistan	A .Mashiatullah, T. Javed, R. M. Qureshi, Z. Shah, Z. Latif and Habib-ur-Rehman
13.	ENERCON and Low Carbon Economy	Asif Masood

Sr. No.	Title of Paper	Name of Author
	2009 – Your Planet Needs You-Unite to Combat Climate Change:	
14.	Social and Economic Benefits of Weather, Climate and Water Services	Dr. Qamar-uz-Zaman Chaudhry
15.	Influence of Climate Change on Upper Indus River Flows	Danial Hashmi and Dr. Muhammad Siddique
16.	Vehicular Emissions and their Impacts on Human Health in Karachi – A Case Study	Muhammad Ashiq, Ambreen Kanwal and Said Rehman
17.	Emission Inventory of Lahore – 2007	B.M. Ghauri and A.N. Khan
18.	Accountability of Chemical Industries Towards Sustainable Development	S.E Benjamin
19.	Environmental Issues Related to Water Resources Development and Integrated Water Resource Management in Pakistan	Dr. Muhammad Nawaz Bhutta
20.	E-Waste : An Impending Challenge	Muhammad Daniel Saeed Pirzada and Farkhanda Nahid Pirzada
21.	Unsafe Drinking Water and Health Hazards	Sabir Ali Bhatti and Zia Mustafa
22.	Environmental Management for Menace of Water Logging of Chashma Jhelum Link Canal in Thal Desert Area – A Case Study	Dr. Allah Bakhsh Sufi, Syed Javed Sultan and Attia Dastagir
23.	Impact of Western Economic Policies on the Planet [With Special Reference to Pakistan]	Dr. Zafar Altaf
24.	Drinking Water Quality Berween Source and Point – of – Use in Satellite Town Rawalpindi – A Case Study	Shaukat Farooq, Imran Hashmi and Sara Qaisar
25.	Drinking Water Quality in Rawalpindi / Islamabad and Adjoining Areas in 2008	Jamal A. Nasir, Birjees Mazhar Qazi, M. Salman and Alam Khatoon
26.	An Overview of Ployethylene Terephthalate Recycling in Pakistan	Dr. Zahiruddin Khan
27.	Poverty alleviation – a Challenge for Pakistan	Shahida Saleem

Sr. No.	Title of Paper	Name of Author
	2010 – Bio-Diversity Connecting with Nature – Many Species, One Planet, One Future	
28.	Deforestation – A Trample on the Moonscapes	Engr. Usman-e-Ghani
29.	River Ravi Potential, Pollution and Solutions; An Overview	Abdullah Yasar Fawad Ali Fateha Arshad Amna Iqbal Zainab Razi
30.	Wetlands in Pakistan: What is happening to them?	Dr. Abdul Aleem Chaudhry
31.	Promoting Better Management Practices An Initiative of WWF – Pakistan to reduce the ecological footprint of thirsty crops	Hammad Naqi Khan Arif H. Makhdum Zernash jamil Asad Imran A.Rasheed Bhutto Lal Khan Babar
32.	Botanical Diversity in Pakistan; Past, Present and Future	Muhammad Ibrar Shinwari, Maryum Ibrar Shinwari
33.	Biodiversity – A stable Ecosystem (A Review)	Dr. Zaheer-ud-Din Khan
34.	Biodiversity and Economic Growth	Shahida Saleem
35.	Climate Change Threats to Biodiversity in Pakistan	Dr. M. Mohsin Iqbal Arshad Ahmad Khan
36.	Future of your Fuel Tank!!!	Umarah Mubeen Zia-ul-Islam Dr. Mian Wajahat Hussain Dr. Kauser Abdullah Malik
37.	Effect on Carbon Nitrogen Ratio, Ammonia Nitrogen in food waste composting using different techniques	Muhammad Khalid Iqbal, Tahira Shafiq Sameer Ahmed Khurshied Ahmed
38.	State of Forests in Sindh as well as the Economic benefits flowing out of it	Muhammad Sadiq Mughal
	2011 – Forests-Nature at Your Services	
39.	Forest and Climate Change	Dr. Abdul Aleem Chaudhry

Sr. No.	Title of Paper	Name of Author
40.	"Moringa: A Miracle Plant of Agro-Forestry and Southern Punjab, Pakistan	Prof. Dr. M. Ashfaq, Shahzad M. Basra and Umair Ashfaq
41.	Medicinal Plant Resources for Economic Development of Rural Community in Mankial, District Swat	Iftikhar Ahmad, Prof. Dr. Nowshad Khan and Fouzia Anjum
42.	Growth and Metal Accumulation in Various Tree Species in Response to Urban Waste Water Irrigation	Muhammad Ayyoub Tanvir Dr. M. Tahir Siddiqui and Zafar Hussain
43.	Significance of Forests in Islam	Engr. Mumtaz Hussain
44.	Creating Forests Resources in Thal Desert for Combating Land Degradation	Raja Attaullah Khan
45.	An Overview of Forests in Pakistan	Engr. Saeed Iqbal Bhatti
	2012 – Green Economy-Does it Include You	
46.	Making Agricultural Economy Green: Reducing Carbon Emissions Through Improved Irrigation Management	Dr. Asad Sarwar Qureshi
47.	Participatory Irrigation Management and its Role in Green Economy	Ch. Karamat Ali and M. Rizwan Aslam
48.	Policies for Improving Water Governance for Better Livelihoods – Managing Water for Green Economy and Green Growth – South Asia Perspective	Sardar Muhammad Tariq
49.	Short Rotation Energy Plantations	Major (Retd.) Shahnawaz Badar, Dr. Muhammad Afzal and Iftikhar-ul-Hassan Farooqi
50.	Water Shortage and Vegetation	Dr. Muhammad Afzal and Iftikhar-ul-Hassan Farooqi
51.	Construction of Large and Medium Dams for Sustainable Irrigated Agriculture and Environmental Protection	Irshad Ahmad, Dr. Allah Bakhsh Sufi, Shahid Hamid and Wassay Gulrez
52.	Energy from Municipal Solid Waste in the form of Solid Waste Briquettes	Dr. Rai Niaz Ahmad, Muhammad Azhar Ali, Abdul Nasir and Altaf Hussain

Sr. No.	Title of Paper	Name of Author
53.	Desertification Control for Improvement of Environment and Sustainable Land Use of Cholistan Desert – Pakisan	Muhammad Akram and Zamir Ahmed Somro
54.	Management of Agriculture Resources in Changing Environment Prospects	Dr. Allah Bakhsh Sufi and Talib Hussain
55.	Water as Crucial and Probably Agriculture's	Lubna N. Bukhari and Zeeshan A. Bhutta
	2013 - Think-Eat-Save	
56.	A Review of Global Food Security: Production, Wastage, Shortage and Solutions	Ms. Asifa Alam, Dr. Engr. Abdullah Yasar, Dr. Amtul Bari Tabinda
57.	Population Explosion and Food Waste	Mrs. Shahida Saleem
58.	Food Security Challenges in Pakistan and Strategies to Overcome	Mr. Muhammad Zubair, Mr. Mumtaz Shah, Mr. Kashif Bashir
59.	Natural Solution to Water Pollution of River Ravi	Mr. Sohail Ali Naqvi, Mr. Ali Hasnain Sayed
60.	Global Food Loss and Waste Within Food Supply Chain (Causes and Preventions with Special Reference to Pakistan)	Ms. Tayyaba Rizvi, Dr. Riffat Saqlain, Mr. Qamber Raza
61.	Transforming Food Waste into a Valuable Resource Through Anaerobic co-digestion	Mr. Muzammil Anjum, Dr. Azeem Khalid, Mr. Tariq Mahmood
62.	Prospects and Perspectives of Precision Agriculture in Pakistan	Chaudhary Muhammad Ashraf, Hafiz Qaisar Yasin
63.	Future Food Challenges for Pakistan – Pothwar as Impending Resource for Food Security	Dr. Ghulam Nabi, Mr. Muhammad Ashraf, Mr. Muhammad Masood
64.	Impact of Water Resources Management on Agriculture and Environment with Dungi Dam in Pothwar Area	Engr. Muhammad Saeed Arain, Engr. Syed Javed Sultan, Engr. Muhammad Mumtaz

Sr. No.	Title of Paper	Name of Author
	2014 – Effects of Climate Change on small Island Developing States (SIDS) and its Mitigation	
65.	Mitigation of Adverse Impacts of Climate Change in Small Islands Developing States	Dr. Muhammad Afzal Chaudhry
66.	A Review of SIDS: Characteristics, Effect of Climate Change and its Mitigation	Sidra Siddique, Asifa Alam, Dr. Engr. Abdullah Yasar, Dr. Amtul Bari Tabinda
67.	Environmental Change Detection of Urban Land cover, Agriculture, Forest and Sea Surface Temperatures Using Satellite Data	Dr. Badar Ghauri
68.	Effects of Climate Change on small Island Developing States (SIDS) and their Mitigation	Engr. Riaz Nazir Tarar
69.	Disaster Vulnerability, Risk Reduction and Mitigation in Small Island Developing States	Saba Dar, Ali Hasnain Sayed, Sohail Ali Naqvi
70.	Vulnerability of Small Island developing States to Climate Change	M. Zia ur Rehman Hashmi, M. Munir Sheikh, M. Mohsin Iqbal, Ghazanfar Ali, Arshad M. Khan
71.	Climate Change Effects on Small Island Developing States Biodiversity and Related Issues	Dr. Abdul Aleem Chaudhry
72.	Small Island States of Indian Ocean and Impacts of Climate Change and its Mitigation	Attia Dastgir, Engr. Ishteqaq Ahmad, Dr. Muhammad Fayyaz Ahmad
73.	Environmental Ethics (A Prologue to Sustenance from Air to Oceans and from Islands to Mainlands)	Engr. Usman-e-Ghani
	2015 – Water and Sustainable Development	
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