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Smog (Air Pollution) and its link with Plate Tectonics-Climatic Emergency

[1]Rani Ummay Farwa, [1,2]Khlieeq Ul Zaman*, [1]Muhammad Awais Khan, [2]Mahmood Iqbal, [3]Jamal Khan*, [4]Khadija Batool, [1,2]Aliha

1-Department of Earth Sciences, University of Sargodha

2-School of Marine Science and Engineering, Nanjing Normal University, Nanjing, China

3-School of Environmental Science, Nanjing Normal University, Nanjing, China

4-Departmental of Environmental Science, University of Layyah

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ABSTRACT:

Globally, the continuous increase in the world's population, combined with the excessive use of pollution-causing agents such as vehicles, the burning of fossil fuels, and industrial machinery, has significantly contributed to adverse climate changes. One of the most pressing environmental challenges emerging from this situation is smog, which has become increasingly prevalent in Pakistan and its neighboring countries. Scientific studies have shown that tectonic factors can also influence the presence and concentration of smog in specific regions due to geographical and atmospheric conditions. Smog poses a severe health threat, leading to respiratory and cardiovascular issues among the population, especially in urban areas. Additionally, it has a detrimental impact on the country's economy by reducing labor productivity, increasing healthcare costs, and disrupting transportation. However, with advancements in Geographic Information System (GIS) technology, early detection and monitoring of smog have become more accurate and efficient. Promoting the use of renewable energy, encouraging green infrastructure like liquid trees, and reducing dependence on conventional vehicles are essential steps to mitigate smog and its harmful effects in the future.

Introduction

The tectonics of Pakistan is a magnificent display of the Earth's geological forces, showcasing the immense power of plate tectonics in shaping our planet's surface. From the towering peaks of the Himalayas to the vast, arid plains of Baluchistan, Pakistan's geology is a testament to the awesome forces that have shaped our planet over millions of years.

The collision of the Indian and Eurasian plates, which began around 50 million years ago, has created some of the most spectacular geological features on Earth, including the towering peaks of the Karakoram and Himalayan ranges, which are home to some of the world's highest mountains, including K2, the second-highest peak in the world (Jackson et al,1984).

Pakistan has unique topography and its climate varied with the change in topography. It lies in the temperate zone and has an arid to semi-arid, cold climate. It has four major seasons. Winter the cool one starts from December to February, and summer, the hotter one, is the spring and autumn season. Pakistan is becoming a dense, populated country day by day. With the increase in population, there has been a major effect on climate (Anjum et al, 2021). Due to different industrial pollution-causing agents, the Climate conditions of Pakistan are changing. It has not been like that it was one before. The Climate conditions of Pakistan are going worst day by day and it has become the world's fourth most polluted country (Fig. 1). The Greenhouse gases that are emitted from industrial and human usage

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machines, are the major cause of getting climate change. One of the major climate changes is the formation of smog (Raza et al, 2021).

Tectonics can play an important role in climate change by influencing the amount of carbon dioxide (CO2) in the Earth's atmosphere, which is a major driver of global warming. Tectonic processes such as volcanic activity, mountain building, and the formation of sedimentary rocks all contribute to the global carbon cycle, which controls the amount of CO2 in the atmosphere.

For example, volcanic eruptions release large amounts of CO2 and other greenhouse gases into the atmosphere, which can cause short-term spikes in global temperatures. Mountain building, on the other hand, can lead to the weathering of rocks and the release of minerals that can absorb CO2 from the atmosphere over long periods of time, which can help to mitigate the effects of global warming.

In addition, tectonic processes can also impact the Earth's climate through their effects on ocean currents and the distribution of landmasses, which can influence regional climate patterns and weather systems.

Overall, the link between tectonics and climate change is complex and multifaceted and requires a deep understanding of the Earth's geological processes and their interactions with the atmosphere and oceans. However, by studying the interactions between tectonics and climate, scientists can gain important insights into the Earth's past climate and make more accurate predictions about future climate trends.

Smog is a mixture of fog and smoke (Pollution particles), it is a mostly yellowish, grayish color that remains suspended in the atmosphere (Xie et al, 2019). Smog mostly consists of different pollutant particles mainly carbon mono oxide, Nitrogen oxide, Particulate matter, and sulfur oxide. These particulates react with sunlight to form a thick layer of greyish smog. The pollution-causing particles that emit from industries go into the atmosphere, and there it will cause air pollution ultimately letting the formation of smog by reacting with the pollutant particles in the presence of sunlight and heat (Tian et al, 2022).

Smog is one of the major concerns as it, directly and indirectly, affects human health. Moreover it causes an impact on the environment and economic conditions. The study of smog is important because it is a major public health concern, as it can cause a variety of respiratory and cardiovascular problems, especially in vulnerable populations such as children, the elderly, and people with pre-existing health conditions. By studying smog, scientists can better understand its composition, sources, and impacts on human health, which can inform public health policies and help protect people from its harmful effects. Smog can also have a range of negative environmental impacts, such as damaging crops and forests, reducing visibility, and contributing to climate change. By studying smog, scientists can gain a better understanding of its environmental impacts and develop strategies to mitigate its effects. It can also have significant economic impacts, such as reduced tourism and decreased property values in areas with poor air quality. By studying smog, policymakers, and business leaders can gain a better understanding of the economic costs of air pollution and develop strategies to minimize these impacts.

World AQI Ranking

Major City	US AQI
Delhi,India	212
Handi,Vietnam	191
Dhaka, Bangladash	191
Lahore,Pakistan	184
Mumbai,India	182
Karachi ,Pakistan	176
Khatmandu,Nepal	171

Fig. 1: Table Showing the US Air Quality Index of different countries (Source : https://www.iqair.com/air-quality-map?lat=29.9497515031&lng=69.3395793748&zoomLevel=6)

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Foot Hills of Himalayan Restriction to Smog

The foothills of the Himalayas are known to have a mitigating effect on smog and air pollution (Fig. 3). This is because the mountainous terrain and vegetation in the region act as natural barriers that help filter out pollutants from the air. In addition, the Himalayas also act as a natural boundary that restricts the flow of polluted air from the north into the Indian subcontinent.

Several studies have found that the foothills of the Himalayas have lower levels of air pollution compared to urban areas in the Indo-Gangetic plain. For example, a study published in the journal Atmospheric Environment found that the concentration of particulate matter (PM10) in the air was significantly lower in the foothills of the Himalayas compared to Delhi, which is located in the Indo-Gangetic plain (Fig. 2).

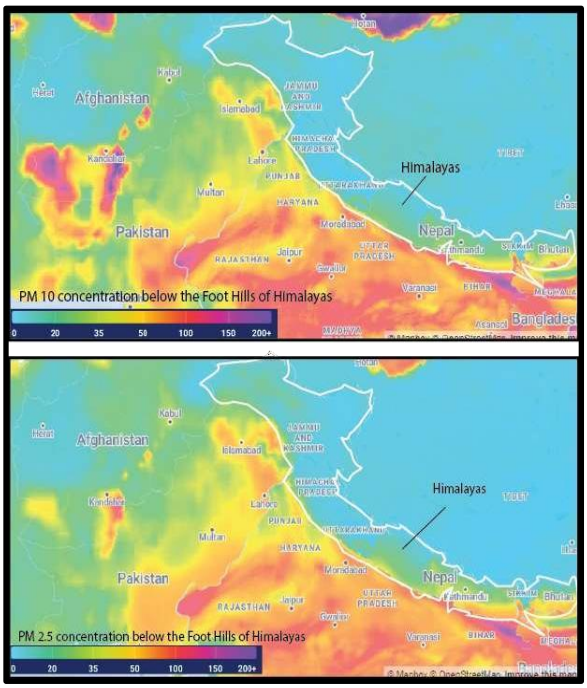

Fig. 2: Particulate Matter (PM 10 AND PM 2.5) Concentration below the foothills of the Himalayas (Source: https://air.plumelabs.com/air-quality-map)

However, it is important to note that the foothills of the Himalayas are not completely immune to air pollution. Human activities such as agriculture, transportation, and industry in the region can still contribute to air pollution. Moreover, during certain weather conditions, the natural barriers of the Himalayas may not be as effective in filtering out pollutants from the air. Therefore, efforts to reduce air pollution in the region are still necessary.

Furthermore, the foothills of the Himalayas are affected by regional weather patterns that can influence air quality. During the winter months, a phenomenon known as the "Himalayan low-pressure system" can cause stagnant air and temperature inversions, which can trap pollutants close to the ground and lead to the formation of smog.

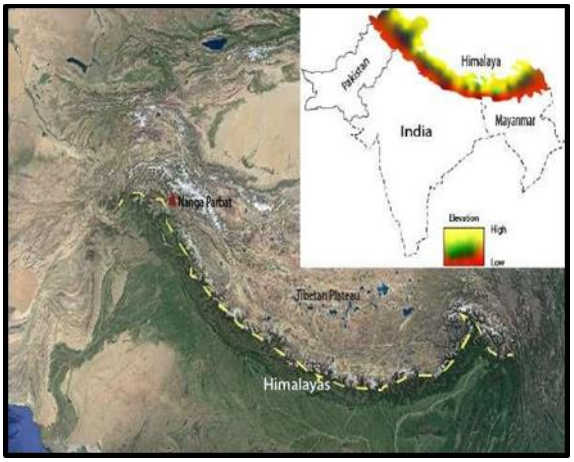

Fig. 3: Map showing Foothills of Himalaya, Source (Google Earth)

Methods

We use paper reviews, report synthesis, and adobe illustrator to digitize the maps, and we use the live satellite and NASA images to highlight the concentration of smog.

Formation of Smog

There is a certain condition that involves the formation of smog. Weather condition is one of the major factors. Although Industries discharge pollutants throughout the year when these pollutants come across a certain condition in the atmosphere they react and form smog. These certain conditions are mostly formed in winter because at that time air is thick, which captures the air pollutants and gives them time to react, while in summer, warm air blows up the pollutants. There are two types of smog, Industrial and photochemical smog (Wong, 2017). These are different from each other, as

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photochemical smog of formed due to the reaction of Particulate particles Nitrogen oxide, and hydrocarbon vapor react in the presence of sunlight, while Industrial smog is formed due to mainly one major particulate matter (sulfur) that emits from industries. It is also called sulfur smog (Fig. 4). There is a major difference between smog and fog. Fog is a compound of water droplets that is near to ground, which remain suspended because the condensation nuclei are not enough big that they fall into the ground when the size of nuclei increases slowly it falls. Smog is different from it, as it is a mixture of fog droplets and air pollutants (Zhang et al, 2023).

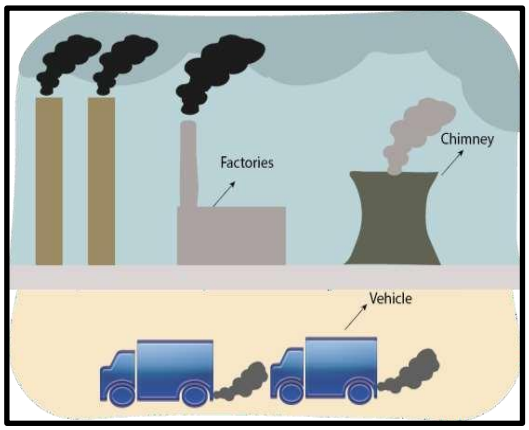

Fig. 4: Smog causing sources i.e. Vehicles, Factories and Chimney

History

In the last century, the Increase of Pollutants concentration in the air, lead to cause different climatic changes. Smog is also prevailing for years ago. Smog concentration is increasing day by day due to the increase in pollution. The First smog was even noticed in Belgium (Meuse Valley) from 1 December to 5 December 1930 (Polivka, 2018). The first extreme pollution rate is measured in the United States, (Donora, October 1948). London which is known for industrial factories, and power plants, experienced a dense fog event from 5 December to 9 December 1952. Officially reports from the government of London show that these smog events cause severe impacts on human health. These smog events still continue to increase day by day, as pollution increases (Ahlers et al, 2020).

Tectonic Subdivision of Himalayas

The Himalayan mountain range is a complex geological feature that has been formed by the collision of the Indian and Eurasian tectonic plates. The range can be subdivided into several distinct tectonic units based on their structural and geological features (Fig. 5).

***Sub-Himalaya or Siwalik Range*:**

This is the outermost range of the Himalayas, and it is composed of sedimentary rocks such as sandstone, shale, and conglomerate. The Sub-Himalaya or Siwalik Range is known for its rich fossil record of ancient animals and plants.

***Lesser Himalaya*:**

The Lesser Himalaya lies to the north of the Sub-Himalaya and is composed of metamorphic rocks such as schist, gneiss, and quartzite. It is characterized by narrow valleys, steep ridges, and high peaks.

***Greater Himalaya*:**

The Greater Himalaya is the highest and most prominent range in the Himalayas, and it is composed of igneous and metamorphic rocks such as granite, gneiss, and marble. This range includes several of the world's highest peaks, including Mount Everest.

High Himalaya Crystalline Zone:

The High Himalaya Crystalline Zone is the core of the Himalayan range and is composed of highly metamorphosed rocks such as gneiss, schist, and marble. This zone is characterized by steep slopes, glaciers, and narrow valleys.

***Tethyan Himalaya*:**

The Tethyan Himalaya lies to the south of the Greater Himalaya and is composed of sedimentary rocks such as limestone and shale. This zone is rich in fossils and is known for its geological and ecological diversity.

These tectonic subdivisions of the Himalayas are important for understanding the geological history of the region and for studying the processes that have shaped this magnificent mountain range.

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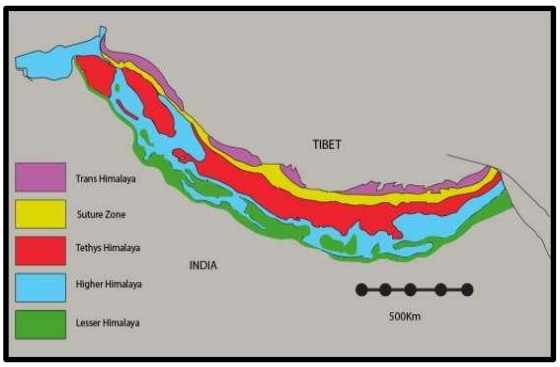

Fig. 5: Map showing tectonic subdivision of Himalaya (Modified after (modified after Sorkhabi and Macfarlane, 1999)

Tectonic Elements of Pakistan and its Link with Smog

Pakistan has a unique and fundamental tectonic setting. Understating tectonics is helpful to understand the structural features of areas. Pakistan is characterized by two active convergent boundaries. These convergent boundaries are connected by the strike-slip faults of the Chamman Transform zone (Qureshi et al, 2020). Pakistan mainly consists of five major tectonic segments (Fig. 6). These are given below:

1. Northern collision belt
2. Subduction complex associated with Ophilites
3. Chamman transform Zone
4. Ophilites Meelange
5. Indian Foreland/Punjab Platform

Northern collision belt:

It mainly started from Sargodha. It is a part of Himalayan orogeny and formed due to the collision of the Indian and the Eurasian plate. According to Yeast and Lawrence, 1984, the Northern collision belt is divided into eight zones 1. Indian platform, 2. Salt Range, 3. Kohat-Potwar plateau, 4. Hill Ranges, 5. Plio-Pleistocene Basin, 6. Southern Kohistan, 7. Nanga Parbat Massif, and 8. Karakorum block.

Subduction Complex associated with Ophiolites:

It is associated with Chamman transform zone and Makran Region in the south. Its association with the Chamman-Ornach Nal fault mainly consists of an arc trench gap and in Makran ranges association it mainly consists of thick flysch deposits. The Volcanic Plutonic arc of Chagi is the northernmost Subduction associated feature in Pakistan. It mainly consists of andesitic and volcanic rock. Makran region is bounded by an accretionary prism In Pakistan, this region is bounded by two strike-slip faults i.e. Chamman fault and Neh fault. Makran Region is an active plate margin.

Chamman Transform Zone:

It is considered to be the most important tectonic feature controlling the structural evolution in Pakistan. From north to South, Its width varies. It is 100 km wide south, narrow to 30-40 km, and then abruptly increases to 200 km in Zhob thrust. It comprises of series of faults. From its eastern margin, it is associated with the zone of ophiolites (Qasim et al, 2018).

Zone of Ophiolite:

The eastern edge of the Chamman transform zone is associated with the Zone of Ophilites. These are Zhob, Waziristan, Bela, and Muslimbagh ophiolites. Bela ophiolites are formed by oblique convergence between the Indian plate and Neo- Tethyan. Zhob ophiolites are present near Suleiman Ranges.

Platform Area:

It is an easternmost feature of Pakistan. It is a much more stable area as it is away from the active plate margins. There is no exposure to rocks here because of no volcanogenic activity.

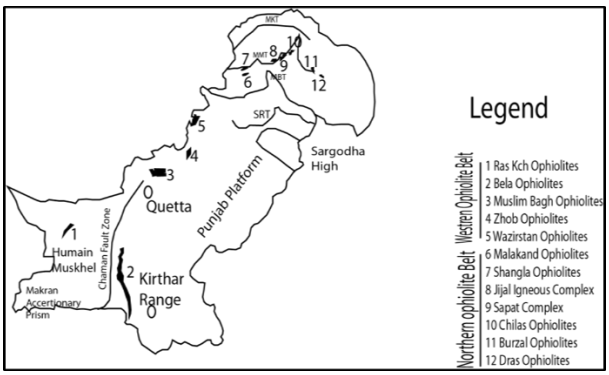

Fig. 6: Tectonic Map of Pakistan showing major Tectonic Elements of Pakistan

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Smog presence is mainly encountered below the MBT, there is not much presence of smog in the Northern Collision belt Zone. Similarly, In Platform areas, there is a much high presence of Smog (Fig. 7). It's shown that in elevated areas, smog exposure is less than in plain areas. Why did this happen? Why there is no smog in Elevated Areas? There are certain reasons, but the major and enhancing reason is the feature of elevation. Smog is mostly present in big cities as there is a number of industries there that emit pollutants and these cities are like a basin that is surrounded by mountains. Air does not move up, and these pollutant particles remain below the air, leading to the formation of smog, while in Elevated areas, there are not many industries and pollutant particles directly go up, thus there will be no time in which they react and form smog.

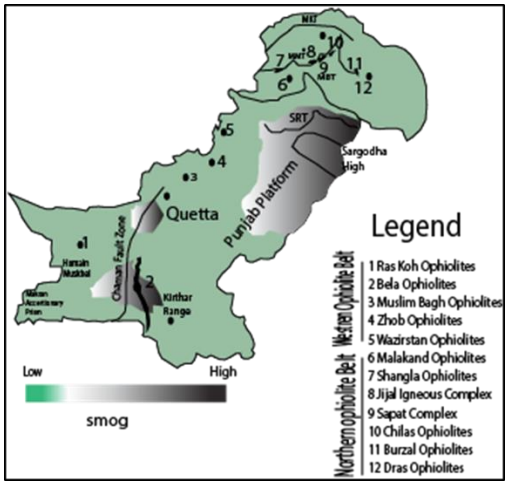

Fig. 7: Tectonic Map of Pakistan, smog pattern is mostly observed below the MBT

Smog occurrence in winters

Does smog mostly occur in winter? Why in Pakistan, big cities, in Lahore have the same condition of emitting pollutants throughout the year (Fig. 8) but during winters these pollutants are visible due to thermal Inversion (Nidzgorska-Lencewicz et al, 2020). Thermal Inversion occurs in winter when cold air act as a lid to trap pollutants near the ground. Air temperature usually falls near the elevation. There is a warm layer of air between the cooler layer, just like the sandwich, this is called Thermal Inversion. There are mainly three types of thermal Inversion that lead to the entrapment of Pollutants (Prasad et al, 2020).

Surface Inversion:

During winter nights, the earth's surface loses the temperatures very fastly the air goes up and cooler the above layer, In this way the warmer air above it is trapped between them.

Subsidence Inversion:

This mainly occurs due to high-pressure Zones. The air continuously moves downward, in this way the air close to the ground becomes cooler than the air above it.

Frontal Inversion:

Frontal Inversion occurs due to density difference. Cooler air thus denser than warmer air, replace it. Lighter warm air move upward to cooler one layer.

CITY	US AQI	Tectonic Zone
Lahore, Punjab	184	Punjab
Mirpur Khas, Sindh	182	Sindh Plain
Peshawar, KPK	182	Axial Belt
Bahawalpur, Punjab	179	Punjab
Karachi, Sindh	176	Sindh Plain
Rawalpindi, Punjab	170	Punjab
Islamabad, Islamabad	162	Potwar
Faisalabad, Punjab	158	Potwar
Abbottabad, KPK	143	Lesser Himalayan
Muridke, Punjab	73	Punjab Plain

Fig. 8: Table showing the Air Quality Index of different zones in Pakistan with its ranking

Source: (https://www.iqair.com/air-quality-map?lat=29.9497515031&lng=69.3395793748&zoomLevel=6)

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Reason for Punjab Smog

Earlier1986, Farmers in eastern Pakistan and Northwestern India Punjab used to harvest crops manually and leave the residue for weeks on land for enhancement of nutrients there, but with the increase of population and advancement in technologies, crops are harvested by machine, and the remaining residue will be burnt (Ashraf et al, 2022). This burning cause poor air quality in Punjab. This burnt smoke remains for three weeks, leading to the formation of smog. Some schools of thought said that India is the reason for Punjab smog. But it was not like that. Mideast Transboundary Pollution causing countries also lead to the formation of smog in Pakistan, Iraq, Syria, and Iran every year hit by dust storms which lead to the formation of dust clouds. This dust cloud travel to other countries. Once it reaches Pakistan it's mixed up with the Thar deserts storm, which ultimately forms smog. Moreover Burning of crops in India will also add up some pollutants, and the reason for smog formation in Punjab but the other major factors are pollution in Punjab that is emitted from industries (Muttana et al, 2021).

A Snapshot of Smog in Pakistan and the Air Quality Index

If we look at the conditions of smog in Pakistan, there are many big cities like Lahore that are covered with high-quality smog and have a bad Air Quality Index. Air Quality in the regions of Pakistan is shown in (Fig. 9).

The most common parameter to measure air quality is PM 2.5. But it has been seen that in Lahore the Particulate matter is increased up to 2.5 Lahore's air quality over to last two months is increasing rapidly (Anjum et al, 2021). In Pakistan, the residual burn in Pakistan and Industries emissions will be the cause of bad air quality. In Lahore and Karachi LANDAST, images show to have a thick layer of grey color inversion. It shows from the last century, smog concentration is increasing.

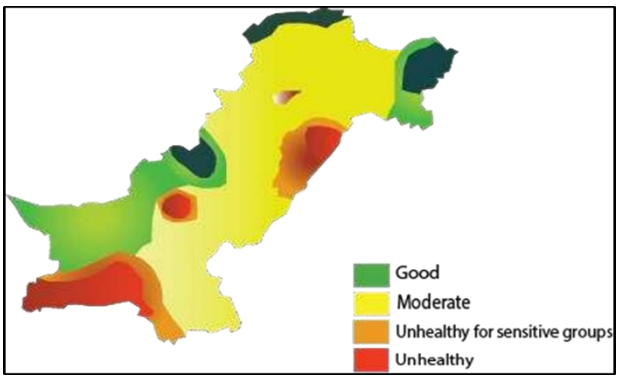

Fig. 9: Map showing Air Quality in different zones of Pakistan (Source data https://www.iqair.com/air-quality-map?lat=29.9497515031&lng=69.3395793748&zoomLevel=6)

Air Pollution prevents Rainfall

In urban and industrial areas where air pollution is high, causing many social- economic effects on humans and also causes major climatic changes. Condensation nuclei that are present in the atmosphere, combine together and precipitate in the form of rain, or snow. But when the pollutant rate is high in the atmosphere. Pollutants can't let the condensation nuclei combine, in this way it prevents rainfall.

Besides industrial pollution and forest fires, volcanic eruption, and excessive waste products construction activities are also sources of air pollutants that cause the formation of smog.

Air Quality Index in China, India, and Pakistan

There are many countries that have been fighting with climatic change and poor air quality. China has long been plagued by severe air pollution, particularly in its urban centers. In response, the Chinese government has implemented a range of measures to minimize the risk of smog and improve air quality. One key measure is the Air Quality Index (AQI), which is a system that measures the concentration of various pollutants in the air and provides a score between 0 and 500, with higher scores indicating worse air quality (Bo. et al, 2019). The AQI is widely used in China and has helped to increase public awareness of air pollution and its health impacts. China has taken many steps to

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decrease the effect of Smog. The Air Quality Index of China is much better now than other countries (Fig. 10, C). It is because of the active actions and implementations that China has been using. China developed the world's largest air purifier (Anti-Smog tower) that produces 100 cubic meters of fresh air every day. Moreover, India is also fighting against the smog impacts. The air quality there is extremely bad because of crop burning and industrial pollution (Fig. 10, A). The government of India has been taking steps to minimize the risk of smog (Naqvi et al, 2021). Air quality index in Pakistan is extremely bad in some cities but also good in many cities (Fig. 10, B).

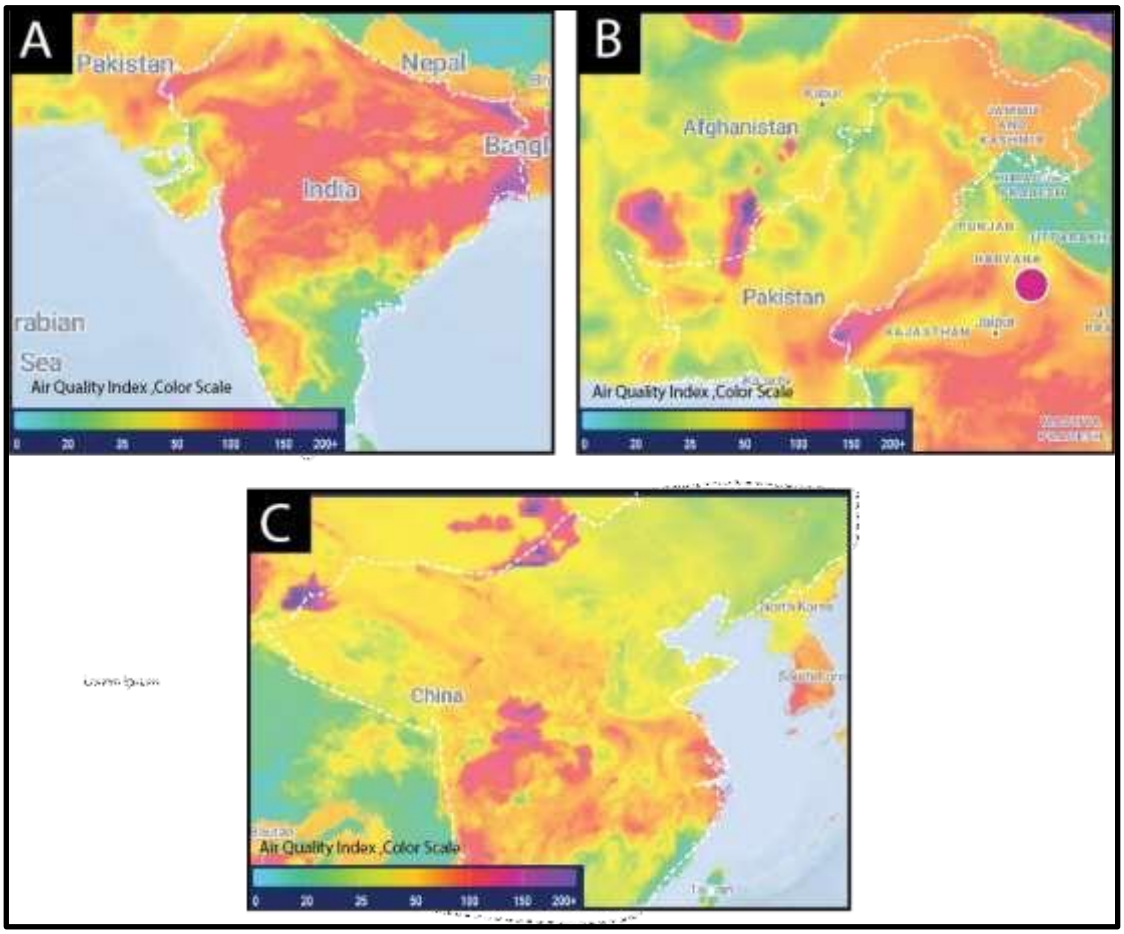

Fig. 10: Air Quality Index In different countries, A (India Air Quality Index Map), B (Pakistan Air Quality Index Map), C (China Air Quality Index Map)

Effects of Smog

Results from London smog and from past centuries' smog events show that it has both chronic and acute health effects. These results came from the air pollutant concentration and analysis. Reports show that Smog that was sustained in London in December 1952, cause cardiac, respiratory as well as chronic health issues. The current studies it's shown that due to the increase in smog concentration events, chronic health effects have been occurring in humans. It causes irritation of the eyes, coughing, Breathing difficulties, immature births, and cancer diseases (Wang et al, 2020).

GIS and Smog Detection

Fog is a natural process that mainly occurs in winter. The increase in pollution converted the fog into Smog. Through GIS, the use of satellite images, and smog detection is more accurate (Jahan et al, 2019).

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Smog detection is shown in (Fig. 11) that have been captured from different dates in Pakistan zones. This also leads to the comparison of smog concentration throughout time.

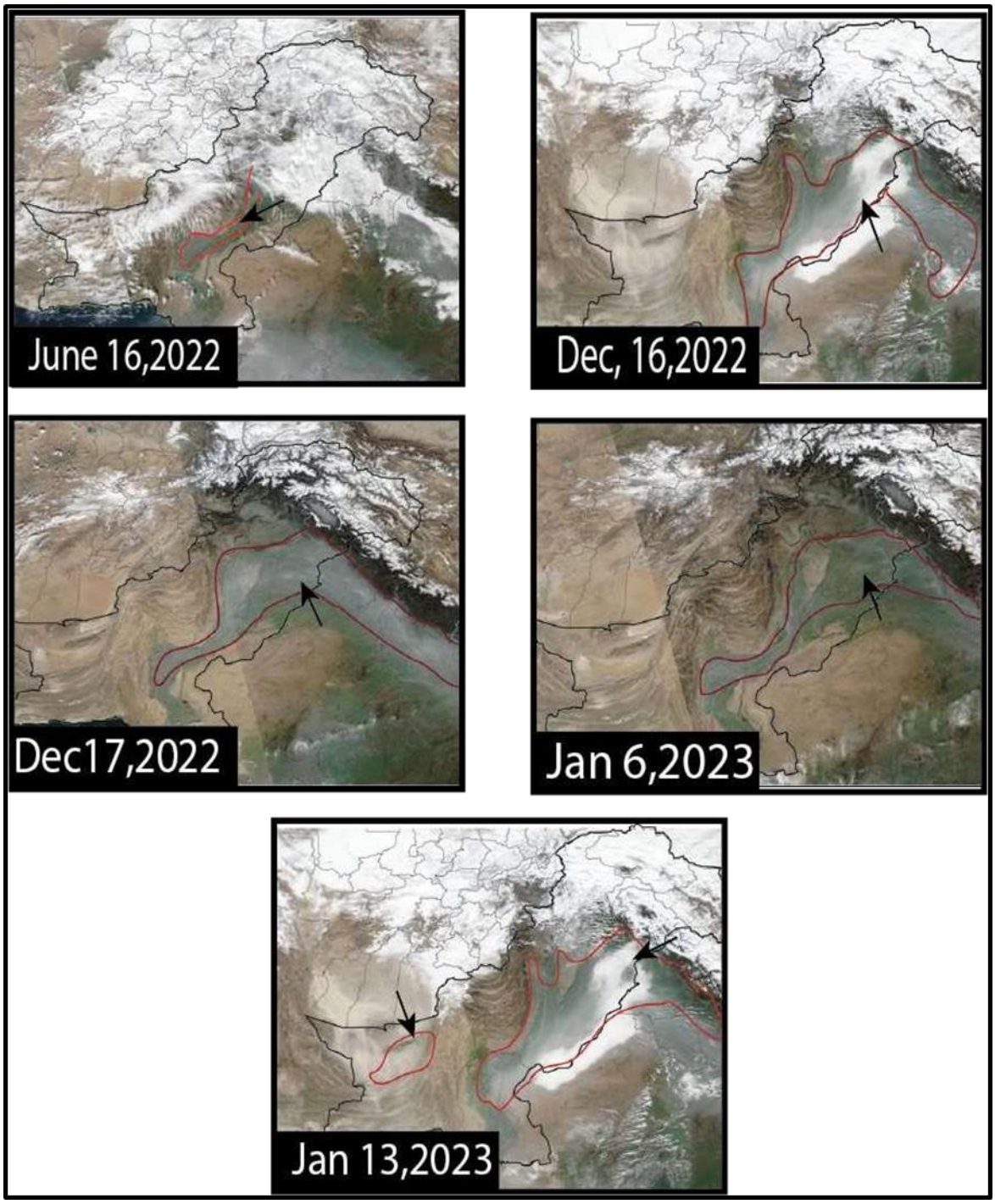

Fig. 11: Map showing the satellite photographs that have been captured on a different date to check the smog behavior. Source (NASA Images)

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Discussion

Pakistan is a developing country. The Population is increasing day by day, which require more space for living the day, for a decade humans continuously polluting the environment which lead to caused serious environmental issue and climatic change. Due to climatic change, the existence of life on Earth seems to be underground, if it continues. Smog is one of the major environmental issues that mainly occur in winter.

The more populated and plain areas are mainly covered with smog every year. Some school of thought says it is a transboundary issue, as Punjab smog is occurring due to pollution coming from India. But it's not only considered the main reason. In fact, the industrial pollution in these areas and being low-lying areas between mountains are the main reason for smog here. At elevated areas smog is almost not present there, it is because windblown up there, and pollutants less sustain there. Moreover, there is less industrial and traffic pollution in these highly elevated areas. To detect smog concentration, GIS is one of the main remedies. GIS is one of the main detection tools, to find the concentration of Smog. We should use advanced technology to remove pollution i.e. using pollution-free fuel and moving toward renewable energy resources, ultimately it leads to lessening pollution and smog. Moreover, personal protection will also protect you from the adverse effects of smog. It has been seen that during Covid air pollution quietly decrease from its range. Thus less use of pollution-causing vehicles and machines is also helpful for adverse climate change. China and other countries have been producing new technologies to fight against climate change. Stopping the Industrial Revolution is not a good step to reduce the smog effect rather than we should move toward advanced technologies that would help to minimize climate change. China developed the world's largest air purifier to minimize the risk of smog. Advanced technology has been developed recently that as Liquid Tress. This would be helpful to minimize the climate risk in urban areas where less space is available for plantation.

Conclusion

1. The adverse climate change i.e. in Pakistan is due to an increase in pollution and more use of fuels that release pollutant particles.

2. Smog is mostly seen in winter because of temperature inversion, and it has been observed that above MBT there is no smog.

3. To lessen the smog concentration we must use pollution-free fuels, moving towards the use of renewable energy resources and self-protection.

4. Moreover, stopping Industrial Revolution is not enough to reduce the smog effect. It would lead to an adverse economic condition in our country, rather than we should promote advanced technology i.e. Liquid Tress, Air purifiers

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