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Using Geographical Information Systems (GIS) to study the concentration of major air pollutants in Lahore City of Pakistan

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Dedication:

To our families

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Chapter 1:
Introduction

The atmosphere, which is surrounding the earth and providing us oxygen to breath, consists of nitrogen, oxygen, water vapour and inert gases. One of the major problems, that is arising concern among all quarters of the world, is the rapidly deteriorating atmosphere occurring due to the air pollution. Until recently, environmental pollution problems have been minor because of earth's own ability to absorb and purify minor quantities of pollution. However, due to the industrialization, the introduction of motorized vehicles, explosion of human population and the indiscriminate discharge of gases into the atmosphere by industries without considering the consequences have increased the magnitude and gravity of this problem.

Air pollutants are the substances in the atmosphere, which have harmful effects on human and biotic life. Organisms are able to deal with certain levels of pollutants without suffering ill effects. However, the pollutant level below which no ill effects are observed is called the "threshold level" (Nebel et. al., 1993).

The major sources of air pollution are power and heat generation, burning of solid wastes, industrial processes, and transportation. Bruce et al (2000) have pointed out three factors which determine the level of air pollution:-

1. Amount of the pollutant put into the air.
2. Amount of the space into which the pollutants are dispersed.
3. Mechanism that removes pollutants from the air.

1.1 Global Effects:

There are several major environmental problems such as smog, acid rain, the greenhouse effect and “holes” in the ozone layer which are the focus of the environment due to their harmful effects on the man and its environment.

Acid rain is one of the major environmental problems, which has always being the focus of the scientists. Chemical analysis of acid precipitation reveals the presence of sulphuric acid and nitric acid. In general about two-third of the acidity is due to sulphuric acid and one–third to nitric acid. Both sulphuric dioxide and nitrogen dioxide gradually react with water vapour and, through a number of steps, become acids. Precipitation becomes acidic, as it flushes these acids from the atmosphere. The pH of the precipitation depends on both the amount of acid and the amount of water. Fog and mist may be mostly acidic because the acid is disclosed in relatively little water.

Some scientists believe that inhalation of highly acidic fog particles and dry acid particles is a major source of breathing and respiratory problems (Dockery et. al., 1994; Thurston, 1991). In addition there is evidence that inhalation of such particles renders lung tissues more susceptible to the carcinogenic effects of to the pollutants.

Climate has always been affected by the human activities (Shafiq, Santos et. al., 2011). However with growth of population and their needs, such as land use and transportation the climatic conditions are being altered very rapidly in the present time. This alteration is being caused by the addition of carbon dioxide and certain other gases to the atmosphere, which causing the earth’s climate to warm resulting in rising sea levels and insecure weather changes throughout the world.

This carbon dioxide effect is also known as ‘the greenhouse effect’, because it is analogues to solar heating, which occurs in the green house or in the car when it left parked in the sea.

Sunlight enters the glasses and absorbed. As the surface became warm, they radiate energy as infrared or heat radiation. The nature of the glass is that, it is highly transparent; it tends to block the infrared radiation. Therefore the energy that enters

as light is trapped and causes the temperature to rise. The carbon dioxide acts as a heat trapper and initiates to increase the temperature level in the lower atmosphere.

On the global level, carbon dioxide in the atmosphere plays a role analogue to the glass. Light energy comes through the atmosphere. It is absorbed and converted into heat energy at the surface and exists as infrared radiation; the natural gases in the atmosphere do not. As carbon dioxide absorbs the infrared radiation, it becomes warms and thus in turn warms the rest of the atmosphere. Consequently, it follows that greater the amount of infrared that will be absorbed and the warmer will be the atmosphere. Climatologists are now in general agreement that if a doubling of carbon dioxide level to 600ppm is used as a reference point, the overall warming will be between 1.5 ^{o}C and 4.5 ^{o}C, warming in likely to be more pronounced in polar region as much as 10 ^{o}C , and less pronounced in equatorial region 1 ^{o}C – 2 ^{o}C.

Depletion of ozone shield is a serious problem in the atmosphere. Radiation from the sun includes the ultraviolet light along with visible light. Ultraviolet is like light radiation but the wavelengths are slightly shorter than violet light, which are the shortest wavelengths seen by the human eye; while ultraviolet light is not visible, the rays are more energetic than those of visible light. On penetrating the atmosphere and being absorbed by biological tissues, they actually destroy protein and DNA molecule. If the full amount of ultraviolet radiation falling on the upper atmosphere came through the earth's surface, it is doubtful if any life could survive, plants and animals alike would simply be "cooked"; even the small amount that does come through is responsible for all the sunburns and some 200,000 cases of skin cancer per year in the USA (Miller, 2000)

We are spared more damaging effects from ultraviolet rays because most of it is absorbed and thus creamed out by a layer of ozone in the stratosphere. It is commonly referred to as ozone shield. There are various man-made pollutants that are causing it to breakdown. The most significant ones are free chlorine atoms, which are highly poisonous to plants and animals (Thomas, 1984).

1.2 Air Pollution in Pakistan

Air pollution is woven throughout the fabric of our life. A by-product of the manner in which we levied our cities, air pollution is the waste remaining from the ways we produced our goods, transport our goods and ourselves and generate energy to heat and light the places where we live. In terms of Pakistan 'Environmental act 1997', the air pollution is the release of any substance like soot, smoke, dust particles, odour, light, electromagnetic radiation, heat, fumes, communication exhaust, gases, noxious gases, noxious gases, hazardous substances and radioactive substances into the atmosphere to the extent, which have adverse environmental effects or on human health and safety and property, or on biodiversity (Barker & Tingey, 1992). Impurities in fuel, poor fuel air ratio, too high or too low combustion temperature cause the main pollution in the air. Industrial resources emit air pollutants through combustion of fuel, chemical processes, manufacturing, grinding, mixing, evaporation, and drying processes (Smith, 1993). The industrial units emit following air pollutants: carbon monoxide, carbon dioxide, nitrogen dioxide, and sulphur dioxide, organic vapour, and organic compounds etc. The mobile sources (Zhou & Levy, 2007) like automobiles, diesel-powered trains, trucks, and airplanes constitute more than 40% of the five major air pollutants.

Sector	1987/88		1997/98	
	CO_2	SO_2	CO_2	SO_2
Industry	26680	423	53429	982
Transport	10250	57	18987	105
Power	11216	95	53062	996
Domestic	24050	16	3998	40
Agriculture	4490	28	6368	40
Commercial	2587	13	4261	25

Table 1.1: Patterns of major pollutants in Pakistan Source: The Pakistan National Conservation Strategy (1999), Government of Pakistan

Table 1.1 shows that carbon dioxide generation from industry is very high and has risen to about 100% in the last decade. While power generation and transportation play the second and third roles respectively in producing high levels of air pollution.

City	PM_{10}	SO_2	CO	NO_2	HC
Karachi	6175	4224	3777380	44675	90584
Lahore	3213	2218	198180	23460	47570
Islamabad	1572	1075	96090	11375	2365
Faisalabad	1344	920	82130	9722	19714
Hyderabad	1148	785	70160	8305	16841
Multan	1094	784	66880	7917	15077
Peshawar	1028	703	62815	7436	7257
Quetta	495	338	30235	3579	-

Table 1.2: Annual vehicular emission in different cities [in tons] Source: EPA

A comparative study indicates that our vehicles emit 25 times more hydrocarbons and 3.6 times more nitrous oxide than those in the US. Nitrogen dioxide present in our environment is much more than UN WHO specified limit of 0.05 ppm.

1.3 Air Pollution in Lahore City

Lahore city is highly polluted city of Pakistan. The major causes of increase in air pollution in Lahore city are industries, more traffic, and high density of population. The major pollutants for this study are sulphur dioxide, oxides of nitrogen, ozone, and particulate matter.