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Air Quality in Rural Areas

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1. Introduction

The immediate environment of man comprises of air on which depends all forms of life. Human beings need a continuous supply of air to exist. The requirement for air is relatively constant about 10-20m^3 per day (Park 2009). Air is a mechanical mixture of gases. The normal composition of external air by volume is approximately as follows Nitrogen 78.1%, Oxygen 20.93%, and Carbon dioxide 0.03%. The balance is made up of other gases which occur in traces e.g. argon, neon, krypton, xenon and helium. In addition to these gases, air also contains water vapor, traces of ammonia and suspended particulate matter such as dust bacteria, spores and vegetable debris. The external air has other compounds and elements along with the already mentioned. Air is rendered impure by a) respiration of man and animals b) decomposition of organic matter, c) combustion of coal, gas, oil etc. d) trade, traffic and manufacturing processes that give off dust, fumes vapors and gases.

Under ordinary conditions the composition of outdoor air is remarkably constant. This brought about by certain self cleansing mechanisms which operate in nature such as wind, sunlight, rain and plant life. Wind dilutes and sweeps away the impurities by its movements so that the impurities do not accumulate in any one place. Sunlight and heat oxidizes the impurities and kill the bacteria. Rain removes the suspended and gaseous impurities and the green plants utilize the carbon dioxide and generate oxygen. But when the rate of pollution becomes too high or the cleansing process becomes ineffective, the air gets polluted and it constitutes a health hazard.

Human occupancy and activity vitiate the air in the occupied rooms and gives a sense of discomfort to the occupants. Unless the vitiated in door air is replaced by the fresh air, it may adversely effect the comfort, health and the efficiency of the occupants. They may feel suffocation and complain of headache, drowsiness and inability to concentrate. There is also a risk of droplet infection and lowered resistance to diseases on prolonged exposure.

Thus the phenomenon called pollution is an inseparable consequence of the presence of man and his activities. The term air pollution signifies the presence in the ambient atmosphere of substances (e.g., gases, mixtures of gases and particulate matter) generated by the activities of man in concentrations that interfere with human health, safety or comfort, or injurious to vegetation and animals and other environmental media resulting in chemicals entering in the food chain or being present in drinking water and thereby constituting additional source of human exposure. The direct effect of air pollutants on plants, animals and soil can influence the structure and function of ecosystems, including self regulation ability, thereby affecting the quality of life (WHO 1987).

In the past, air pollution meant smoke pollution and it was limited to the urban areas. Today, air pollution has become more subtle and recognizes no geographic or political boundaries. The air pollution is one of the present day health problems throughout the world. The objective of this chapter is to highlight the public health importance of the so far neglected issue of quality of air in rural areas and to attract the attention of scientific community for further research on the subject.

2. Air quality in rural areas

Off late researchers, policy makers and governments has focused their attention on air quality in the urban areas only. Air quality in rural areas remains a neglected issue so far. The common belief is that rural areas are free from air pollution. On the contrary air quality in the rural areas all over the world and particularly in the developing countries may be more polluted than some of the urban areas. Rural areas suffer from out door air pollution as well as indoor air pollution. Major sources of out door air are indiscriminate use of insecticides/pesticides sprays and burning of wheat and paddy straw. This leads various health problems mainly affecting the respiratory and cardio-vascular system. In door air pollution exposes more people worldwide to health risks than out door air pollution. Air in big cities like Delhi in India and Xian in China, contains a daily average of 500/m^3 of total suspended particulate, whereas, smoky houses in Nepal have peak level of 10000/m^3 or more (World Bank 1993). Rural people in developing countries may receive as much as two-thirds of the global exposure to particulates. BaP the best known Poly-nuclear Aromatic Hydrocarbons (PAH) can increase to very high concentrations in door. BaP level of 6u/m3 were found in houses without chimneys in Southern China. In India BaP exposure averaged about 4u/m3 during cooking with biomass fuels (Smith et al. 1983). Owing to its carcinogenicity no safe level of PAH can be recommended. This contributes to the acute respiratory infection in the young children, chronic lung disease and cancer in adults and adverse pregnancy out comes in for pregnant women exposed during pregnancy. The third source of pollution affecting rural areas results from the transport of emissions far from their primary emission point—even continents away—and their conversion into health hazards. Some emissions such as hydrocarbons in particular, that are themselves relatively harmless, are converted to hazardous ones by sunlight and interactions with other pollutants.

3. Major air pollutants in rural areas

More than 100 substances which pollute air have been identified. They may be in the form of solids, liquids (vapors) or gases. They differ greatly from place to place depending upon the specific complex of contaminant source. They may be from natural sources or from anthropogenic sources (human activity). Whilst man-made pollution and poor air quality is major environmental concern, there are many natural sources of air pollution which are often much greater than their man-made counterparts'. Some of the important pollutants are given below.

3.1 Sulphur dioxide

It one of the several forms in which sulphur exists in the air. The main source of sulfur dioxide is the combustion of fuels containing sulfur. Fossil fuels, most notably coal and oil, contain varying amounts of sulfur according to their source but typically between 1% and 5%. On combustion, the sulfur in the fuel is converted almost quantitatively to sulfur dioxide. Sulfur is most abundant in the less volatile fractions of crude oil and hence shipping, which burns residual fuel oil, can be a very high emitter of sulfur dioxide. The sintering process used in metal smelting, which involves roasting metal sulfide ores in a stream of air, can also be a major mechanism of sulfur dioxide production. In less developed countries, however, unabated burning of coal and the use of fuel oils and automotive diesel with higher sulfur content are major sources of sulfur dioxide. Natural sources of sulphur dioxide include release from volcanoes, biological decay and forest fires. Actual amounts released from natural sources in the world are difficult to quantify. In 1983 the United Nations Environment Program estimated a figure of between 80 million and 288 million tonnes of sulphur oxides per year from natural sources compared to around 69 million tonnes from human sources world-wide. Further oxidation of SO_2, usually in the presence of a catalyst such as NO_2, forms H_2SO_4, and thus acid rain (WHO 2005).

3.2 Nitrogen oxides

In a process parallel to that of sulfur dioxide production during fuel combustion, nitrogen in fuels is converted to oxides of nitrogen in the combustion process (WHO 2010). Coal is the most important fuel in this context, as oil and gas contain much lower levels of nitrogen. However, there is a further process in which atmospheric nitrogen and oxygen are combined during high-temperature combustion to form oxides of nitrogen. This occurs in all high-temperature combustion processes and explains why road traffic and electricity generation tend to be among the predominant sources of these gases. Natural sources of nitrogen oxides include volcanoes, oceans, biological decay and lightning strikes. Estimates range between 20 million and 90 million tonnes per year nitrogen oxides released from natural sources compared to around 24 million tonnes from human sources worldwide.

3.3 Carbon monoxide

Carbon monoxide is one of the most common and widely distributed air pollutants. This is a gas formed during the incomplete combustion of carbon-containing fuels. While complete combustion leads to the formation of carbon dioxide, most combustion systems involve some fuel-rich regions in which a proportion of carbon is oxidized only to carbon monoxide. The most important example is the combustion of petrol in road vehicles. Estimates of man made carbon monoxide emission vary from 350 to 600 million tonnes per annum (WHO 1987). Some wide spread natural non-biological and biological sources have also been identified.

3.4 Ozone

Ozone is one of the strongest oxidizing agents. There are no significant anthropogenic emissions of ozone in the atmosphere. It is a secondary photochemical pollutant formed near ground level as a result of chemical reactions taking place in sunlight (Park 2009). About 10 to 15% of low level ozone, however, is transported from the upper atmosphere (called the stratosphere), where it is formed by the action of ultraviolet (UV) radiation on oxygen (the ozone layer). Atmospheric concentration of ozone has been observed higher in rural areas as compared to urban areas.

3.5 Carbonaceous particles

The particles emitted from burning fossil fuels and biomass, for example in diesel and petrol engines, are typically composed largely of carbon, both in the elemental form and as organic compounds of low volatility (WHO 2005). The elemental carbon is in the form of microcrystalline graphite formed from the build-up of carbon-containing free radicals into polycyclic aromatic structures within the flame. When these build only relatively small molecules they are emitted as polycyclic aromatic hydrocarbons, an important pollutant in their own right often associated with airborne particles (Smith et al. 1998). If larger graphite structures are created in the flame, these will be emitted as particles of elemental carbon. Such combustion systems also tend to emit hydrocarbons of low volatility, deriving for example from lubricating oils, and these will typically condense on to the carbon particles. Carbon present within organic compounds, rather than as elemental carbon, is referred to as organic carbon.

3.6 Non-carbonaceous primary particles

An important source of non-carbonaceous particles is fly ash, which comprises particles largely of mineral material freed from a fuel such as coal in a combustion source and carried into the atmosphere with the flue gases (WHO 2005). Purely mechanical processes such as quarrying can also create fragments of rock small enough to become suspended in the atmosphere and, as mentioned above, the action of the wind can suspend particles of soil and dust from land surfaces into the atmosphere. Construction and demolition activity can be an important source of coarser particles (Charron & Harrison, 2005), even in a street canyon where traffic emissions typically dominate. Natural sources of particulate matter are less important than man-made sources. These include volcanoes and dust storms. However, such sources do account for intense high particulate pollution episodes, occurring over relatively short times scales. It is not unknown for Saharan dust to be deposited in the UK after being blown thousands of miles.

3.7 Volatile organic compounds (VOCs)

VOCs comprise a very wide range of hydrocarbons, oxygenates, halogenates and other carbon compounds existing in the atmosphere in the vapour phase (WHO 2005). The predominant source is typically through leakage from pressurized systems (e.g. natural gas, methane) or evaporation of a liquid fuel such as benzene from the fuel tank of a vehicle. However, combustion of fossil fuels and incineration processes also give rise to combustion emissions containing some unburned or partially burned fuel fragments that are emitted in the form of VOC. Organic solvents, used for example in paints and adhesives, are designed to disperse in the atmosphere to allow the active ingredients to dry. VOCs are also naturally produced by plants and trees. Isoprene is a common VOC emitted by vegetation, and some believe it to be a more significant trigger for asthma, another allergic reactions than man-made irritants. Plant, grass and trees are also a source of pollen, which can act as triggers in some asthmatics. Pollen is in the air year round, but the concentration is highest during the growing season, from March to the first frosts in autumn.

4. Causes of air pollution in rural areas

Rural areas suffer from air pollution caused by both natural as well as because of human activities. Air pollution from Natural causes occurs when contaminants drawn from animals, plants and land resources get disseminated in the atmosphere in normal course. Natural pollution also results from forest fire, coal fires, volcanic eruptions, dust storms and sand storms. Natural contaminants include spores, pollens, moulds, fur, feather, hair, dander, dust, grit and other types of particulate matter. Human activities like burning solid fuel indoors and tobacco smoking apart from agriculture, mining, coal processing and cement making produce high levels of pollution.

Meteorological factors also play an important role in quality of air in rural areas. The level of atmospheric pollution at any one time depends upon meteorological factors, e.g., topography, air movements and climate. Winds help in the dispersal and dilution of pollutants. If the topography is dominated by mountains or tall buildings the winds become weak and calm and the pollutants tend to concentrate in the breathing zone. The vertical diffusion of the pollutants depends upon the temperature gradient. When there is rapid cooling of the lower layers of air (temperature inversion), there is little vertical movement of the air and the pollutants and water vapors tends remain trapped at the levels and the result is 'smog'. The temperature inversion which is more frequent during the winter months than in the spring or the summer is a threat to human health.

5. Sources of air pollution in rural areas

5.1 Natural sources

5.1.1 Air pollution from coal fires

Underground coal fires are consuming 20 to 30 million tons of coal a year, pumping tons of ash, carbon dioxide, methane, carbon monoxide and sulfur compounds into the atmosphere (Jeffrey Hays 2008). Coal produces thick, smoggy smoke. High sulphur coal is particularly nasty. It produces a rotten egg smell. Some of the fires have been burning for centuries. By one count there are 56 underground coals fires currently burning in China (Figure 1). The Coal fires produce as much carbon monoxide each year as all the cars in the United States. The underground coal fires are revealed by fumes and smoke that pour from cracks in the earth. The Wude coal field in Inner Mongolia, one of China's largest coal fields, is the home

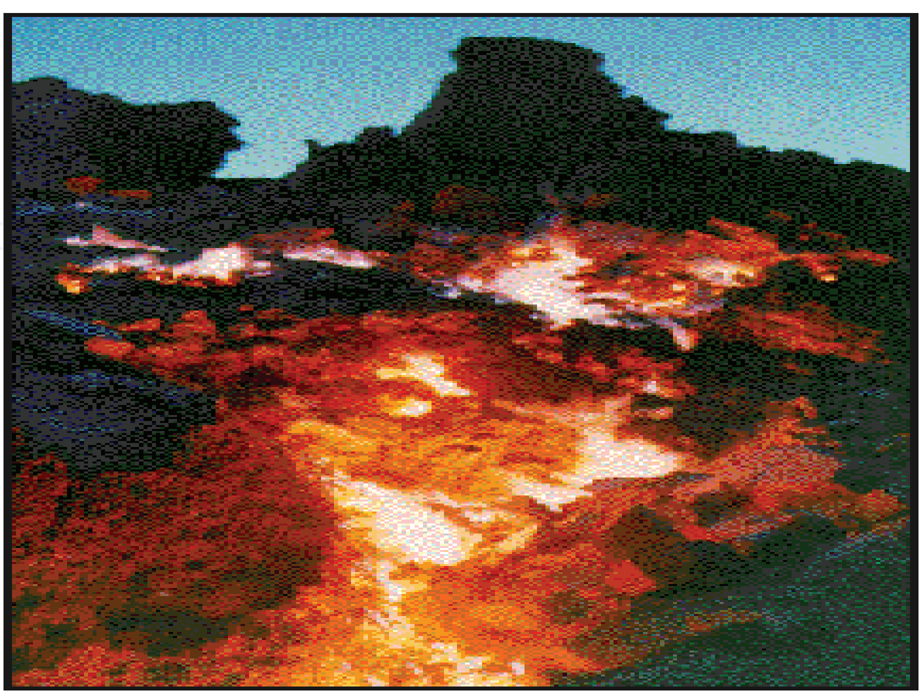

Fig. 1. A Coal fire in China

of China's largest coal fire and some argue one of the world's worst environmental disasters. Sixteen of China's coal fires burn here, spewing out acrid clouds of sulfur dioxide. The fires at the Wude field are at a depth of between 110 to 220 feet. They advance about 100 feet a year. Workers try to extinguish the fires by starving them of oxygen by burying them under a 3-foot-layer of dirt. Pouring water on them produces dangerous methane gas, so workers pour a water-clay slurry into cracks instead of water if a dousing strategy is employed. Even when the fires are extinguished the ground can take years to cool down. Only 10 percent of China's coal underground fires are being fought. There have been some successes. In 2003, a centuries-old fire was extinguished near Urumqi after a four year battle. In 2009, a number of coal fires, one of which had been burning for 60 years, were put out in Xinjiang. The fires, which have been caused illegal mining and spontaneous combustion, had spread to more than 900,000 square meters and consumed 10 million tons of coal a year. The fires were put out through a coordinated plan of drilling, water injection and using earth to cut off oxygen.

5.1.2 Air pollution from volcanoes

One of the most important natural causes of air pollution is volcanic eruption. The most problematic gases emitted in a volcanic eruption include sulfur dioxide, carbon dioxide and hydrogen fluoride. In nearby places, sulfur dioxide gas can cause acid rain in nearby places and air pollution in downwind areas from the volcanic site. Besides the volcanic gases, there is also volcanic ash. Volcanic ash can move hundreds to thousands of miles downwind from a volcano. Fresh volcanic ash is gritty, rough, and at times corrosive. The ash can cause respiratory problems for young children, the elderly or those already with respiratory ailments. Volcanic eruptions can generate so much polluting gases and ash into the air that the sun's rays could be blocked, and land temperature in the affected area lowered, as with the Mount Pinatubo eruption in 1991. Kilauea Volcano on the Island of Hawai`i emits about 2,000 tons of sulfur dioxide (SO_2) gas each day during periods of sustained eruption (Figure 2).

Fig. 2. Kilauea Volcano on the Island of Hawai`i

Air pollution caused by sulfur dioxide and other volcanic gases became a frequent problem on the island in mid-1986, when the volcano's ongoing eruption, which began in 1983, changed from episodes of spectacular lava fountaining (shown here) to a nearly constant but quiet outflow of lava and gas (USGS Fact Sheet 2000).
People in areas downwind of the volcano began reporting a wide range of problems, including reduced visibility, health complaints, and damage to crops. The word "vog," an abbreviation for volcanic smog, was coined to identify this form of air pollution, which unfortunately has become a part of everyday life for people in Hawai`i. Vog is a visible haze consisting of gas plus a suspended mixture of tiny liquid and solid particles, called aerosol. The aerosol in vog is composed primarily of sulfuric acid and other sulfate compounds. Small amounts of several toxic metals, including selenium, mercury, arsenic, and iridium, have also been found in the volcanic air pollution coming from Kilauea.

Fig. 3. "Laze" another form of volcanic air pollution

Molten lava from Kilauea Volcano frequently flows through underground lava tubes to reach the Pacific Ocean, where it vigorously reacts with cold seawater to create large steam plumes laden with hydrochloric acid (USGS Fact Sheet 2000). These plumes, known as "laze", are another form of volcanic air pollution (Figure 3) and pose a local environmental hazard along the Island of Hawaii's southeast coast, especially to people who visit these ocean-entry sites.

5.1.3 Air pollution from forest fires

Forest fires are not uncommon, in remote regions, fires are often started by lightning, but in more populated areas people are the main cause. Following are some of the facts (Vegetation Fires Fact Sheet 2000)

- Fires in tropical monsoon forests recur every 1 to 3 years.
- In North America and Eurasia, between 5 and 20 million hectares (ha) of forest are consumed by uncontrolled fires every year.
- In tropical savannahs, it is estimated that over 300 million metric tons of vegetative matter burn annually.

Gas and particle emissions produced as a result of fires in forests and other vegetation impact the composition of the atmosphere. These gases and particles interact with those generated by fossil-fuel combustion or other technological processes, and are major causes of urban air pollution. They also create ambient pollution in rural areas. These fires are also sources of "greenhouse" and reactive gases. All forest fires emit carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, and particulate matter. Carbon monoxide, which is a poisonous gas, can be emitted in large amounts during forest fires. Particulates, which are mixtures of soot, tars, and volatile organic substances, either solid or liquid, are emitted in large quantities from forest fires. The particulates, which can be smaller than 2.5 micrometers in diameter, if deeply inhaled into the lungs, can damage lung tissues and cause respiratory and cardiovascular problems. Nitrogen oxides are released at temperatures greater than 1,500 degree centigrade. Therefore nitrogen oxides are released in significant quantities only during the most severe fires. Sulfur dioxide emissions are significantly less serious with forest fires, as concentration of the dioxide in most forest fuels is usually less than 0.2 percent. However, forest fire sites with "peat" and "muck soil" may be exceptions.

In 1997-98, forest fires in South-east Asia affected some 200 million people in Brunei Darussalam, Indonesia, Malaysia, the Philippines, Singapore and Thailand. Massive movements of population fleeing the fires and smoke added to the emergency, while the increase in the number of emergency visits to hospitals during the crisis demonstrated its severity (Vegetation Fires Fact Sheet 2000). The comparison of medical data reported during the 1997/1998 forest fire events in South-east Asia with corresponding data in 1995/1996 revealed the following impact of smoke on public health which is consistent with our knowledge of the effects of fine particles.

- The number of cases of pneumonia increased 5-25 times in South-east Kalimantan (Borneo) and 1.5-5 times in South Sumatra.
- The number of outpatient visits with respiratory diseases in Malaysia increased 2 to 3-fold.
- In September 1997 in Jambi (Sumatra), the number of reported cases of upper respiratory tract infections was 50% higher than in the previous month.

Health-related consequences of smoke from forest fires in the Americas have also been documented:

- During the fires in 1997 in Alta Foresta, Brazil, outpatient visits for respiratory disease increased 20-fold.
- During the 1993 California fires, a 40% increase in asthma and a 30% increase in emergency visits for chronic obstructive pulmonary diseases was recorded.

Early warning systems for fire and atmospheric pollution are essential components of fire and smoke management, and are based on space, ground and climate monitoring, as well as modeling. The use of "fire-weather" forecasts and assessment of vegetation dryness may also be included.

5.1.4 Dust/sand storms

Dust storms are a kind of severe natural disaster that frequently occurs in the arid and semiarid regions. Dust storms have local, national and international implications concerning global warming, and land degradation. They also impact human health. When the dust cloud moves downwind it inevitably passes through populated areas, contributing to the air pollution (Figure 4). As the dust settles over a populated area and people breathe in these tiny dust particles, those with asthma and other respiratory disorders will suffer. Dust particles have been shown to cause a wide range of respiratory disorders including chronic

bronchitis and lower respiratory illness. More sinister are the health related problems in areas where the dust is salt laden or is contaminated by toxins (Mattson & Nilsen 1996).
The 5.5 sand-dust storm (Yang Gengsheng 1996) that prevailed in the Hexi Corridor brought suspension dust to Lanzhou (hundreds of Kms further east) where atmospheric air quality was severely polluted and all factory workshops and office buildings had to turn on their lights during the day. Air inside rooms was full of mud smell and irritated the nose. Whitewash dusts floated everywhere. Respiratory diseases were spread. Particularly, the tailings dust exhausted from the metallurgy industry caused heavy metal pollution as these particles were entrained and transported.
Abbas et al. (2007) reported in a study on Impacts of Dust Storms on Air Pollution and Public Health in Sistan region in Iran that these caused air pollution and respiratory diseases have spread in the region. Due to all the villages are located in wind corridors' path and most often exposed to dust storms, therefore the number of patients in villages is more than the city. Also, drought and dust storms caused the agricultural land has transformed into wasteland. Hence, villagers live in complete poverty so they are not able to pay remedy costs. Most respiratory patients visit hospital during the summer season when the dust storms occur. Therefore dust storms have led to widespread damage and loss of life. It seems that the loss of life is more than property damage.

Fig. 4. Air pollution from a dust storm

There are many other air pollution causes like wind erosion, pollen dispersal, evaporation of organic compounds, and natural radioactivity. However, these causes are usually not significant. Although there is no doubt that the impact of natural causes for air pollution can sometimes be drastic, take for example volcanic eruptions, but they are usually not frequent.

5.2 Human sources of air pollution in rural areas

Agricultural activities are the major human source of air pollution in rural areas. Burning of stubble in the field after harvesting, threshing operation, grain dust and large scale use of tractors harvester, combines and diesels operated tube well are major factor contributing to air pollution. Agricultural use of organophosphorus and organochloride compounds creates a potentially serious air pollution problem in farming areas. Sprinkling of pesticides on farm from helicopters is another source of air pollution.

5.2.1 Air pollution due to burning of crop residue

It is estimated that 22289 Gg of rice straw surplus is produced in India each year out of which 13915 Gg is estimated to be burnt in the field. On an average, total amount of stubble generated for paddy and wheat per acre was around 23 and 19 quintals, respectively (Kumar & Kumar 2010).The two states namely Punjab and Haryana alone contribute 48 percent of the total and are subject to open field burning (Gadde et al. 2009).

Fig. 5. Burning of crop residue in northern India

The rice and wheat system (RWS) is one of the widely practiced cropping systems in northern India. About 90-95 percent of the rice area is used under intensive rice wheat system (RWS) in Punjab (Gadde et al. 2009). Widespread adoption of green revolution technologies and high yielding variety of seeds increased both, crop as well as crop residue. In the last few decades intensive mechanization of agriculture has been occurring and combine (The combine harvester, also called combine, is a machine that harvests grain crops. It combines into a single operation processes that previously required three separate operations, that is, reaping, binding and threshing) harvesting is one such input, particularly in the RWS. Note that in the RWS a short period of time is available between rice harvesting and wheat plantation and any delay in planting adversely affects the wheat crop. This coupled with combine harvesting compels the farmers to burn the residue to get rid of stubble left out after the harvest (Figure 5). Burning of straw emits emission of trace gases like CO_2, CH_4, CO, N_2O, NO_X, SO_2 and large amount of particulates which cause adverse impacts on human health. It is estimated that India annually emits 144719 Mg of total particulate matter from open field burning of rice straw (Gadde et al. 2009).

5.2.2 Air pollution due to pesticides/insecticide sprays

Agricultural use of organophosphorus and organochloride compounds creates a potentially serious air pollution problem in farming areas. Pesticides can enter the human body through inhalation of aerosols, dust and vapor that contain pesticides; through oral exposure by consuming food and water; and through dermal exposure by direct contact of pesticides with skin. Pesticides are sprayed onto food, especially fruits and vegetables, they secrete into soils and groundwater which can end up in drinking water and pesticide spray can also drift and pollute the air. Inappropriate pesticide application can lead to off-target contamination due to **spray drift** and "run-off" from plants, causing contamination of the bystanders, the soil, water courses and other environmental pollution.

Pesticide drift occurs when pesticides suspended in the air as particles are carried by wind to other areas, potentially contaminating them (Cornell University Pesticide fact sheet). Pesticides that are applied to crops can volatilize and may be blown by winds into nearby areas, potentially posing a threat to wildlife (National Park Service. US Department of the Interior, August 1, 2006). Also, droplets of sprayed pesticides or particles from pesticides applied as dusts may travel on the wind to other areas (US Environmental Protection Agency 2007), or pesticides may adhere to particles that blow in the wind, such as dust particles (Environment Canada 2001). Ground spraying produces less pesticide drift than aerial spraying does (Palmer et al. year of publication not available). Farmers can employ a buffer zone around their crop, consisting of empty land or non-crop plants such as evergreen trees to serve as windbreaks and absorb the pesticides, preventing drift into other areas. Such windbreaks are legally required in the Netherlands (Science Daily 1999). Pesticides that are sprayed on to fields and used to fumigate soil can give off chemicals called volatile organic compounds, which can react with other chemicals and form a pollutant called tropospheric ozone. Pesticide use accounts for about 6 percent of total tropospheric ozone levels (UC IPM Online 2006).

With placement (localized) spraying of broad spectrum pesticides, wind drift must be minimized, and considerable efforts have been made recently to quantify and control spray drift from hydraulic nozzles (Figure 6). On the other hand, wind drift is also an efficient mechanism for moving droplets of an appropriate size range to their targets over a wide area with ultra-low volume (ULV) spraying. Himel (1974) made a distinction between exo-drift (the transfer of spray out of the target area) and endo-drift, where the active ingredient (AI) in droplets falls into the target area, but does not reach the biological target. Endo-drift is volumetrically more significant and may therefore cause greater ecological contamination

(a) (b)

Fig. 6. Localized insecticide (a), pesticide (b) spraying

(e.g. where chemical pesticides pollute ground water). Although there has been much public concern and research into spray drift, several studies have concluded that point source pollution (allowing pesticides to enter water courses/groundwater following spillage of concentrate or after washing equipment) can cause the greatest harm to the environment. As with pesticide application in general, crop dusting is associated with a number of environmental concerns, including spray drift, soil contamination, water pollution, and occupational health concerns. In the U.S. in 1970, lawsuits and court cases involving spraying of pesticides, such as aerial application in commercial agriculture were a growing area in law, combining areas such as negligence, products liability, strict liability, statutory regulation and commercial law (William et al. 1970). Environmental and human rights issues associated with crop dusting is greatest in developing countries, where government oversight is weaker or absent, few safety practices are used, and chemicals are used that are banned in most developed countries.

5.2.3 Air pollution due to Grain dust

Grain dust is produced when cereal crops and maize are harvested, dried, moved, stored and processed (Figure 7). The dust includes bacteria, fungi, insects and possibly pesticide residues as well as dry plant particles. Inhaling grain dust can cause ill-health; for example asthma, bronchitis and grain fever. Some people can become sensitized to the dust; this means that any subsequent exposure, even at a low level, can result in nasal or eye irritation or trigger an attack of asthma. Grain dust may contain mould spores that, if inhaled, can cause the potentially fatal disease, Farmer's Lung. The maximum permissible exposure limit, measured over 8 hours, is 10 milligrams per cubic meter (mg/m3). The HSE

Process	**Dust level measurement averaged over 8 hours**	**Comments**
Combining (no cab)	18 to 41 mg/m3	2-4 times daily legal amount
Combining (with cab	0.2 to 2.5 mg/m3	1/4 of daily amount
and air filtration)	1 to 40 mg/m3	Up to 4 times legal daily amount
Grain carting work	4 to 57 mg/m3	Up to almost 6 times legal amount
Grain drying	0.1 to 11 mg/m3	Can exceed daily legal amount
Milling and mixing		

Table 1. Levels of dust in an operator's breathing zone.

(a) (b)

Fig. 7. Grain dust causing air pollution during wheat harvesting by a) threshing b) combine

information sheet no.3 (Controlling grain dust on farms 2002) below (table 1) gives the levels of dust in an operator's breathing zone.
Some people who work with high levels of grain dust over many years may develop chronic lung disease that is similar to that developed after years of smoking. This has been shown to persist even after removal from the exposure.

5.3 Indoor air pollution

Problems of indoor air quality are recognized as important risk factors for human health Indoor air is also important because people spend a substantial proportion of their time in buildings. In indoor environments, tobacco smoke and combustion of solid fuels for cooking and heating are the most significant sources. In addition, construction material, furniture, carpeting, air conditioning, and home cleaning agents and insecticides can also be significant sources of chemical and biological pollutants indoors.
It has been estimated that approximately half the world's population, and up to 90% of rural households in developing countries, still rely on biomass fuels (WRI, 1999). Although the portion of global energy derived from biofuel has fallen from 50% in 1900 to around 13% currently, this trend has leveled and there is evidence that biofuel use is increasing among the poor (WRI, 1999). Poverty is one of the main barriers to the adoption of cleaner fuels and slow pace of development in many countries implies that biofuels will continue to be used by the poor for many decades. Biomass fuel, or biofuel, refers to any plant or animal based material deliberately burned by humans. Wood is the most common biofuel, but use of animal dung and crop residues is also widespread. These fuels are typically burned indoors in a U-shaped construction made from mud (Figure 8), or simple household cook stoves, such as a pit, three pieces of brick (Figure 9), which burn these fuels inefficiently and are often not vented with flues or hoods to take the pollutants to the outside. Some countries, including China and South Africa also use coal extensively for domestic needs. Animal dung is on the lowest rung of the ladder progressing to crop residues, wood, charcoal, kerosene, gas, and finally electricity. People generally move up the ladder as socio-economic conditions improve. Other sources of indoor air pollution in developing countries include smoke entering the home from nearby houses, burning of forests, agricultural land and household waste, the use of kerosene lamps, and industrial and vehicle pollution.

Fig. 8. U shaped household mud stove

Fig. 9. Three brick cook stove

Environmental tobacco smoke (ETS), is another source of indoor air pollution exposures which can be expected to increase in importance in developing countries. It is important also to recognize that the open hearth (Figure 10) and resulting smoke often have considerable cultural and practical value in the home, including control of insects, lighting, drying food, fuel and housing materials and for flavouring foods (Smith, 1987).

Fig. 10. A women burning crop residue using house hold cook stove

Biomass smoke contains many thousands of substances, many of which damage human health. Most important are particulates, carbon monoxide, nitrous oxides, sulphur oxides (more with coal), formaldehyde, and polycyclic organic matter which include carcinogens such as benzo[a]pyrene (WHO 2010). Small particles of diameter less than 10 microns (termed PM10), and in particular those less than 2.5 microns (PM2.5), are able to penetrate deep into the lungs and appear to have the greatest health-damaging potential. In developing countries, individuals are typically exposed to these very high levels of pollution for between 3 and 7 hours each day over many years. During winter in the many cold and mountainous areas, exposure may occur over a substantial portion of each 24 hour period Cultural practices common in developing countries may promote exposure of infants, women, the elderly and the sick. Since it is the women who generally cook, therefore their exposure is much higher than that of men. Young children are often carried on their mother's back while she is cooking, so that from early infancy, children spend many hours breathing smoke.

5.4 Trans - boundary pollution

The rural areas have also to bear the effects of air pollution which is generated in the urban area and move towards the rural areas with the wind. It has been observed that the polluted air is not just the local phenomena rather the polluted air blows across the coutries as well continents across the globe. During the spring there are fierce dust and sand storms in the Gobi desert and northern and western China. As the dust and sand are blown eastward by westerly winds, they pick up air pollution particles, especially over heavily industrialized areas in northeast China like Shenyang, and carry them further east into South Korea and Japan and further east. South Koreans and Japanese also complain that the winds that carry the sulfur and nitrogen oxides also pick up heavy metals and carcinogens and dump them in their countries. Deaths attributed to yellow-sand-caused cardiovascular and respiratory diseases have been reported in South Korea. A group called Project Asia Brown Cloud—using aircraft and ground stations in China, South Korea and Japan—have observed that clouds of industrialized pollution that originate in Shenyang and merging with dust and sand clouds that originate in the Gobi Desert and Xinjiang (Jeffrey Hays 2008). Increasing amounts of pollution are being blown across the Pacific Ocean to North America. Pollutants carried by the jet stream can reach the United States in days. Pollutants from Asia reaching the United States are rising at a rate of 5 percent to 10 percent a year. By some estimates 25 percent of the air pollution in Los Angeles comes from China. American heath officials find this figure alarming when is tacked onto pollution that already exist in the United States (Jeffrey Hays 2008). Increases in amounts of ozone and fine particulate matter found in the air in the United States are blamed on "transpollution" from China. Scientists estimate that in 2010, on third of the ozone in Los Angeles will originate in Asia, much of it in China. Asian soot has been blamed for speeding up the thinning of Arctic ice and other polar environmental changes. Soot, dust and chemical pollutants from China have been captured in a weather observation stations on the summit of Mount Bachelor in Cascade Range in Oregon. Soot, dust, ozone and nitrous oxides can be detected by satellites moving across the Pacific. But just as the Americas worry about air pollution from Asia, Europeans worry about pollution carried by winds from the Americans and Asians worry about pollution carried by winds from Europe (Jeffrey Hays 2008).

6. Health impacts of air pollution in rural areas

Health impact of air pollution depends on the pollutant type (Table 2), its concentration in the air, length of exposure, other pollutants in the air, and individual susceptibility. Different people are affected by air pollution in different ways. Poor people,

Pollutant	Health Impact
Tobacco smoke	Tobacco smoke generates a wide range of harmful chemicals and is a major cause of ill health, as it is known to cause cancer, not only to the smoker but affecting passive smokers too, ranging from burning sensation in the eyes or nose, and throat irritation, to cancer, bronchitis, severe asthma, and a decrease in lung function.
Biological pollutants	These are mostly allergens that can cause asthma, hay fever, and other allergic diseases.
Volatile organic compounds	Volatile compounds can cause irritation of the eye, nose and throat. In severe cases there may be headaches, nausea, and loss of coordination. In the longer run, some of them are suspected to cause damage to the liver and other parts of the body.
Formaldehyde	Exposure causes irritation to the eyes, nose and may cause allergies in some people
Lead	Prolonged exposure can cause damage to the nervous system, digestive problems, and in some cases cause cancer. It is especially hazardous to small children.
Radon	A radioactive gas that can accumulate inside the house, it originates from the rocks and soil under the house and its level is dominated by the outdoor air and also to some extent the other gases being emitted indoors. Exposure to this gas increases the risk of lung cancer.
Ozone	Exposure to this gas makes our eyes itch, burn, and water and it has also been associated with increase in respiratory disorders such as asthma. It lowers our resistance to colds and pneumonia.
Oxides of nitrogen	This gas can make children susceptible to respiratory diseases in the winters.
Carbon monoxide (CO)	CO combines with haemoglobin to lessen the amount of oxygen that enters our blood through our lungs. The binding with other haeme proteins causes changes in the function of the affected organs such as the brain and the cardiovascular system, and also the developing foetus. It can impair our concentration, slow our reflexes, and make us confused and sleepy.
Sulphur dioxide. (SO2)	Sulphur Dioxide in the air is caused due to the rise in combustion of fossil fuels. It can oxidize and form sulphuric acid mist. SO2 in the air leads to diseases of the lung and other lung disorders such as wheezing and shortness of breath. Long-term effects are more difficult to ascertain as SO2 exposure is often combined with that of SPM.
Suspended Particulate Matter (SPM)	SPM consists of dust, fumes, mist and smoke. Lead is of major concern, others being nickel, arsenic, and those present in diesel exhaust. These particles when breathed in, lodge in our lung tissues and cause lung damage and respiratory problems. The importance of SPM as a major pollutant needs special emphasis as a) it affects more people globally than any other pollutant on a continuing basis; b) there is more monitoring data available on this than any other pollutant; and c) more epidemiological evidence has been collected on the exposure to this than to any other pollutant.

Table 2. Some of the indoor air pollutants and their health impacts

undernourished people, very young and very old, and people with preexisting respiratory disease and other ill health, are more at risk. Poor people are also more likely to suffer from ill health and disease, as they have less access to the health care. Air pollution has both acute and chronic effects on human health. Health effects range anywhere from minor irritation of eyes and the upper respiratory system to chronic respiratory disease, heart disease, lung cancer, and death. Air pollution has been shown to cause acute respiratory infections in children and chronic bronchitis in adults. It has also been shown to worsen the condition of people with preexisting heart or lung disease. In addition, evidence is now emerging of links with a number of other conditions, including asthma, tuberculosis, low birth weight, cataracts, and cancer of upper airways. Indoor smoke from solid fuels causes about 35.7% of lower respiratory infections, 22.0% of chronic obstructive pulmonary disease and 1.5% of trachea, bronchus and lung cancer (WHO 2002). Indoor air pollution may also be associated with tuberculosis, cataracts and asthma. In total, 2.7% of DALYs worldwide are attributable to indoor smoke, 2.5% in males and 2.8% in females.

Both short-term and long-term exposures have also been linked with premature mortality and reduced life expectancy. WHO estimates that exposure to indoor smoke from solid fuels may be annually responsible for about 1.6 million premature deaths in developing countries and 2.6 percent of the global burden of disease (WHO 2002). In India 3–5 percent of the national burden of disease is attributable to use of solid fuel (Smith 2000). Kumar & Kumar (2010) found that total annual welfare loss in terms of health damages due to air pollution caused by the burning of rice straw in rural Punjab (India) amounts to 76 millions. Measurement of health parameters also poses many challenges for the study of health impacts of air pollution. For example, in many developing countries, vital statistics and cause of death data are not routinely collected or are not reliable. Clinical data are also highly unreliable because there is often considerable selection due to differential access to health services and awareness of health problems. Multiple sources of health care, varying quality of services, poor diagnosis, and poor record keeping further complicate the study of health impacts.

7. Conclusion

While there has been considerable research on health impacts of tobacco smoking, and there is growing evidence on the effects of ambient air pollution, the research on health effects of indoor air pollution from household use of unprocessed solid fuels is particularly weak. There is need to strengthen both the quantity and quality of evidence linking air pollution and various health outcomes, especially for developing countries and for health conditions with weak or no evidence. This can be accomplished by measuring exposure levels more directly; by including clinical measures of disease outcomes; and by adequately accounting for social, behavioral, nutritional, and environmental confounding factors. In these efforts, there is need to use more powerful study designs, such as prospective cohort studies and randomized intervention trials, designed specifically for rural areas with weak data.

Many efforts to address air pollution have done little to alleviate its total impact. Installing chimneys to vent smoke from indoor stoves, for example, simply moves the pollution a few feet away, just adding to outdoor pollution. Moving industries from urban to rural areas similarly shifts the pollution from one environment to another. Future efforts to reduce the health effects of air pollution should consider a pollutant's total impact—in rural as well as urban areas.

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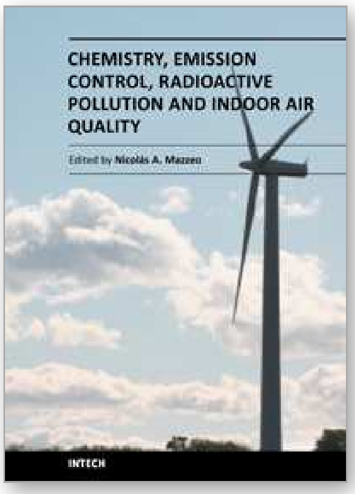

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The atmosphere may be our most precious resource. Accordingly, the balance between its use and protection is a high priority for our civilization. While many of us would consider air pollution to be an issue that the modern world has resolved to a greater extent, it still appears to have considerable influence on the global environment. In many countries with ambitious economic growth targets the acceptable levels of air pollution have been transgressed. Serious respiratory disease related problems have been identified with both indoor and outdoor pollution throughout the world. The 25 chapters of this book deal with several air pollution issues grouped into the following sections: a) air pollution chemistry; b) air pollutant emission control; c) radioactive pollution and d) indoor air quality.