

Air pollution assessment in urban areas and its impact on human health in the city of Quetta, Pakistan

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Received: 7 November 2008 / Accepted: 18 February 2009 / Published online: 1 April 2009
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Abstract Nowadays, air over major cities throughout the world has become overburdened with gases produced by automobiles. The death rate due to automobile pollution is increasing rapidly in the metropolitan areas. With passage of time, people realized that polluted air has serious effects on their health, climate and economics. Weather and climate have integrated impact on human activities resulting in worldwide concentration of the particulates of environmental pollution, viz., chlorofluorocarbons, carbon dioxide, methane, nitrogen oxide, lead and several other dust and gaseous particles. Like many other mega cities in the world the ambient air quality of Quetta, Pakistan is also deteriorating nowadays. Automobile exhausts and certain industrial pollutants produce O₃ by photochemical reactions. The particulate matter, particularly less than 10 μm in size, can pass through the natural protective mechanism of human respiratory system and plays an important role in genesis and augmentation of allergic disorders. Sources of air pollution in the area and the unique problem arising out of the emission from the vehicles, industries, etc. have been described. Ambient air quality was monitored along with micrometeorological data and the results are discussed. The status of air pollution in the area has been evaluated and a

questionnaire survey was conducted to estimate the allergic symptoms and exposure to assess the respiratory disorders. The data are analyzed to evaluate the critical situation arising out of the emission of air pollutants and the impact on human health due to respirable diseases (RDs) in middle class sub-population (activity-wise) in the area assessed. A strategic air quality management plan has been proposed. For the mitigation of air pollution problems in the city, different measures to be adopted to maintain the balance between sustainable development and environmental management have been discussed. Air pollution has significant effects on exacerbation of asthma, allergy and other respiratory diseases.

Keywords Vehicular emission · Respiratory diseases · Inhalable dust · Small-scale industries

Introduction

In developing countries, the air quality crisis in cities is often attributed in large measures (40–80%) to vehicular emission. Because of the source emissions of CO, O₃, toxicants and particulates (Davis 1998) the public health implications (Anon 1997a, b; Utell et al. 1998) are substantial. An improved understanding of the association of the particulates with morbidity suggests the importance of sub-micron particles (PM₁₀) to which motor vehicles are major contributors (Anon 1995).

Most of the cities in Pakistan are growing at a faster rate than the national average, as subsistence workers migrate from rural areas to cities in search of disposable income. Existing cities are expanding, new urban areas are being created, and adjacent cities are merging. Urban Pakistan depicts a picture of metamorphosis. Feudal towns have

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changed into industrial cities, cities into metropolis and metros into megalopolis. Owing to the expanding economic base, there is an influx of population migrating from the rural areas and urban fringe to the core city for the better quality of life. Pakistan is an agricultural country, more than 70% of the population is involved in agriculture and per capita income is about US\$ 480. Agriculture accounts for more than 35% of the GDP. The economic statistics reveals the increased contribution of urban areas to GDP. The influx of population of the existing cities in Pakistan stresses the overstretched infrastructure of the urban areas and is unable to cater to the ever-growing needs of immigrants. Transportation systems are increasing everywhere. The improved performance of technology is presently insufficient to balance the growth of vehicles (Anon 1980). Projections, therefore, consistently show worsening air quality in the cities of Pakistan. Rapid technological advancement represents the real hope of fulfilling the legitimate aspiration of the people of Pakistan for a higher standard of living without severe deterioration of the urban environment (Streets et al. 1999). Overexploitation of nature in the name of urbanization and development is causing degradation of our environment. At the same time, we do realize that we cannot stop development in the name of saving environment. A balance between sustainable developments is the need of the hour (Ghose and Majee 2001). Environment impact assessment (EIA) plays a crucial role in resolving the conflicts (Canter 1977). Thus, it is necessary to evaluate the status of urban air pollution and to assess its impact on human health so that proper mitigative measures can be implemented. To evaluate such impacts a fact finding survey is essential. In this study, attempts have been made to evaluate the status of urban air pollution in the city of Quetta, Pakistan and assess its impacts on human health.

Description of the study area

Balochistan is Pakistan's largest province. Quetta is the capital city of Balochistan. Quetta is one of the largest mega cities in Pakistan and its ambient air quality is being deteriorated day by day. A 'no care' attitude and gross negligence coupled with ever-increasing needs and demands over the years have taken the problem to a threatening dimension. Rapid and unplanned urbanization, enhanced potential for industrialization, continued growth of metropolis are some of them and impact of Afghan war. Uncontrolled and awfully mixed vehicular density on insufficient and badly cared road space, lack of adequate parking facilities, low turnover of old vehicles with frequent breakdowns, indisciplined drivers, indifferent pedestrians together with a bad traffic management strategy have

profound effect on urban air pollution. Widespread use of solid fuels in slums and busty-like areas, consisting of a substantial portion in Quetta city, have allowed indoor air pollution to threaten human health and life. Widespread malnutrition, poor hygiene sense and indifferent attitude among the population exacerbate and complicate the impact on human health due to multiple environmental risks. Children are the worst effected groups in Quetta.

Quetta is in the grip of serious air pollution problem. Suspended particulate matter (SPM), respirable particulate matter (RPM), SO₂, NO_x, Pb, CO₂ are not only the main contribution of air pollution but are also always present in a much higher concentration than the permissible limit. The use of leaded petrol fuel is high in Quetta than any other city because of smuggled petrol from Iran and Iraq. Comparative studies showed that the Pb in the blood level was 28.3 µg/dL in Quetta and in Tokyo it was 6.0 µg/dL (Misra and Khandekar 1994). Approximately, 70% of the total pollution load of the city is contributed by automobile exhaust. Unplanned increases in vehicles especially by two-stroke engine vehicles have brought the ambient air to an alarming level. These petrol-driven three wheelers emit large quantities of unburnt hydrocarbons beside carbon monoxide and particulate (Ferguson 1990).

The mode of public transport system of Quetta city comprises buses, taxis and autorickshaws. The main mode of public transport is bus, especially private bus. Most of these buses are very old and the exhaust emission level of these buses is much higher than the permissible limit. Approximately, 755,000 vehicles ply in the city streets and 3,550 new vehicles are added every month. Because of very little road space (only 10%) and unplanned traffic, the normal vehicular movements get restricted, increasing the fuel consumption as well as exhaust emission.

There are two thermal power plants within Quetta city area under Water and Power Development Authority (WAPDA). There are 25 brick kilns in Quetta city area. A number of small-scale industries are also located in the Quetta city area, although the exact figure is not known. Leather processing industries and a number of gold processing industries are also emitting pollutants. Coal is the major fuel used by the families of middle-to-low income groups and by those people who live in slums, roadside shops and tea stalls. LPG is used as fuel by about 80% of population. Kerosene is also used as standby or permanent fuel for cooking. Cigarette smoking is another source of air pollution, which has serious adverse effect on health.

Methodology adopted

Seven ambient air quality monitoring stations were selected in the area starting from Siryab and one at Manan

Chock covering Cantt, Airport and Municipality areas. Ambient monitoring stations were selected at a height of 10 m from the ground and placed on the roof of nearby domestic houses, which were about 200 m from the traffic intersections. Locations of the air monitors were selected on a random basis. The details of the monitoring stations are given in Table 1.

The sampling was conducted twice in a week from October to December. Air samples were collected for 24 h in three 8 h siffs corresponding to day (8–16 h), evening (16–24 h) and night (24–8 h). Micrometeorological data were collected on the roof of the Department of Physics, University of Balochistan main building continuously during the air monitoring period with respect to wind direction, wind velocity, humidity and temperature (Ilyas 2005).

For the collection of samples of SPM, glass fiber ambient (GF/A) filter paper was used in a high-volume sampler (HVS) and for respirable dust particulate matter. GF/A was used in respirable dust sampler (RDS) at a flow rate of 1.1–1.5 m³/min that allows the SPM to deposit on the filter paper. Particulate with size range of 0.1–100 µm was collected by HVS (Ghose and Majee 2000). The cut-point diameter of RDS was less than 10 µm. HVS, having impingers (bubbler trains) in series with sodium tetrachloromercurate as absorbing solution, was operated at an average flow rate of 0.5 L/min for collection of SO₂ (as per IS: 5182, Part II, 1969) for 24 h. In the case of collection of NO_x, sodium hydroxide was used as absorbing solution and collected at an average flow rate of 0.5 L/min for 24 h (as per IS: 5182, Part IV, 1976). The impinger samples were put in ice boxes immediately after sampling and transferred to a refrigerator prior to analyses (Ghose and Banerjee 1995). The samples were analyzed spectrophotometrically using West and Gake methods and Jacob and Hocheiser modified methods for the analysis of SO₂ and NO_x, respectively (APHA 1977). SPM and RPM were computed after weighing the filter paper before and after sampling. The filter paper was conditioned in a dry atmosphere before weighing (Ghose et al. 1999).

For the determination of CO in air, samples were collected in a glass tube with stopcocks at either end. The air sample was collected by HVS at the rate of 2 L/min for 5 min in vacuum (700 cc of Hg) sausage tube. From the tube, a syringe drew air sample and a known volume of air sample was injected into the injector of Gas chromatograph column (for CO Porapack-Q with mithanizer and for HC only Porapack-Q) using a carrier gas. The Gas chromatograph column separated methane from CO. The methane was eluted first from the Gas chromatographic column through a catalytic reduction tube to a flame ionizer detector. The CO is next eluted into the catalytic reduction tube and was reduced to methane before entering the detector. The response of the detector is directly proportional to the weight of hydrocarbon in the carried gas stream. The concentration of the CO and HC was determined from the peak height or the area recorded on the chart paper and comparing them with those of the standard gas. For determination of Pb in SPM, four circles of 18 cm² were cut from the filter paper on which SPM sample was collected. These were digested in hot 1:1 HNO₃. The solution was then analyzed by atomic absorption spectrophotometer (AAS) to determine Pb.

Results

The mean SPM concentration of ambient air monitoring station varied from 170 µg/m³ (at station Qta-2) to 500 µg/m³ (at Qta-1) with an overall mean concentration of 370.52 µg/m³. The SPM concentration exceeded the permissible limit of 200 µg/m³ stipulated by National Air Quality Standard (NAQS) at all the locations except Qta-2 and Qta-4. From the results of SPM concentration, it is evident that vehicular traffic, a cluster of industries and brick kilns surrounding the Quetta city area were responsible for this. The shiftwise mean SPM concentration results are given in Fig. 1. RPM concentration found to be minimum at Qta-2 (75 µg/m³) and maximum at Qta-1 with an overall average 160.28 µg/m³. Mean RPM concentration results are shown in Fig. 2.

Table 1 Locations of ambient air monitoring stations

| Location | Monitoring station no. | Position | Height from the ground level (m) |
|--------------|------------------------|---|----------------------------------|
| Siryab road | Qta-1 | At the rooftop of a residential house at Siryab road | 10 |
| Manan Chock | Qta-2 | At the rooftop of a residential house at Manan Chock | 10 |
| Cantt area | Qta-3 | At the rooftop of a residential house at Cantt area | 10 |
| Airport area | Qta-4 | At the rooftop of a residential house at Airport area | 10 |
| Alamdar road | Qta-5 | At the rooftop of a residential house at Alamdar road | 10 |
| Barori road | Qta-6 | At the rooftop of a residential house at Barori road | 10 |
| Sirki road | Qta-7 | At the rooftop of a residential house at Sirki road | 10 |

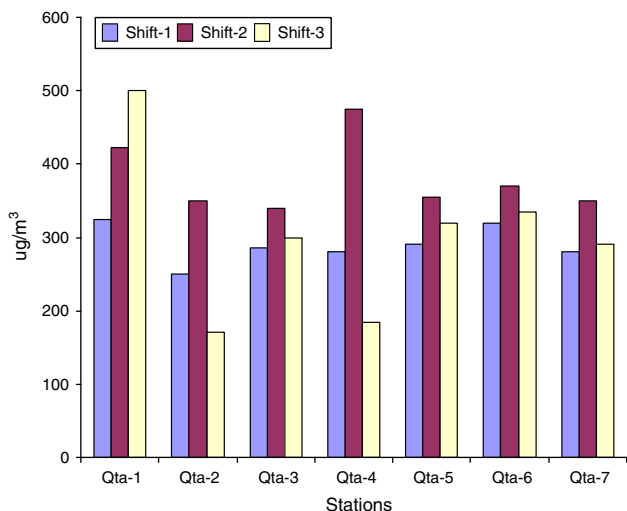


Fig. 1 Shiftwise SPM concentration at ambient stations

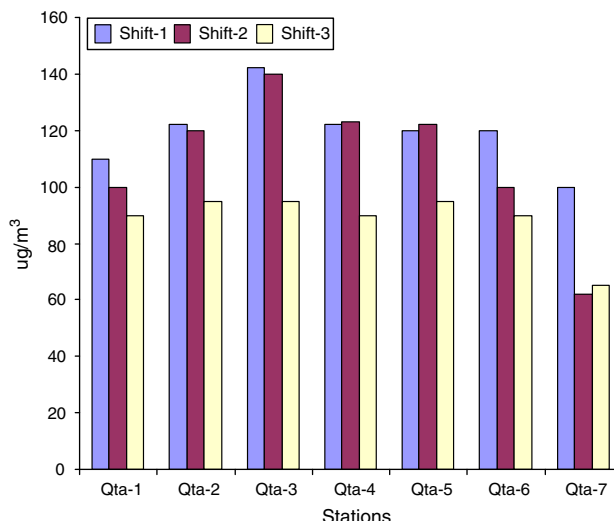


Fig. 3 Shiftwise NO_x concentration at ambient stations

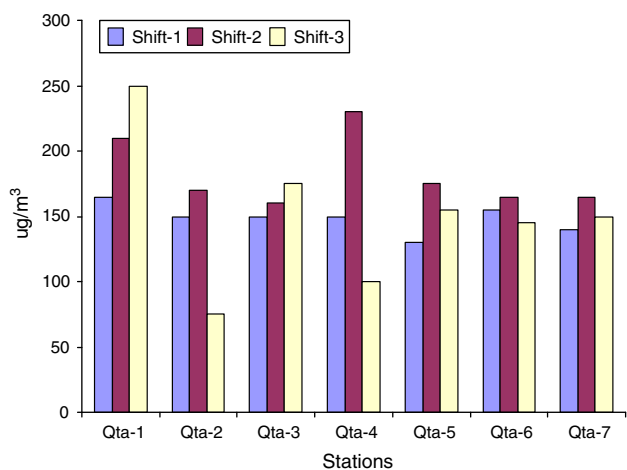


Fig. 2 Shiftwise RPM concentration at ambient stations

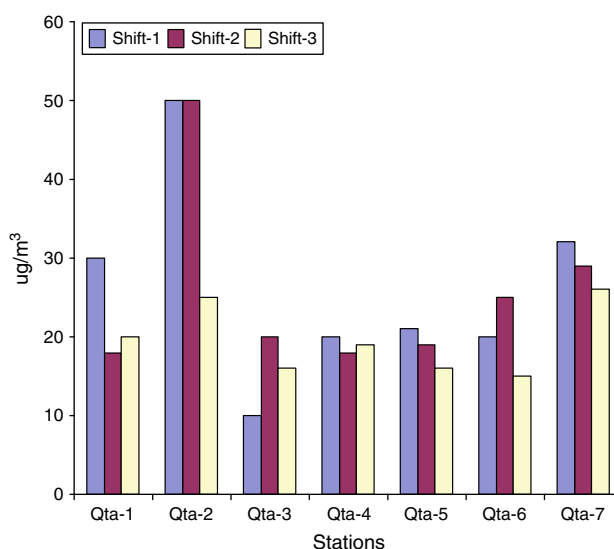


Fig. 4 Shiftwise SO₂ concentration at ambient stations

NO_x concentration was found to be minimum at Qta-7 (62 μg/m³) and maximum at Qta-3 (142 μg/m³) with overall average of 97.05 μg/m³. Except at the location Qta-7, NO_x exceeded the permissible limit of 80 μg/m³ stipulated by NAQS. Shiftwise variation of NO_x is given in Fig. 3. SO₂ concentration ranged between 15 μg/m³ (at Qta-6) and 50 μg/m³ (at Qta-2) with respect to the permissible limit of 80 μg/m³. Shiftwise SO₂ concentration is given in Fig. 4 .

The mean CO concentration was found to be minimum at Qta-4 (3,000 μg/m³) and maximum at Qta-6 (5,700 μg/m³) with an overall average of 3,800.6 μg/m³ with respect to the permissible limit of 2,290 μg/m³. Shiftwise CO concentration results are given in Fig. 5. The overall mean Pb concentration was found to be 0.8762 μg/m³ and varied from 0.4 μg/m³ at Qta-4 to 1.5 μg/m³ at Qta-7 with respect

to NAQS of 0.5 μg/m³. Shiftwise Pd concentration is given in Fig. 6.

The temperature varied from 0 to 28.0°C with an average of 14.0°C, average humidity was found to be 10.2%, average wind speed was 3.8 m/s. No rain fall was observed during the study period but low visibility was observed during some days due to dense fog early in the morning and dust particles in the evening. Sometimes, altostratus clouds were visible in the sky and substantial reduction of sunshine was observed. Remarkable drop in wind speed was observed during the last week of November and first week of December and caused uncomfortable weather.

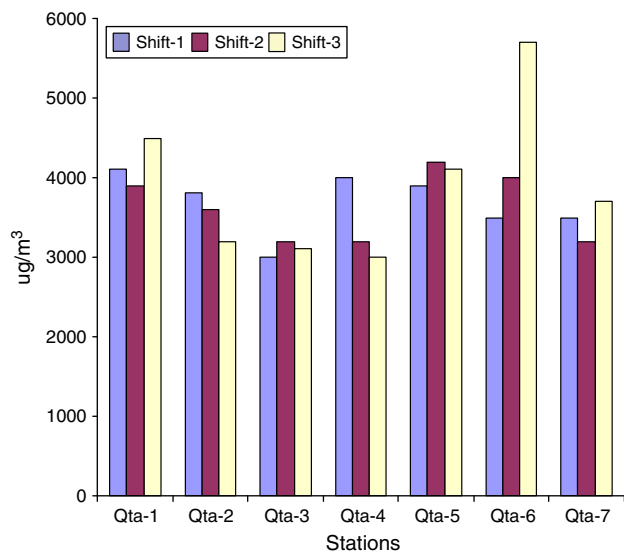


Fig. 5 Shiftwise CO concentration at ambient stations

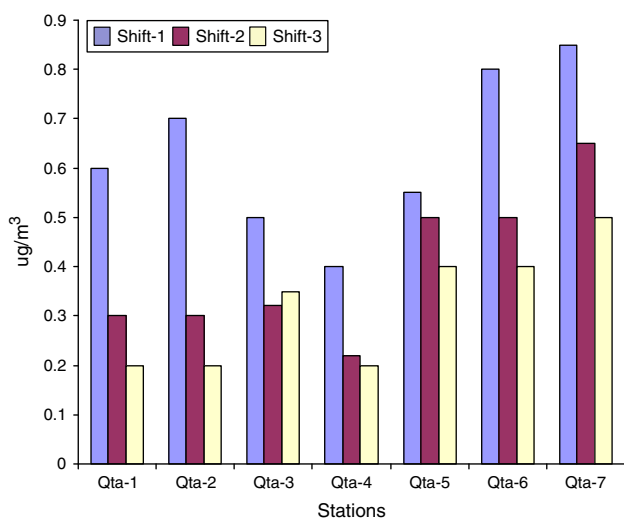


Fig. 6 Shiftwise lead concentration at ambient stations

Discussion

Pollutant particulate matters, which remain suspended due to buoyancy, are in the sub-micron range, i.e. 10^{-6} m in diameter. An improved understanding of the association of the particulates with morbidity suggests the importance of sub-micron particles (PM_{10}) to which motor vehicles are major contributors (Japan 15whec2005 reference). They dispersed to a long distance and damage the mechanisms by chemical reaction with the molecules of respiratory system bringing about adverse chemical changes. These may reduce the lung capacity in humans. The second mechanism by which these react is obstructive or interfering in nature without chemical reaction. The thinner

particulate deposited in human lung interferes with normal functions and causes lung diseases or non-specific functional changes such as asthma, blood pressure, ENT (eye, nose and throat), fatigue, gastrointestinal diseases, bronchitis or reduction of lung capacities and cancer. If there is a chemical reaction of the material, it may bring about silicosis and pneumoconiosis. If it contains things such as hydrocarbons, etc., it may bring about fatal diseases such as cancer. Particulate by covering the leaves' surfaces and plugging the stomata reduces the absorption of CO_2 from the atmosphere, the intensity of sunlight and thus suppresses the photosynthesis and growth of plants. It also reduces visibility by absorption and scattering by solid and liquid droplets.

Total exposure to an individual to a specific pollutant is determined by the concentration of contaminant and the duration of its exposure (Spengler and Dockery 1981). Exposure to indoor and outdoor air quality is different because they always change with time and diurnal pattern (TERI 1995). The health status and the exposure level of a typical population have similarity in terms of habitat, drinking water source, indoor microclimate, domestic fuel consumption, movement pattern, overall living standard, general sense of health and hygiene literacy and interaction with locality and work place (Anon 1997a, b). Certain airborne particulates such as pollen, fungal spores, house dust mite and animal dander (Tilak 1989) upon inhalation cause certain allergic reaction involving respiratory system such as allergic rhinitis, topic dermises and asthma (Arruda et al. 1992; Fernandes 1995). Secondary photolytic reactions in the atmosphere with organic fractions and oxides of nitrogen and sulfur further increase the PAH concentration (Schoentia 1964). These are of marked environmental concern due to air pollution as several of them are either known to be carcinogens or are suspected carcinogens and mutagens (Andrews et al. 1978; Hoffman and Winder 1968).

Exposure to SPM is also an equally serious risk to health. Inhalable SPM, particularly less than $10\ \mu m$ in size, can pass through the natural protective mechanism of human respiratory system. The smallest particulate ($2\ \mu m$ or less), which are coming primarily from diesel, pose a much greater risk because of their greater ability to pass through the human respiratory system and cling to inner tissue of the lung. It has been reported that more than 2,000 premature deaths occurred in Quetta in 2004 due to SPM. SPM includes all air-borne particles in the size range of $0.5\text{--}100\ \mu m$. The actual health damage caused by dust particles depends upon its nature and composition (Binder et al. 1976). The effects of SPM are attributed to mild eye irritation mortality (David 1995).

Automobile exhausts and certain industrial pollutants contain NO_2 , which by photochemical reaction produce O_3

and affect allergic asthmatics by augmenting allergic responses (Steinberg et al. 1991). Similarly, SO₂, NO, particulate matter and acid aerosols affect pulmonary function and cause inflammation of bronchial mucous (Giuseppe et al. 1993; Karen and Michak 1991). It has been observed from several studies that air pollution plays an important role in the genesis and augmentation of allergic disorder and it is described as a disease of civilized society (Bonai et al. 1994; Dennis 1996). Most of the developed western countries have adopted 25 and 1.5 µg/dL as the safe limits for blood Pb levels in adults and children, respectively (Neelman 1993). In view of toxicity at all levels, options have been suggested to adopt 10 µg/dL as blood Pb limit for general population (Boeck 1980).

Assessment of impact on human health

The basic objective of this study was to determine the status and level of typical population (target group). The middle class population was the target group for this study and they were classified as per their activity. Especially, the shopkeepers and the hawkers were identified as the main target group as they reside in high exposure area and for a maximum period of time. A questionnaire was prepared and survey was conducted particularly for suspected allergic population by inquiring the recurrence of the type of allergic symptoms. The occasions of this onset were recorded with each individual to assess the allergic status. For example, if a person exhibited severe sneezing and running nose, etc. after being exposed to house dust, and similarly, if was also allergic to multiple causative agents. The data generated from the survey were analyzed to assess the percentage of allergic population and the suspected allergy causing agents. The results are shown in Table 2.

The assessment of respiratory disorders (RDs) in the middle class sub-population was obtained from the questionnaire survey from the doctors. The assessment of RDs was carried out for various age groups activity-wise. On the

Table 2 Estimation of allergic symptoms

| Complaint | Total no. of cases | Condition | No. of persons | Percent of incidence |
|--------------|--------------------|--------------|----------------|----------------------|
| Nose block | 60 | Allergic | 45 | 89 |
| | | Non-allergic | 15 | 25 |
| Sneezing | 70 | Allergic | 63 | 97 |
| | | Non-allergic | 7 | 12 |
| Cough | 87 | Allergic | 70 | 84 |
| | | Non-allergic | 17 | 40 |
| Hyperacidity | 40 | Allergic | 25 | 71 |
| | | Non-allergic | 15 | 59 |

Table 3 Imprint classification of respiratory diseases

| Imprint class | Imprint score | Symptoms |
|---------------|---------------|---|
| I | 0.0 | No RD: healthy, free from any respiratory disease |
| II | 3.7 | Mild RD: suffering from only upper track respiratory infections (UTRI) |
| III | 7.4 | Moderate RD: suffering from UTRI as well as lowest track respiratory infections |
| IV | 14.8 | Severe RD: suffering from bronchitis, asthma, allergic rhinitis, fibrosis, asbestosis, pneumoconiosis and non-malignant RDs |

basis of the survey of the SPM-related RDs each disease was recorded for indexing the imprint class I to IV. The highest imprint score depicts the maximum severity of RDs. The imprint score obtained for various age groups, groupwise as well as activity-wise, is given in Tables 3 and 4.

Mitigation of urban air pollution

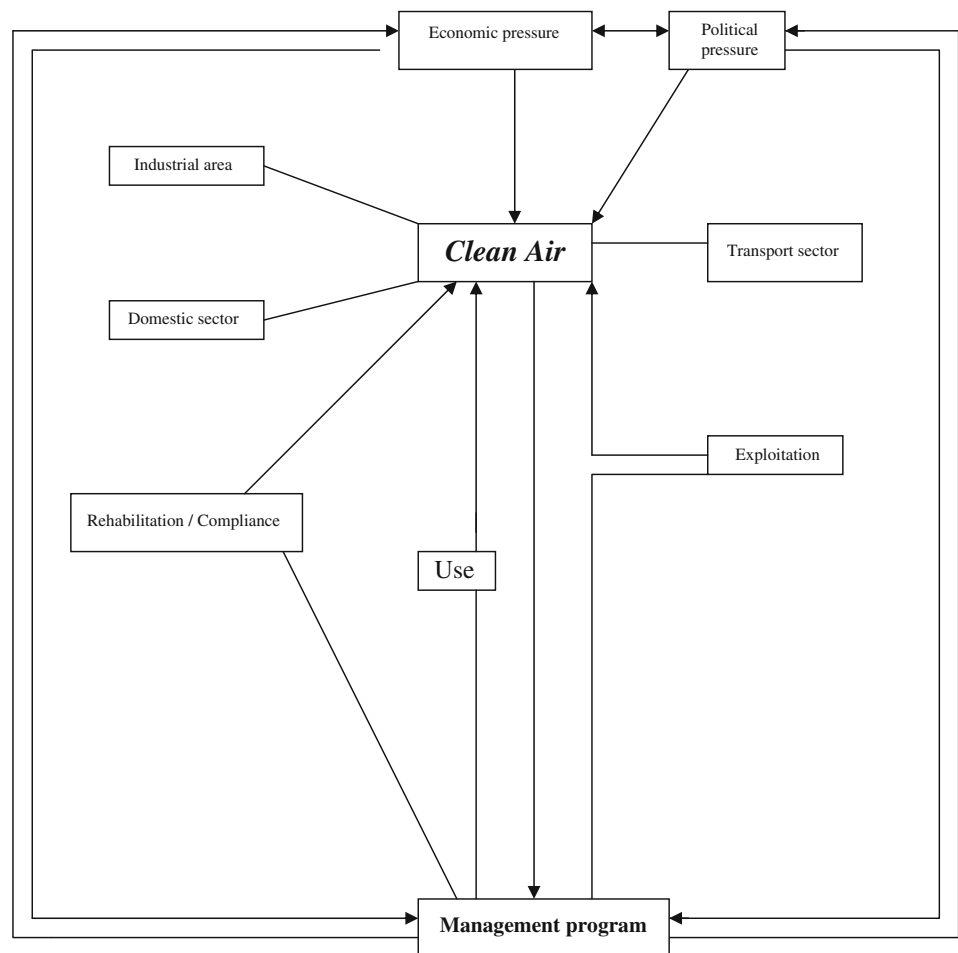
The improvement of the socioenvironmental conditions and reductions of health burden within Quetta city can be argued not only on the public health grounds but also on the basis of long-term economic prosperity of the city.

The pollution problem has reached such an alarming level that no soft option would help to salvage the situation. A strong-willed government backed by alert populace can address the problem of increasing air pollution and RDs in an effective way (Shukla et al. 1997). A variety of problems need a variety of solutions. But it is equally important to stress upon air quality monitoring as well as the study on the health effects. A model for the assimilation has been made and is given by a first-order dynamic function (McEnvoy 1990). The empirical model for predicting long-term average SPM concentration can be utilized for analyzing the effects of various traffic reduction strategies.

To create a strategic plan for air quality management (AQM) program, a consultation with a wide array of interests is required. Figure 7 depicts the urban AQM program. Epidemiological data from hospitals and other agencies are to be considered as the starting point for identifying linkage between ambient air quality levels and chronic or acute health problems. Some target groups (i.e. traffic constables, roadside hawkers, etc.) and non-target groups (such as people living in parts of the city where traffic congestion is less or rural people) were selected on a random basis and monitored. This phase of data collection constituted the critical phase in developing a meaningful AQM program. The benefits of reducing air pollution are to be projected. AQM program becomes successful if it

Table 4 Intensity of RDs in middle class sub-population (activity-wise) in the area

| Sub-population | No. of respondents | Mild RDs (%) | Moderate RDs (%) | Severe RDs (%) | Asthma RDs (%) | No. of RDs (%) | Imprint score |
|---|--------------------|--------------|------------------|----------------|----------------|----------------|---------------|
| Infant and school going children | | | | | | | |
| 0.5–4 years | 20 | 21 | 34 | 12 | 3 | 58 | 255 |
| 4–12 years | 80 | 28 | 16 | 21 | 5 | 62 | 250 |
| 12–18 years | 150 | 30 | 10 | 24 | 10 | 66 | 213 |
| Total | 250 | 26 | 20 | 19 | 6 | 62 | 239 |
| Adult males (>18 years) | | | | | | | |
| Office working | 115 | 31 | 27 | 29 | 26 | 50 | 338 |
| Businessman | 61 | 28 | 25 | 27 | 20 | 58 | 228 |
| College student | 24 | 27 | 16 | 25 | 16 | 68 | 253 |
| Retired citizen | 66 | 38 | 26 | 36 | 42 | 40 | 427 |
| Total | 266 | 31 | 24 | 29 | 26 | 54 | 310 |
| Adult females (>18 years) | | | | | | | |
| Office working | 40 | 30 | 20 | 26 | 16 | 50 | 340 |
| Housewife | 126 | 36 | 29 | 24 | 40 | 42 | 350 |
| College student | 33 | 20 | 20 | 28 | 20 | 58 | 328 |
| Total | 199 | 29 | 23 | 26 | 25 | 50 | 1,018 |

Fig. 7 Strategic plan for urban air quality management program

includes the assessment to justify the necessary expenditures. There are many influencing tools which are to be used for full compliance of environmental goal, i.e. clean air.

Specifying is necessary in selecting the option for mitigating of air pollution. Although the main source of air pollution is the transport sector, industry also plays a key role. For mitigating air pollution in the city of Quetta, limiting emissions from both stationary (industry) and mobile (transport) will be required. A future plan is to shift phasewise the medium and low polluting industries in industrial area outside the city limit. Industries should be encouraged to switch over to cleaner fuels such as natural gas. Energy conservation options are to be encouraged. Industries should be encouraged to develop methodology to tap alternative energy source. Internal control regulation should be made obligatory for all industrial sectors.

Options for reducing air pollution from mobile sources include replacing old vehicles, maintaining in-use vehicles more effectively, using alternative cleaner fuels, reformulating fuels, improving traffic management, expanding mass transit systems and improving the road capacity (Calvert et al. 1993). In Quetta, the lead concentration was found to be high. Therefore, the regulations mandating removal of lead thus may not be of high priority. Most of the vehicles are diesel driven and SPM concentration was also found to be high. The cost of reformulating diesel oil is high, but it should be high priority to reduce SPM. Liquid petroleum gas (LPG) and compressed natural gas (CNG) should be introduced in a phase manner. Catalytic converters that reduce exhaust emission and emission standards of vehicles should be enforced strictly.

Quetta grew up so haphazardly that improving the infrastructure is a logistic and economic nightmare. By keeping the main arterial road pothole free, footpaths free from hawkers and widening the roads wherever possible should be given top priority. Quetta has only 6% road area compared to Lahore (20%) and Karachi (16%) whereas ideally it should be 25–30%. Improved practices for managing traffic can reduce congestion significantly. An improved plan can include incentives and disincentives such as restricting use of main arteries, encouraging car pooling, providing incentives to use public transport, improving public transit system or establishing new ones, taxing cars entering the city limits, imposing steeper parking fees, and imposing environmental tax on automobiles. Traffic management and road improvements should be given high priority to reduce the air pollution in Quetta. Canal network system should be developed, circular railway should be made more efficient and regular, and metro railway system should be expanded. In all these proposals, health benefits should be included to prove justification for

subsidies. The number of trees per square kilometer was found to be 2 whereas ideally it should be 100. Therefore, immediate steps should be taken to increase the number of trees after proper inventory of all species in Quetta. Open spaces and parks (2 ft² per person) should not be encroached upon, and proper eco-designing of these areas should be done immediately.

Conclusion

Quetta is found to be one of the most polluted cities in Pakistan. The study shows that the status of air pollution is found to be very critical and has reached threatening dimensions. Air pollution assessment and impact of on human health arising out of RDs in the area showed high level of imprint score. The premature death due to SPM is reported to be very high and the children are the worst affected groups in Quetta. A strategic AQM plan has been proposed and the mitigation measures suggested to control the urban air pollution would improve situation if implemented properly. There is no well-defined guideline for the assessment of the status of urban air pollution and its impact on human health. No systematic studies have been reported to evaluate the status of urban air pollution and its impact in the cities of Pakistan and there will be immense implications of the suggested approach and the future application of such assessments is to manage the urban air pollution problem. The methodology adopted may have formed a guideline for such studies and may be useful on industrial scale for various sites.

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