Impact and Ratio of Lead in Ambient Air from Vehicular Emission in Quetta Valley, Pakistan.

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Abstract. Air pollution is the fourth leading fatal health risk factor consider worldwide, resulting in 4.8 million premature deaths in 2013. Lead in Ambient Air remains a serious problem in many developing and industrializing countries, as well as in some developed countries. Toxic effects of lead is affecting many people especially in motorized, urban environments. Pakistan is the most urbanized country in South Asia and deteriorating Ambient Air conditions particularly in large urban cities are damaging the people’s health and quality of life and contributes to environmental degradation. Monitoring of Air Pollution was conducted in Quetta Valley. The seasonal Annual average concentration of Lead in Ambient Air was calculated. The ratio of vehicular emission from exhaust pipe of vehicles was also calculated in Ambient Air. The results were compared with the WHO standards and found four times higher than WHO Standard i.e. 0.5-1 μg. The concentration was found higher in spring and found lower in summer. The results were compared with the major cities of world and within Pakistan. The paper also highlighted the impacts of Lead pollution in Quetta Valley.

Key Words: lead toxicities, Ambient Air, Urban environments, Vehicular emission

1. Introduction

The problem of air pollution is a dominant factor in major cities of the world [1]. Many of the urban centers in the developing countries are beset with the environmental problem especially air pollution due to rapid industrial growth, the population explosion, resource depletion, alteration of the chemical composition of the atmosphere and the cycling of carbon, nitrogen and phosphorous are factors largely responsible for changing the basic physiology of the earth [2]. The WHO criteria pollutants that are responsible for the deterioration of air quality are Oxide of Nitrogen (NOx) Ozone, Oxides of Sulphur (SOx), Carbon Monoxide, Hydrocarbon (HC), Particulate Matters (PM), and Lead (Pb).

Lead is a versatile element due to its low melting point, softness, high density, malleability, ability to form alloys with other metals and resistance to corrosion. There are over 200 naturally occurring ores containing lead. The atomic configuration of lead has the ability to blend with silicate glass to form the colorant. Due to the bright colors it is used in the paints, cosmetics, hair dying and eye shadows. The toxic properties of these compounds have been exploited in the form of pesticides, preservatives and tragically as adulterants especially in wines [3]. Lead is also used in petrol additives. Lead is used to sheathing for electrical cables, shield ionizing radiation, in sound proofing, and soldering. To glaze the tiles the compounds of lead as a poly-vinyl-chloride stabilizer in plastics. The largest use of lead is in the batteries. Therefor the widespread use of lead make lead a strategic and critical element on earth. Now a day the global lead consumption has increase four times and cross the limits of 4 million metric tons. Estimate shows that Lead in atmosphere have exceed 200 times due to anthropogenic sources, about 880 million pounds per year from petrol additives, smelting of lead, iron, zinc and copper and coal combustion. The primary source of lead industrial emissions is still combustion of leaded petrol...
Lead is added to petrol as the organic liquids tetra ethyl lead and tetra methyl lead. About 75% of the lead is emitted from the exhaust pipe of vehicles. Contemporary researches indicate that vehicular exhaust is one of the major or primary source of lead pollution in urban areas. The mean particle size diameter of lead in aerosols in urban air has been reported to be 0.2-0.4 μm [5]. As the particle size is small, the dispersion of exhaust lead can be considered in terms of the well-established theory of diffusion of gases and smokes. Dispersion is determined by wind and turbulence, since the sedimentation velocity of the particles is smaller compared with turbulent air velocities. In spite of the great improvements in most developed countries due to reduced use of leaded fuels, still road emissions of lead remain a persistent air quality problem [6]. Lead and its public health impacts are drawing increased concern from the environment point of view. Objective of this research work was to collect data on the concentration of lead from different sources. Analysis the data to find ratio concentration between ambient air and vehicular emission of lead.

2. Methodology

2.1. Research Location
Quetta is a funnel shape valley and the capital city of Balochistan, Pakistan and lies between 66015/00// to 670 15/00// Easting and 300 00/00// to 300 25/00// Northing in the survey of Pakistan Topo-sheets 34 N/3 & 4 and 34 J/15 & 16. The main valley of Quetta or Shal proper (comprising an area of 1720 sq. km), which unites the two sides at the toe of the horse-shoe, is a parallelogram about sixteen miles by eight [7]. The general character of the city is mountainous. In Quetta city, the three prime locations are selected according to the guidelines provided by the United Nation Environmental Program (UNEP) for the collection of air data i.e. every city has residential, commercial and industrial area. These are illustrated in the map and are briefly defined as below:

2.2. Monitoring Points
2.2.1 Prince Road Choak (Site-1)
Prince Road is an area connecting all the major roads, crossing and commercial sites in Quetta City for example Saleem Complex, Petal Road, and is near the heart of commercial site such as Liaquat Road, Mission road, Quadari Bazar and Alamdar road, etc. Within half a mile of diameter there are also located all the important buildings such as Civil Hospital, Banks, High Court Building, Girls College, State Bank Building, Police Head Quarter Building, Govt. Schools etc. There are all sorts of shops in the vicinity such as cloths, handy craft, shoes, electronics, dry fruits shops, etc. The rush hour of shopping starts from 9:30 A.M. to 8:00 P.M. There are about approximately 10,000 shops in the vicinity.

2.2.2 Satellite town / Bus stand (Site-2)
Satellite Town is a residential area and mobile source. It is densely populated. There are about 10,000 houses and 1000 shops in that area. Adjacent to satellite town there lies Main Bus Stand, about 1000 buses move in and out of the city through this bus stand. Thousands of people travel up and down the country through this bus stand. Within half a mile of diameter there lies residential site of University of Balochistan, University of Balochistan, Phustoonabad, Baloch Colony, etc.

2.2.3 Sirki Road (Site-3)
Sirki road is a small Industrial state situated into the middle of the city. The Industries that are located within vicinity are Chiltan Ghee Mill, Small Industrial Wood Work Center, Soaps Industries, Ice Plants, Marble Cutting Plants etc. Adjacent to Sirki Road there are some residential area also such as Govalmandi choak, Jan Mohammad Road, Faeqer Mohammad Road, etc.

2.2.4 Methodology for Lead in Ambient Air:
Particulate Matter was collected by using high volume sampler, series model 302, Sierra Anderson, USA. The samples were collected at three different sites on Watman 41 filter paper, 20 x 25 cm. the pore size of the filter paper is 0.45 micron. Weighing the filter paper before and after the sampling at constant humidity will give the net weight of the particulate matter in the atmosphere at the particular
site. The sampling time was 10 AM to 9 AM next day. The filter paper than analysis in the atomic absorption spectrometer and value of Lead is found.

2.3. Methodology for Vehicular Emission:

2.3.1. Bladder Method

100 vehicles (20 numbers were auto cycle, 20 numbers were Auto Rickshaws, 20 numbers were motor car, 20 numbers were Wagons and 20 numbers were Bus/Trucks) were selected on different streets in Quetta Valley. Smoke Particles were collected by tying the bladder on the exhaust pipes of the vehicles. The bladders were weight before and after filling the smoke. After collecting the smoke, the bladder were tightly closed for about 24 hour and then air was released in such a way that no smoke particle escape from the bladder. The bladder contents were analysis for lead on atomic absorption spectrometer.

2.3.2. Traffic count

Traffic density at each location was determined using digital photography. Table and graph give daily average of vehicles counted at monitoring sites.

2.3.3. Standards for Lead

The World Health Organization (WHO), European Council (EC), United States Environmental Protection Administration (USEPA) and Russian limit/standards are summarized in table 1.

| Pollutants | WHO | EC  | USEPA | Russia |
|------------|-----|-----|-------|--------|
| Lead       | 0.5-1 | 2.0 | 1.5   | 0.3    |
|            | μg/m³ | μg/m³ | μg/m³ | μg/m³  |

3. Results

The concentration of TSP was experimentally measured in 2013-2014 using high volume sampler at three sites in Quetta valley. The average concentration of particulate matter in ambient air was found 545 μg/m³, which is more than four times the WHO standards, i.e. 70 μg/m³. The measurement shows that out of 545 μg/m³ of particulate matter, the lead concentration in ambient air is 4.058 μg/m³. The lead concentration in ambient air is more than four times the WHO standards, i.e. 0.5-1.0 μg/m³. The highest concentration of lead was recorded at site-1 i.e. 5.8 μg/m³, in the season of spring. This is the main crossing of Prince Road and Jinnah road, the hub of the city. The traffic density at that point was maximum, congestion and traffic jam occurred frequently. The lowest lead concentration was recorded at site-2 i.e. 2.31 μg/m³, in summer. Overall the lead concentration at site-2 and site-3 are approximately equal and site-1 has highest concentration of lead in ambient air. Annual mean seasonal average concentration for 2013-2014 was found 4.058 μg/m³ in ambient air.

The vehicular exhaust is one of the major sources of lead [Pb] contributor in Ambient Air in Quetta city, which are produced from motorcycles, Auto rickshaws, cars, buses, trucks, tractors, pickups etc. Smoke particles were obtained by bladder method from the exhaust of various types of vehicles. The concentration found in the smoke ranged from 1.5 μg to 4.5 μg. The average concentration of lead emitted from vehicles is found 3.25 μg. The percentage ratio of lead in ambient air from vehicles is 80.09 % and other sources contribute only 19.91 %. The results are summarized in table below:
Figure 1. The percentage ratio of lead in ambient air from vehicles Source: Compiled

Figure 2. The percentage ratio of lead in ambient air from vehicles Source: Compiled
Figure 3. The percentage ratio of lead in ambient air from vehicles Source: Compiled

Table 2. The table below shows average lead emission from vehicles Source: Compiled.

| Mode of Transportation | Pb Concentration |
|------------------------|------------------|
| Auto Rickshaw          | 3.0 μg           |
| Auto cycle             | 1.5 μg           |
| Cars/Jeeps             | 4.0 μg           |
| Buses/Truck            | 4.5 μg           |
| Total                  | 13.0 μg          |
| Average                | 3.25 μg          |

Table 3. Average Traffic Flow Per Hour Source: Compiled.

| Sites   | Average Traffic Flow per Hour |
|---------|-------------------------------|
| Site-1  | 793                           |
| Site-2  | 1076                          |
| Site-3  | 524                           |
Table 4. Seasonal Ambient Air Lead concentration in Quetta Valley Source: Compiled.

| Seasons | Site-1 (μg/m³) | Site-2 (μg/m³) | Site-3 (μg/m³) | Seasonal Average (μg/m³) |
|---------|----------------|----------------|----------------|-------------------------|
| Autumn  | 5.2            | 4.11           | 4.24           | 4.5                     |
| Winter  | 4.71           | 3.44           | 3.56           | 3.90                    |
| Summer  | 3.81           | 2.31           | 2.54           | 2.89                    |
| Spring  | 5.8            | 4.7            | 4.28           | 4.93                    |
| Std. Deviation | 0.72 | 0.88 | 0.70 |
| Total   | 19.52          | 14.56          | 14.62          | 16.22                   |
| Average at site | 4.88 | 3.64 | 3.65 | 4.05 |
| Annual  | 4.058          |                |                |                         |
| Average |                |                |                |                         |

Figure 4. Seasonal Variation of Lead in Quetta City

4. Discussion
Recent researches indicate that vehicular exhaust is one of the major or primary source of toxic air pollutants and contribute significantly to emission inventories especially in urban areas [6]. The pollutants which are cause of concern with respect to transport are CO, HC, NOx, PM and Lead [8]. The ground level vehicles use different types of fuels such as gas fueled, petrol fueled, diesels fueled, solar and bio-product fueled. The physical and chemical physiognomies of natural gas, petrol and diesel are dissimilar in regions around the world, like lead, benzene, Sulphur content [9,10] making it difficult for the findings in one site to be generalized to other locations. This complex situation is further complicated by the effect of different meteorological conditions, different percentage of heavy and light polluter vehicles (more motorcycles in the developing world), design of roads (graded or non-graded), driving behaviors, different maintenance level of the vehicles as well as quality of and control measures for vehicles, and at the end most important exposure profiles of the people [11].

Technologically advanced republics have fought for unpolluted air quality by regulating all major and minor sources of air pollution standards. In these countries industrial and vehicular emissions have reduced significantly. For example, due to new motor vehicles emission standards in 1988, new vehicles are designed, which are 90 % cleaner than those manufacture in 1970 but unfortunately in developing countries these standards are not applied or even in some countries there exists no standards to cope with the pollution problem. As the vehicles fleet continue to grow, vehicular emissions and
associated products enter the atmosphere and make changes in the atmosphere. Random acceleration and deceleration due to non-motorized vehicles in developing countries are becoming increasingly important contributors to nearly every major air pollution problem facing the world [6]. In metropolitan cities, where more than 70% of the population confined the levels of vehicle’s pollution frequently exceeded the guideline of WHO standards [1].

Pakistan is one of the unfortunate developing country (EPA laws are not applied properly), now facing the pollution problem from various ways [12, 13]. One of the sources of pollution in Pakistan is vehicular emissions [14]. Pakistan had 0.85 million cars on road in 1982, from 1991 to 2012, the number of motorcycles and scooters grew more than 450%, and motor cars, close to 650% and an average annual growth rate in excess of 8.5%. The economic survey of Pakistan pinpoint that vehicular and industrial emission are the main causes of poor air quality in Pakistan and world bank report says that urban air pollution is causing estimated US $ 369 million to the national economy of Pakistan [1].

Airborne Pb is associated with the density of motor vehicles traffic using fuel and the concentration of Pb additive in the fuel. Most of the petrol/gasoline in Pakistan contains 1.5 to 2.0 g/liter of teta alkyl lead as anti-knocking agent in automobiles. Additionally, so called lead free gasoline available in Pakistan also contains lead quantity ranging from 0.60 to 0.95 g/liter. Lead concentration in all the major cities of Pakistan shows alarming level of lead in ambient air [15, 16]. The lead concentration in all the major cities is more than three times to the standards of WHO and double to the USEPA and EC standards and multiple fold higher from the standard of Russia. In Pakistan a vehicle produces 20 times more HC, 25 times Carbon, 8 times more Lead and 3.6 of NOx in gram per KM compared with an average vehicle in US.

Table 5. Lead concentration in major cities of Pakistan, [16].

| City            | Pb Concentration |
|-----------------|------------------|
| Quetta          | 4.058 µg /m³    |
| Karachi         | 3.954 µg /m³    |
| Peshawar        | 3.915 µg /m³    |
| Lahore          | 3.51 µg /m³     |
| Rawal Pindi     | 3.35 µg /m³     |

Due to reluctance of the Government to implement the Environmental Protection Agency’s laws passed by the Federal Government in 1997. It is feared that an estimated Outdoor air pollution alone caused more than 80,000 hospital admissions per year [1]. The main reason for the deteriorating air quality in metropolis cities is becoming worse because of haphazard industrialization and rapid increase in the number of vehicles. Growing lead concentration in ambient air is also associated with the lead in blood [1, 17]. Lead and its public health impacts are drawing increase concern from the environment point of view [4]. Higher lead level in blood are also recorded in Karachi, Islamabad, Lahore and other major cities of Pakistan [18, 19]. The lead concentration in all the major cities shows more than three times to the standards of WHO and double to the USEPA and EC standards and multiple fold higher from the standard of Russia while the acceptable blood level is ≥5 µg/d L [20], which results in many dangerous diseases such as blood cancer [21]. Similar studies were carried out by Kamal 1996, and Zaidi, 1997, for Quetta Valley and found high correlation between the distribution of lead deposited on roadside trees and the occurrence of high blood pressure, ear, nose and throat related illness, fatigue, gastrointestinal diseases and cancer among people living in those areas. Beside that lead in air have fatal effect on trees and plants [22].

Quetta is the provisional capital of Balochistan with a vehicular density more than 100000 and is increasing at a rate of 12% per year. Measurement in Quetta city shows that organic lead vapors accounts for 80.09% of total lead. The concentration is found higher near filling stations; road crossing, congested and traffic jam places and busy streets/road. Quetta city has heterogeneous traffic flow, a substantial part of total traffic is non-motorized which enhance severe congestion and pollution.
problems especially on road intersection. The popular mode of transport is two stroke engine/motorcycles and Rickshaws and reliance on private cars. Journeying through by buses or public transport especially is very low. A slow and reckless driving habit of the Quetta’s population is also one of the main causes that burns more fuel and in return high emission of lead from vehicles.

Quetta is a boarder city therefore smuggle oil/gasoline is easily available in the city. The smuggled oil/gasoline is not of high quality and has high contents of lead and Sulphur. The situation gets worse when adulteration/impurities/ mixing are added to gain little profit. Because of smuggled oil/gasoline decline in sell is recorded at government approved Petrol Pumps and this is severely affecting the economy of the country. In Quetta majority of the vehicles are more than five to six years old because government of Pakistan gave subsidies tax rate to allow import of reconditioned automobiles more than five-year-old. In addition to this, different kinds of second hand engines are imported/ smuggled from different part of the world whose economical life is over.

Government had introduced compressed natural gas (CNG) and liquid Petroleum gas (LPG) used as alternate fuel in automobiles. For example, Introduction of four stroke Rickshaws in Quetta Valley to cope with the problem of air pollution is an effort by the Government. According to the Government these Rickshaws are environmentally friendly and are able to provide door to door services in the streets geometry of the congested and narrow roads of Quetta city. These Rickshaws which are built locally and are without catalytic converter therefore they also add lead concentration in the ambient air. [13, 23, 25, 26]. Due to some of the above reasons and non-compliance of adequate air quality standards, Quetta is becoming one of the top-most Lead polluted city in the world. Lead concentration in major cities of the World is given in table 6.

| City     | Pb Concentration | City     | Pb Concentration |
|----------|------------------|----------|------------------|
| Quetta   | 4.058 µg/m³      | Calcutta | 0.73 µg/m³       |
| Mexico   | 3.83 µg/m³       | Delhi    | 0.67 µg/m³       |
| Bombay   | 3.60 µg/m³       | Jakarta  | 1.86 µg/m³       |
| Dhaka    | 3.12 µg/m³       | Manila   | 1.3 µg/m³        |
| Sydney   | 3.33 µg/m³       | London   | 0.229 µg/m³      |
| Santiago | 2.30 µg/m³       | Moscow   | 0.07 µg/m³       |
| Los Angeles | 0.70 µg/m³ | New York | 0.12 µg/m³     |
| Kyoto    | 0.40 µg/m³       | New Jersey | 0.41 µg/m³ |

**Figure 5. Standards Comparison of Lead Level with Quetta City Source: Compiled**
5. Conclusions

The study analysis that Quetta is becoming one of the topmost Lead polluted city in the world. It is also well-established fact that Lead in Petrol/gasoline is the major source of Lead pollution in ambient air. At present there is no legislature regulation to check and control the content of Lead in Petrol/Gasoline in Pakistan. Establishment of proper rule & regulation and strict enforcement of these regulations are needed to control the Lead and other toxic pollutants in air for the safety and health of the general public.

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