UNLEADED GASOLINE AND LEAD LEVEL IN HUMAN BLOOD

Kim Dae-Seon, Cha Joung Hoon

Dept. of Epidemiological Survey
National Institute of Environmental Research, 2-1 Kyung Seo Dong, Inchon, Korea

ABSTRACT: Rapid economic development and industrialization has been accompanied by an increase of energy demand and environmental pollution. The consumption of gasoline has increased totally, but decreased in use of leaded gasoline after 1988 in Korea. On the other hand, risk assessment of environmental pollutants requires reliable dose estimates. Source oriented monitoring is not providing adequate information to estimate human exposure. The Health Surveillance Project has been launched in Korea from 1980, which questioned their symptoms based on questionnaires and medical examinations for inhabitants in the vicinity of 13 industrial areas and 2 non-industrial areas. 10,598 inhabitants living in these 15 areas had medical checkups and donated their blood for heavy metal analysis from 1980 to 2000 through this project. Especially lead levels in inhabitants' blood of these areas were determined and monitored. Totally 4,967 samples in target areas were used to review the trend of blood lead level in this paper. Average lead concentrations by areas were from 15.2 to 21.0 ug/dl in 1981 and 22.3 to 34.3 ug/dl in 1988, but were 8.8 to 11.1 ug/dl in 1992 and 4.4 to 4.8 ug/dl in 1995. On the other hand, the consumption of leaded gasoline was at a peak in 1988. Blood lead level showed a very close relationship with the consumption of leaded gasoline in the change pattern($p<0.01$) and showed a rapid declining trend since the use of unleaded gasoline, especially from 1988 when Seoul held the olympic games. For example, the blood lead levels were 15.2 ug/dl in 1981, 20.2 ug/dl in 1985, 24.3 ug/dl in 1988 and 3.9 ug/dl in 1993 in Yochon area.
China also had monitored blood lead levels of general population. 7,015 inhabitants living in 28 areas donated their blood for heavy metal analysis from 1981 to 1988. Average lead concentrations by areas were from 5.1 to 8.6 ug/dl before 1984 but were from 2.8 to 11.2 ug/dl after 1984. Average lead concentration in blood showed increasing trends clearly in most of the areas. The recent policy of unleaded gasoline use for automobile will be a very beneficial policy for the management of atmospheric lead pollution & health risk assessment for the general population in China. It is recommended that it should be propelled more widely and rapidly to the entire country.

Keyword: Monitoring, Lead, Blood

1. INTRODUCTION

Lead in humans may originate from many different sources. Lead is present in the working environment, in ambient air, in drinking water, in food, and in nonfood items such as, for example, paint. The best way to estimate total exposure is, therefore, through biological monitoring. This is possible because sufficient information on metabolism is available. The lead level in blood is the best indicator of current exposure, absorption, distribution and elimination of lead(Friberg et al., 1985).

The main sources of human exposure to lead include leaded gasoline, industrial process such as lead smelting and coal combustion, lead-based paint, and lead- containing pipes or lead based soldier in the water supply system. The special properties of lead to improve auto engine performance by increasing the resistance of the internal combustion engine to early ignition(measured by the octane rating of gasoline) was discovered in 1921. By the 1970s, the worldwide use of lead as a gasoline additive reached 375,000 tons(Lee, Chung, 1993). However vehicular traffic remains the single largest source of environmental lead pollution in most urban areas in developing countries, typically accounting for over 90% of all lead emissions into the atmosphere(Friberg et al., 1985). Besides posing an immediate health risk through inhalation, vehicular lead emissions also accumulate in the soil, and enter the food chain, contributing to exposure through ingestion for long periods of time. High blood lead levels have been detected in urban areas where gasoline with high lead content is widely used, contributing to large public health costs. In Jakarta, for example, these costs were estimated between US$ 40 and 97 million in 1990(World Bank. 1995).

In 1982, the results of an international UNEP/WHO project(Marie et al., 1991) of human exposure to lead and cadmium through biological monitoring showed that there was considerable variation in metal exposure between the areas studied(median value ranged from 60 ug pb/l in Beijing and Tokyo to 346 ug Pb/l in Mexico city). The reasons for the differences in blood lead levels among the countries were estimated, however, that lead in gasoline may be one important source of exposure to lead.

In Japan, lead in regular gasoline was phased out in 1985 and lead has not been added to total gasoline including premium gasoline from 1986. Korea has begun not to use leaded gasoline partially by newly produced automobiles from July, 1987 and lead in automobile gasoline has been totally phased out from 1994(MER, 1997).

Recently, China has also begun to provide unleaded gasoline initially in Beijing from June, 1997 and expanded to supply it to Shanghai, Tianjin, Guangzhou in 1997, and will provide it to the entire country by 2000. It is remarkable to phase out lead in gasoline for health risk assessment and management in China.

In order to provide a reference for the policy establishment of unleaded gasoline provision to some countries using leaded gasoline including China, we introduce a change of blood lead level in the general population according to the use of unleaded gasoline through the brief introduction of the health surveillance project in Korea.

EXPERIMENTAL METHODS

2.1 Survey Design of The Health Surveillance Project

The health surveillance project for the inhabitants in the vicinity of industrial areas was initiated in 1980 not only to assess exposure to environmental pollutants but also to prevent environmental diseases for the inhabitants in the vicinity of industrial areas and to identify the causal relationship between pollution and environmental diseases in Korea.

Target area was the area within 3-4 km from an industrial complex which the regional EPA pointed out. Finally, 13 industrial areas and one non-industrial area have been covered to 1997(MOE, 1994, MOE, 1997).
In the first year of this project, only one area, Ulsan was surveyed. From the 2nd year, 2-4 areas have been surveyed every year by the request of the regional EPA. But, it has been impossible to monitor the same area every year, the same population every time because of some difficulties including the budget situation. So, it was designed to survey one area again about every 5 years.

The project have had some changes in design. In the beginning stages of this project, a target area and a comparative area were pointed out and surveyed in one industrial area and it had been continued until 1987. The comparative areas have been the most far administrative units without any industrial factory in the boundary of that area. Since 1988, according to the survey result to 1987 which shown no differce between 2 areas in medical checkups, only target area has been pointed out and the comparative area has not been surveyed in one survey area anymore. But for the reference, two non-industrial areas were surveyed in 1988 and 2000 respectively. Totally, 10,598 inhabitants living in these 15 areas had been questioned of their symptoms based on questionnaires and underwent medical examinations for this project from 1980 to 2000. Table 1 shows number of annual medical checkups by area from 1980 to 2000.

Table 1. Annual Medical Check-ups for Local Residents by Area

(unit : person)

Area	1980-1987	1988-1992	1993	1994	1995	1996	1997	1998	2000	Total
Ulsan	1,899	-	-	-	143	-	-	401	-	2,443
Onsan	1,639	52	-	241	-	-	-	-	-	1,932
Yochon	1,063	128	247	-	-	-	-	-	-	1,438
Pohang	812	163	-	-	-	-	-	-	-	975
Pusan[1]	880	145	-	-	-	165	-	-	-	1,190
Taegu[1]	201	145	-	-	-	185	253	-	-	784
Kangnung[2]	-	150	-	-	-	-	-	-	-	150
Kumi	-	147	-	-	-	-	-	-	-	147
Taejon[1]	-	143	-	169	-	-	180	-	-	492
Inchon[1]	-	136	-	-	-	-	-	-	-	136
Chonju	-	135	-	-	-	-	-	-	-	135
Yongam[3]	-	164	-	-	-	-	-	-	-	164
Kunsan	-	-	223	-	-	-	-	-	-	223
Chongju	-	-	-	-	311	-	-	-	-	311
Chunchon[2]	-	-	-	-	-	-	-	-	78	78
Total	6,494	1,508	470	410	454	350	433	401	78	10,598

1. Great towns of which population is 1-4 million
2. Non-industrial area which was surveyed as a reference area in this project
3. Rural area of which the population is about 10,000
4. The others are middle & small towns

2.2 Target Group

As mentioned above, target areas have been selected according to the request of regional EPA every year. Female volunteers greater than 20 years of age in those areas have been selected under some conditions. Those conditions are as follows ;

- They should be nonsmokers more than 5 years
- They should have lived in that area for more than 5 years
- They shouldn't have had any vocational exposure

These conditions had been also applied to the comparative areas to 1987.

2.3 Medical checkups

Before a medical checkup is actually provided, preliminary tasks were carried out. Among them, environmental factors at target areas were studied, and the residents to be examined and local medical institutions to be used were selected. A survey of the residents was then conducted through questionnaires concerning individual characteristics, their health situation and symptoms. The main medical checkups themselves included a full battery of tests such as a blood & urine tests, an X-ray, a pulmonary function test, a liver function test, and a doctor's medical examination. The participating doctors endeavored to identify patients who had contracted an environmental disease, based on the results of various tests.

2.4 Analysis of lead in blood

In this context, some heavy metals in blood including lead have been determined. Blood samples were taken from the cubical vein of each volunteer, especially before breakfast for other chemical examinations. National Institute of Environmental Research(NIER) has taken part in the blood lead alaysis and lead in each sample has been determined by atomic absorption spectrophotometer(AAS). But a flame AAS (Perkin Elmer 372) with D.D.T.C.-M.I.B.K. extraction method had been used to 1989 and a flameless AAS(Perkin Elmer 5100) equipped with HGA 500 has been used since 1990.

For the quality assurance in flameless AAS, recovery tests have been made using an additional method in laboratory. Usually 5, 10 and 20 ug/dl of lead have been added to blood samples and recovery rates have showed 99.7 - 101.2 %. NIER also has joined an external quality control program for blood lead determination since the introduction of a flameless AAS. On the ther hand, when flame AAS had been used, recovery tests had been also done. But, detailed information on quality assurance were not recorded except the results of medical checkups and some metal concentrations in samples.

RESULTS

The results of lead analysis in blood in 15 areas and for 20 years were summarized in Table 2. But sample size in this table is a number of blood samples for blood lead levels in total medical checkups. Totally 4,967 samples were selected among 10,598 medical checkups for the same conditioned target groups of every year. Average concentrations ranged 15.2 - 21.0 ug/dl in 1981, 22.3-34.3 ug/dl in 1988, 8.8-11.1 ug/dl in 1992 and 4.4-4.8 ug/dl in 1995. They showed increasing trends to 1988 but showed decreasing trend thereafter.

On the other hand, in order to explain the change pattern of average, we studied the the trend of gasoline consumption and the estimated amount of lead emission from gasoline. Leaded gasoline was consumed at 4,615 thousand barrels in 1982 and increased thereafter. The consumed leaded gasoline was 10,541 thousand barrels and at a peak in 1988.

On the other hand, unleaded gasoline has been begun to be consumed since 1987 and the consumption of leaded gasoline showed a declining trend since 1988, which Seoul held the olympic games. Moreover, it showed a steep declining slope since 1993 as we could found that it was consumed at 5,432 thousand barrel in 1992 and 301 thousand barrel in 1993 (MOER, 1997). They were summarized in Table 3.

Table 2. Average Concentrations of Blood Lead by area and Year

(unit : ug/dl)

Year	Ul san	On san	Yo chon	Po hang	Pu san	Tae gu	Kang nung	Ku mi	Tae jon	In chon	Chon ju	Yong am	Kun san	Chong ju	Chun chon
'80	10.4 (110)														
'81	18.7 (100)	21.0 (50)	15.2 (50)	17.0 (50)											
'82	18.0 (53)		17.2 (48)												
'83	20.8 (30)				17.2 (51)										
'84		21.3 (52)		31.1 (53)											
'85		17.6 (180)	20.2 (60)												
'86	18.1 (64)				24.3 (86)										
'87				25.6 (85)		19.0 (109)									
'88			24.3 (126)				22.3 (149)	34.3 (146)							
'89									22.2 (142)	18.3 (136)					
'90				19.4 (141)	13.9 (139)										
'91		17.3 (52)									10.3 (130)				
'92						8.8 (145)						11.1 (159)			
'93			3.9 (245)										3.4 (219)		
'94		3.7 (241)							3.6 (169)						
'95	4.4 (143)													4.8 (311)	
'96					4.3 (165)	3.3 (185)									
'97						2.8 (102)			2.9 (75)						
'98	3.8 (399)														
'00															3.35 (17)

( ) is number of blood samples

Table 3. The Trend of Gasoline Consumption and Estimated Lead Emission

Year	Consumed gasoline(thousand barrel)			Estimated lead emission(ton)		
	Leaded	Unleaded	Total	Leaded	Unleaded	Total
1980	7,019	0	7,019	334.8	0	334.8
1981	6,004	0	6,004	286.3	0	286.3
1982	4,615	0	4,615	220.1	0	220.1
1983	4,622	0	4,622	220.4	0	220.4
1984	5,395	0	5,395	257.3	0	257.3
1985	6,914	0	6,914	329.8	0	329.8
1986	8,557	0	8,557	408.1	0	408.1
1987	10,047	307	10,354	479.2	0.6	479.8
1988	10,541	3,037	13,578	502.7	6.3	509.0
1989	9,926	8,369	18,295	473.4	17.3	490.7
1990	8,687	15,006	23,693	414.3	31.0	445.3
1991	7,108	21,605	28,713	339.0	44.7	383.7
1992	5,432	29,816	35,248	259.1	61.6	320.7
1993	301	42,207	42,508	14.4	87.2	101.6
1994	168	50,943	51,111	8.0	105.3	113.3
1995	179	59,208	59,387	8.5	122.4	130.9
1996	56	67,015	67,071	2.7	138.5	141.2
1997	0	71,358	71,358	0	147.5	147.5
1998	0	61,089	61,089	0	126.3	126.3
1999	0	63,879	63,879	0	132.0	132.0
2000	0	62,382	62,382	0	128.9	128.9

Even if different areas have been surveyed every year, a remarkably close relationships have been shown between the consumption of leaded gasoline and blood lead level(Figure 1) and between the amount of estimated lead emission and blood lead level(Figure 2). Moreover, the values of blood lead level by year have showed declining trends according to the consumption of leaded gasoline since 1988($p<0.01$).

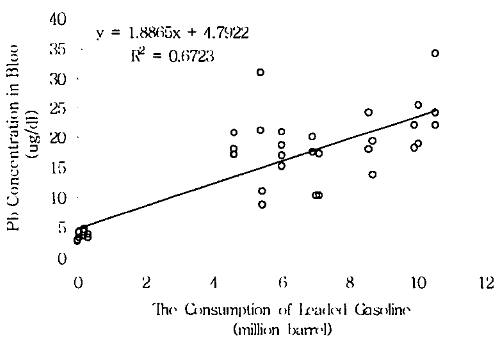

Fig. 1. Correlation between Consumed Leaded Gasoline & Blood Lead Level

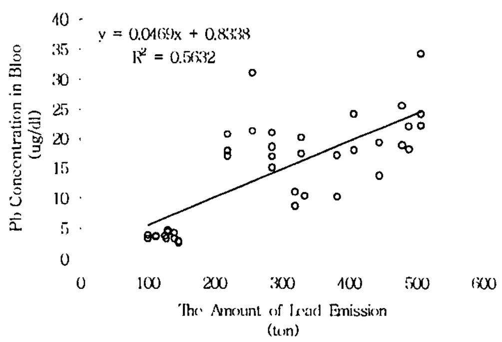

Fig. 2. Correlation between Lead Emission & Blood Lead Level

DISCUSSION

4.1 Health Effect of Lead

Lead in the environment may enter the body through either inhalation, oral intake or percutaneous absorption. The latter route is considerably less significant than the respiratory and gastrointestinal routes for uptake of inorganic lead(Marie et al., 1982). Lead has long been recognized as a neurotoxin. However, it's adverse effects on the brain development of children at lower concentrations were not understood until the 1970's, when scientific evidence showed that lead retarded the mental and physical development of children, causing reading and learning disabilities, hearing loss, hyperactivity, and reduced attention span even at low levels of exposure. A highly significant association has been found between the exposure of children to lead and their IQ(Fu et al., 1993). In adults, exposure to even low concentrations of lead has been demonstrated in elevated blood pressure and hypertension, resulting in an increased risk of cardiovascular diseases. No threshold has been identified under which adverse health effects cannot be detected.

Ingestion is the main route of exposure to lead in children, who represent the highest risk group due to their propensity to ingest significant quantities of contaminated dust and dust and soil, the high lead absorption rate of their digestive systems, and the susceptibility of their nervous systems to lead-induced disruptions. Adults are more susceptible to lead exposure through inhalation(Kang et al., 1996).

4.2 Leaded Gasoline

Countries around the world are at various stages of tackling the problem of human exposure to traffic-related lead emissions. Many countries have simultaneously reduced the lead content of gasoline and increased the market share of unleaded gasoline. In some countries, the introduction of unleaded gasoline was initially driven by the intention of protecting the catalytic converters of new cars that were installed to reduce tailpipe emissions of various pollutants and required the use of unleaded gasoline. In others(for example, in the European Union), the regulation of lead levels in gasoline preceded the wide spread use of catalytic converters. Lead has been totally phased out from gasoline in several countries including Austria, Brazil, Colombia, Japan, New Zealand, Slovakia, Sweden and Thailand. In a large number of developing countries, however, the use of gasoline with high lead content (frequently exceeding 0.8 grams per liter) is still standard practice, and unleaded gasoline has not been introduced yet(e.g., Cuba, Bangladesh, India, Lebanon, Uganda, Zimbabwe). Without significant changes in public policies, leaded gasoline can be expected to create large health damages in these countries as their urbanization and motorization increases (World Bank, 1995 / Shi. et al., 1996).

4.3 Lead Emission from Gasoline in Korea

Standard of lead concentration in gasoline is less than 0.3g/l in leaded gasoline and less than 0.013g/l in unleaded gasoline(KGC, 1989). If we estimate the amount of lead emission using these standards, it will be 479.8 tonnes in 1987, 509.0 tonnes in 1988, 490.7 tonnes in 1989, 445.3 tonnes in 1990, 101.6 tonnes in 1993 and 147.5 ton in 1997. Anyway, the consumption of leaded gasoline and the amount of estimated lead emission peaked in 1988 and declined thereafter. The trend of gasoline consumption and estimated lead emission in Korea was shown in Table 3.

A number of countries include lead in their ambient air quality standards, which is average concentration for 3 months not to exceed 1.5 ug/m^3 in Korea(Lee, 1993). China also includes lead in ambient air quality standard as a seasonal average not to exceed 1.5 ug/m^3 and yearly average not to exceed 1.0 ug/m^3 (NEPA, 1996). The standard for atmospheric lead was established in 1992 in Korea (MOE, 1997). And the health surveillance project has been focused on medical checkups to prevent environmental diseases. That's a major reason that atmospheric lead levels were not determined in surveyed areas at those times.

For the reference, The declining trend of atmospheric lead concentrations in 7 major cities in Korea was shown in table 4 and 5 of them are surveyed areas of this health surveillance project. Available data were from 1993 to 1996.

Table 4. Atmospheric Lead Concentrations in Major Cities in Korea (unit : ug/m^3)

Year	Seoul	Pusan	Taegu	Inchon	Kwangju	Taejon	Ulsan
1993	0.2090	0.1759	0.0476	0.2588	0.0536	0.2573	0.0866
1994	0.1907	0.1438	0.0439	0.2455	0.0470	0.2761	0.0826
1995	0.1844	0.0705	0.0138	0.2427	0.0487	0.3666	0.0457
1996	0.1495	0.1023	0.0315	0.2160	0.0442	0.1405	0.0662
1997	0.1088	0.0829	0.0302	0.1704	0.0331	0.1806	0.0688
1998	0.0936	0.1096	0.0358	0.1256	0.0089	0.0885	0.0703
1999	0.0984	0.1030	0.0367	0.1263	0.0086	0.0990	0.0663

4.4 Lead in Blood

NAS collected and analysed 801 blood samples from 14 countries and suggested the mean value as 17±21 ug/dl & the range as 15-60 ug/dl(Lee, Chung, 1993). Marie et al.. (1982) reported mean value of lead concentration in nonsmokers was 20.5 ug/dl in Bangalore, 6.2 ug/dl in Beijing, 15.0 ug/dl in Brussels, 8.5 ug/dl in Jerusalem, 5.7 ug/dl in Tokyo, 9.6 ug/dl in Lima, 22.7 ug/dl in Mexico city, 7.2 ug/dl in Stockholm, 7.1 ug/dl in Baltimore, 9.6 ug/l in Zagreb through an UNEP/WHO project. Friberg et al.(1985) also reported the data in 1981 and 1983 as the result of an international UNEP/WHO project that lead concentration in blood in 4 countries was 16.5 and 13.7 ug/dl in Belgium, 30.7 and 24.3 ug/dl in Malta, 26.9 and 19.5 ug/dl in Mexico and 8.3 and 5.9 ug/dl in Sweden. The reason for the differences in blood lead levels among the countries estimated, however, is that lead in gasoline may be one important source of exposure to lead. Gu et al.(1998) in China mentioned normal value of Blood lead is less than 40 ug/dl. Swedish EPA(1993) reported that blood lead level of non smoking female in Stockholm was 1.5-44 ug/dl.

Korea also had its own reference value of heavy metals in blood of the general population. 13.02±6.64 ug/dl was suggested as an average lead concentration for women in Korea in 1989(Cho et al.. 1989) But, according to the change of gasoline consumption, the necessity of new reference value was increased. In 1997, the survey was accomplished in some areas which didn't have any metal pollution source, and had comparatively low air pollution. Finally less than 8.54 ug/dl of blood lead concentration was suggested for nonsmoking females and less than 10.11 ug/dl for smoking males as reference values(Lee et al., 1997).

If a health surveillance project has been designed for only blood lead level, the follow up study of the same people in non-industrial areas is more recommandable. But, the health surveillance project has focused on cross-sectional medical checkups, not on the trend of blood lead level. Although it has been surveyed in the vicinity areas of Industrial Complexes, they are mixed areas with inhabitation areas, lead levels in ambient air in large towns including industrial complexes which is mentioned in Table 4 have been under the national ambiant air standard, and blood lead levels have been in normal reference values. In this context, we think that blood lead levels in these areas also can be considered as general levels and that's the reason they can be used to review the trend of blood lead level in Korea.

Even if different areas have been surveyed every year, a remarkably close relationship has been demonstrated between the consumption of leaded gasoline and blood lead levels. The consumption of leaded gasoline was at a peak in 1988 and declined thereafter. The amount of estimated lead emission was also at a peak in 1988 and showed the declining trend to 1995. Blood lead level showed a very similiar pattern with the consumption of leaded gasoline and the amount of estimated lead emission in their change pattern during 20 years. The relations between blood lead levels from 39 times of survey in 15 areas and the consumption of leaded gasoline were studied and showed a very close relationship($p < 0.01$). Moreover, the values of blood lead level by year have showed declining trends according to the consumption of leaded gasoline since 1988($p<0.01$). And 7 areas(Ulsan, Onsan, Yochon, Pohang Pusan, Taegu, Taejon) which have been surveyed more than 3 times for 18 years showed very clear patterns. For example, the blood lead levels were 15.2 ug/dl in 1981, 20.2 ug/dl in 1985, 24.3 ug/dl in 1988 and 3.9 ug/dl in 1993 in Yochon and 19.0 ug/dl in 1987, 8.8 ug/dl 1992, 3.3 ug/dl in 1996 and 2.8 ug/dl in 1997 in Taegu. They showed a remarkable decrease in blood lead level since 1988. That is a significant reason that we consider the consumed amount of leaded gasoline affects the blood lead level. Figure 3 shows the relationship between blood lead level and year. And for the reference, the declining trend of the highest blood lead level by year according to a decrease in leaded gasoline consumption was depicted in Figure 4.

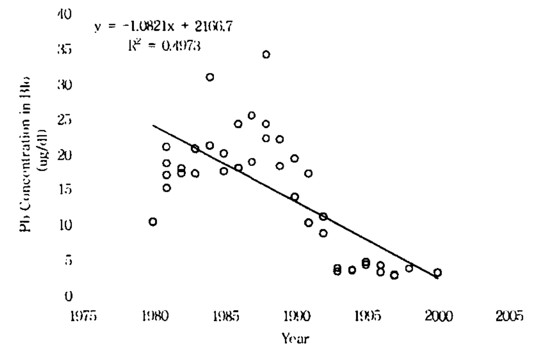

Fig. 3. Correlation between Blood Lead Level & Year

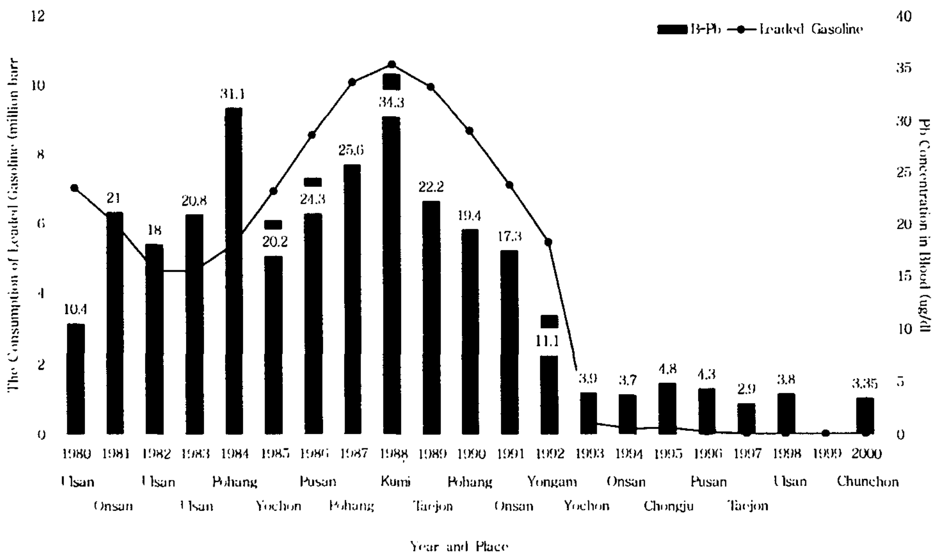

Fig. 4. The Trend of Blood Lead Level and The Consumption of Leaded Gasoline

Centers for Disease Control and Prevention in United States(CDC)(1994) reported average values of blood lead level in American have decreased from 12.8 ug/dl to 2.8 ug/dl, and also reported average values of blood lead level in children have decreased from 15.0 ug/dl to 2.7 ug/dl(1994).

4.5 Chinese Situation

Recently, China has developed rapidly and environmental science is also highly developed correspondingly. From the 1980's the number of vehicle have increased rapidly in China, and the increase rate has been about 13%, vehicle population was about 10.40 million at the end of 1995(CBS, 1997). According to urbanization, vehicle population increased in great cities. The amount of gasoline consumption and the estimated lead emission increased rapidly too. But lead levels in ambient air in these areas were under the environmental standard and the general levels(He et al., 1996). Shi et al.(1996) introduced the increase of vehicle, gasoline consumption and lead emission by year in China. They were summarized in table 5.

Table 5. The Increase of Vehicle, Gasoline Consumption & lead emission by Year in China

	'80	'82	'84	'86	'87	'88	'89	'90	'91	'92	'94	'95
No. of vehicles (million units)	1.78	2.05	2.60	3.62	4.08	4.64	5.11	5.51	6.06	6.92	9.42	10.4
Gasoline consumption[1] (million ton)	-	-	-	15.0	16.2	17.9	18.5	18.9	22.1	25.1	27.0	-
Estimated lead Emission (ton)	-	-	-	1338	1392	1472	1566	1640	1594	1756	1695	-

* Gasoline in this table means leaded gasoline.

On the other hand, blood lead levels in the general population had been monitored in China under the WHO/UNEP project. 7,015 inhabitants living in 28 areas had donated their blood for heavy metal analysis from 1981 to 1988. The result of monitoring in China was summarized in table 6.

This table shows blood lead level of 3,838 nonsmoking females in 28 cities in China. Blood lead level by areas was 5.1 - 8.6 ug/dl before 1984 but was 3.6 - 11.2 ug/dl from 1984 to 1986 and 2.8 to 9.2 ug/dl from 1984 to 1986. Blood lead level showed increasing trends clearly in most of the areas which the monitoring survey was carried out more than once, like Beijing, Baoding, Shanghai, Nanjing, Hangzhou, Fuzhou, Jinan and Xian.

Table 6. Average Blood Lead Concentration of Non-smoking Female by Area and Year in China

(unit : ug/dl)

Year	Bei Jing	Bao Ding	Tai yuan	Huho hot	Shen yang	Chang chun	Haer bin	Cece haer	Shang hai	Nan jing	Hang zhou	He bei	Fu zhou	Nan chang
'83-'84	5.6 (118)	6.4 (97)					8.6 (126)		7.5 (86)	5.1 (118)	6.0 (120)			
'85-'86	6.3 (121)	7.7 (22)		5.1 (97)	11.2 (126)				7.6 (193)	5.5 (60)	7.3 (50)	5.6 (63)	6.7 (120)	
'87-'88		9.2 (52)	5.8 (110)			6.0 (126)		2.8 (107)	8.0 (59)	5.3 (53)		5.3 (73)	7.0 (55)	7.6 (99)

Year	Ji nan	Zeng zhou	Wu han	Chang sha	Guang zhou	Nan ning	Chong qing	Cheng du	Gui yang	La sa	Xi an	Xi ning	Yin chuan	Urumu chi
'83-'84	6.3 (125)						5.1 (67)				5.8 (112)			
'85-'86	7.6 (45)					5.4 (117)	3.6 (43)	5.3 (110)		8.5 (32)		6.8 (68)		
'87-'88		5.9 (87)	5.6 (88)	6.4 (110)	7.4 (120)	5.4 (54)			6.3 (97)		6.1 (51)	6.1 (51)	6.1 (104)	4.0 (106)

( ) is number of blood samples

China has begun to use unleaded gasoline for automobile in the Beijing area since June 1, 1997, and it was also introduced to Shanghai, Tianjin and Guangzhou in the same year. According to this policy, unleaded gasoline will be provided to the entire country by the year 2,000. This is a very proper policy for the management of health care and health risk assessment of the general population in China. Even if the informations after 1988 of blood lead level were not included in this paper, it is estimated that blood lead level of the general population would increase by the end of 1990's in China(Zheng et al., 1990). In this context, It is recommended that unleaded gasoline policy should be propelled more widely and rapidly and recommanded also the blood lead level of the general population to be monitored for several years, which is before and after unleaded gasoline is provided to the whole country in order to assess lead exposure and health risk management in China.

REFERENCES

Chinese Bureau of Statistics(1997), *Chinese Yearly Statistics*, CBOS

Cho T. W. et al(1989), Studies on the Content of Trace Metals in Human Biological Samples, *NIER Annual Report* Vol. 11

Fu et al(1993), The Effect of Env. Lead Pollution to Intellectual Quality in Children, *Chinese Journal of Hygiene Research*, Vol. 22, Supplement 4

Gu Xinping et al. (1998), Env. Lead Pollution & Health, *World Elemental Med.*, Vol. 5, No.1

He K.B. et al(1996), The Status & Trend of Vehicle Pollution in China, *Chin. J. Env.Sci.*, 17(4)

Kang,I.G.(1996), *Studies on the Assess. of Bio. Exposure to Heavy Metals*, NIER,Korea

Friberg L. et al.(1985), *Assessment of Human Exposure to Lead*, Karolinsks Ins.,Sweden

Lee, Ch. K.(1993), *Environment and Health*, Haso Press

Lee, Y. H., Chung M. H.(1993), *Metal and Man*, Shinkwang Press

Lee, Y. W. et al(1997). *Estimating the Reference Value of Heavy Metals in Blood and Urine amoung the Residential Area population*, NIER, Korea

World Bank(1995), *Environmental Department Dissemination*, Note No. 32

Marie Vahter et al.(1982), *Assessment of Human Exposure to Lead and Cadmium through Biological Monitoring*,

Karolinsks Institute, Sweden
Marie Vahter et al.(1991), Methods for Integrated Exposure Monitoring of Lead and Cadmium, *Env. Research* 56, 78-89
Ministry of Energy & Resources(MER) (1997), *Yearly Report of Energy*, MER, Korea
Ministry of Environment(MOE) (1994), *The Report of Comprehensive Analysis & Assessment on The Health Surveillance Project in Korea*, MOE, Korea
Ministry of Environment(1997), *Environmental Protection in Korea*, MOE, Korea
NEPA(1996), *Ambient Air Quality Standard*, GB3095-1996, NEPA, China
Swedish Env. Protection Agency(SEPA)(1993), *Envi. Pollution and Health*, SEPA
US Centers for Disease Control and Prevention(CDC)(1994), *Blood Lead Level Laboratory Reference System*, 'http://www.cdc.gov/neeh/pubcantns/1994/cdc/fshe et/bllrs.htm'
US CDC(1997), *Blood Lead Level Keep Droping - New Guidelines Recommended for Those Most Vulnerable*, 'http://www.cdc.gov/nhanes'
Zheng X. Q. (1990), *Status and Trend of Toxic Substances in Human Body in China. Vol. 2 Lead and Cadmium*, Chin. Resear. Insti. of Preventive Med.
Shi D. H., Zh Z. W., Wu G. Sh(1996), *Research on Lead Phase out in Gasoline in China*, The Report of Lead Phase out Research Group, p. 2-3, 10-11