Lead Pollution in Iraqi Kurdistan Region

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Abstract **-- In addition to the research which was published by the authors which dealt with different environmental issues in Iraqi Kurdistan, this research deals with a specific type of very dangerous pollution to the health and the environment which is represented by lead as a hazardous and poisonous matter.**

This environmental issue was tackled in two ways.

The first one is a result of the big increase in the volume of vehicles which are registered and used in the region during the last few years which is accompanied by a comparable increase in the numbers of scrap batteries with a potential risk of what they contain from lead which is regarded as a very dangerous contaminant to the health and environment and also Sulphuric Acid (H2SO4) which is contaminant as well.

The second environmental hazard is caused by the large increase in oil production and refining in Kurdistan during the last few years. This is accompanied by a comparable increase in the production of Gasoline which is connected by an imminent increase in the consumed Tetra Ethyl Lead (TEL) which is used as an additive to the Gasoline in order to improve its qualities and to increase its octane number. The emitted lead to the air from this TEL after being used is proved to be as a very harmful and hazardous substance.

The researchers have collected some statistics from reliable sources to be used as a tool to perform this research and to tackle these environmental issues in a quantitative manner.

At the end, some relevant conclusions were deduced and adequate recommendations were made as outlined below:

- **The big increase in the numbers of vehicles which are registered and used in Kurdistan Region generally, which is accompanied by a comparable increase in the used scrap batteries and the connected increase in the production of lead pollutant as a very hazardous and poisonous matter was in the order of 11.51 times between 2006 and 2011, whereby the amount of lead produced from scrap batteries reached an amount of 3705 tons in the year 2011.**
- **In addition to these amounts of lead pollution from scrap batteries which are left on the ground surface, another pollution due to Sulphuric Acid (H2SO4) as a component of these left scrap batteries was recorded during that period but to a lesser extent. The increase of pollution due to this acid increased by 11.52 times between 2006 and 2011. The recorded amount of this pollutant acid reached 841 tons in 2011.**
- **The increase in the capacities of oil refining in Kurdistan Region, which indicated an overall increased level of consumption of TEL (Tetra Ethyl Lead) by the order of 12.4 times between 2006 and 2011, is accompanied by an imminent increase of the risk of lead pollution in the same order during that period, whereby the amount of pollution due to lead from such source reached an amount of 1039 tons during 2011.**

***Keywords*-- hazardous, pollutant, contaminant, TEL (Tetra Ethyl Lead), octane number, emission, catalytic, antiknock, automotive, toxic, occupational disease.**

I. INTRODUCTION

The use of TEL (Tetra Ethyl Lead) as a gasoline additive is especially important because of its implications for catalytic converters, gasoline composition, antiknock performance, valve wear, engine life and lead emissions. Worldwide, motor vehicles consume over 2 billion liters of gasoline every day, about two thirds of which is unleaded [6].

A fuel's octane number is a measure of its resistance to detonation and "knocking "in a spark-ignition engine. Knock reduces engine power output, and severe or prolonged knock damages the engine. The past twenty years have seen a substantial reduction in the use of lead in gasoline as the adverse health impacts of lead have become better known. Lead in the environment is poisonous to humans, and the lead antiknocks in gasoline are by far the largest source of lead aerosol- among the most toxic air pollutants in many developing countries, including Iraq [6].

Historically, controversy erupted in 1924 after refinery accidents left workers dying from violent insanity due to lead. Finally an international phase-out of leaded gasoline emerged. In October 1924, workers in a standard refinery in Bayway, New Jersey went violently insane after making leaded gasoline. Seven men died and 33 were hospitalized there, meanwhile, ten more were killed at a DuPont facility, and at least two died and 40 were hospitalized in Dayton, Ohio. Lead poisoning is one of the most frequently observed causes of occupational disease. From roman antiquity through the industrial revolution, the cumulative effects of lead had become well known through painful experience.

Lead's effects on industrial workers in the 19th and early 20th centuries were documented by writers and health professionals. Charles Dickens wrote about the terrifying effects of lead poisoning on London workers who could find no other employment.

In 1962, GM (General Motors) and Standard sold their interest in the Ethyl Corporation to a small group of independent investors. A decade later, GM and the rest of the world's automakers began producing automobiles that used unleaded gasoline. By 1986 leaded gasoline had been taken off the market in the United States, and by 2000 it had been banned in Europe. Most developing nations are now phasing out leaded gasoline.

Despite the historical knowledge of lead's dangers, the automotive industry was interested in the metal's potential to prevent engine knock when used as a fuel additive. It rose what is now called "octane "which is the anti-knock property of gasoline measured by iso-octane reference fuel. The anti-knock power of 2 – 4 grams of TEL suspended in a gallon of gasoline was discovered December 3, 1921, at GM research laboratories in Dayton, Ohio. Warnings about the danger of leaded gasoline came directly to Midgley GM's division head) and Kettering (GM's vice president for research) from Robert Wilson of MIT, Reid Hunt of Harvard, Yandell Henderson of Yale and Charles Kraus of the University of Pottsdam in Germany. Kraus had worked on TEL for many years and called it " a creeping and malicious poison " that had killed a member of his dissertation committee [5].

POLLUTION OF LEAD IN KRG

A. *Lead pollutions due to batteries scrap*

TABLE 1
ACCUMULATED AUTOMOBILE PROFILE IN ERBIL THROUGH THE PERIOD FROM 2006 - 2011

Vehicle Type	2006	2007	2008	2009	2010	2011	Batt. Type
Private	29845	62034	98323	132309	183034	241907	55 AH
Taxi	6464	12163	18056	25739	35135	79036	60 AH
Tracks	5651	12086	24893	39173	64737	122902	75 AH
Motorcycle	1	474	4354	6504	8359	9549	20 AH
Agricultural	26	47	149	647	1097	1675	90 AH
Construction	164	206	623	1380	2074	3167	90 AH
Total	42151	87010	146398	205752	294436	458235	

Assumption 1: Average life of battery equal to 1.5 years
Assumption 2: Standard battery 55 AH , conversion factor = capacity of battery / 55
Three samples taken for assuming standard lead acid batteries (55 AH)
Sample 1= 14.36 Kg, Sample 2= 14.368 Kg, Sample 3= 14.901 Kg

TABLE 2
ACCUMULATED AMOUNT OF SCRAP BATTERIES IN ERBIL THROUGH THE PERIOD FROM 2006 - 2011 IN TONS

Years	Tons of battery Scrap	Tons of Lead	Tons of waste sulfuric acid Sp Gr 1.2
2006	435	316.5	72
2007	896	651	148
2008	1501	1091	248
2009	2128	1547	351
2010	3082	2240	509
2011	4917	3573	811

Sample calculation: to determine the lead weight in batteries of different capacities wt_n=

$$\textbf{Weight of lead in Battery } wt_n = \textbf{Weight of lead in standard } wt_{st} \times \frac{\textbf{Capacity of battery}_n}{\textbf{Capacity of standard Battery } (55AH)}$$

Weight of lead in 90 AH capacity battery = 10.57 × (90 / 55) = 17.3 Kg

Sample of calculations:

To determine the amount of lead in 2006 for example =((numbers of private cars × weight of lead in 55 AH battery which is assumed standard battery / 1.5 year battery life) + (number of taxis × weight in 55 AH capacity battery × (battery capacity 60 Ah/ standard battery capacity 55 AH) / 1.5 years battery life) + (number of trucks × weight of lead in 55 AH battery × (battery capacity 75 Ah/ standard battery 55 AH) / 1.5 years) + (number of motorcycles × weight of lead in standard battery × (battery capacity 20 Ah/ standard battery 55 AH) / 1.5 years battery life) + (number of agricultural and construction vehicles × weight of lead in standard battery × (battery capacity 90 Ah/ standard battery 55 AH) / 1.5 years battery life). = total wt. of lead in kg

((29845 × 10.57)/1.5) + (6464 × 10.57 × (60/55) / 1.5) + (5651 × 10.57 × (75/55) / 1.5) + (1 × 10.57 × (20/55) / 1.5) + ((26 + 164) × 10.57 × (90/55) / 1.5) = 210308 + 49691 + 54301 + 3 + 2191 =316494 kgs of lead = 316.5 tons of lead.

And similarly, the amount of acid can be determined.

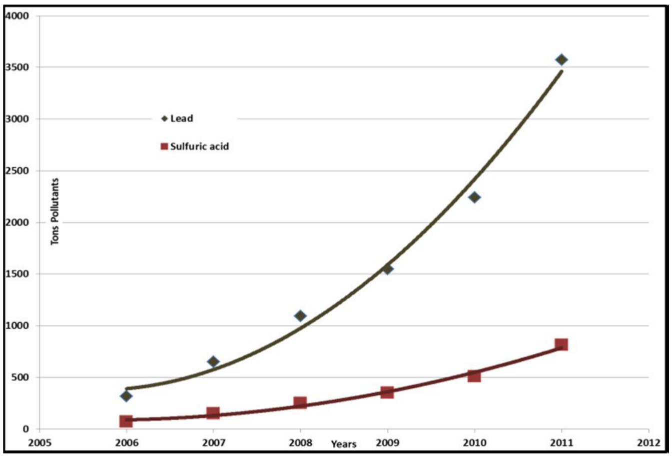

Fig. 1 Accumulated amount of lead pollution and waste of sulfuric acid in Erbil during the period from 2006 – 2011

TABLE 3
ACCUMULATED AUTOMOBILE PROFILE IN SULAIMANIYA THROUGH THE PERIOD FROM 2006 - 2011

Vehicle Type	2009	2010	2011
Private	17155	45836	73591
Taxi	3355	8800	16635
Tracks	12543	30393	44704
Motorcycle	1965	4299	6153
Agricultural	418	692	1102
Construction	621	1261	2022
Total	36057	91281	144207

TABLE 4
ACCUMULATED AMOUNT OF SCRAP BATTERIES IN SULAIMANIYA THROUGH THE PERIOD FROM 2006 - 2011 IN TONS

Years	Tons of battery Scrap	Tons of Lead	Tons of waste sulfuric acid Sp Gr 1.2
2009	27	20	4
2010	68	49	11
2011	107	78	18

3 Samples of 55 AH batteries (weight Kg):		
Average battery total weight:	14.54	Kg
Average weight of acid sp. gr. 1.2 :	2.40	Kg
Average weight of plastic box and PE separators:	1.57	Kg
Average weight of lead materials:	10.57	Kg
Lead percent in standard battery	73%	
Acid percent in standard battery	17%	

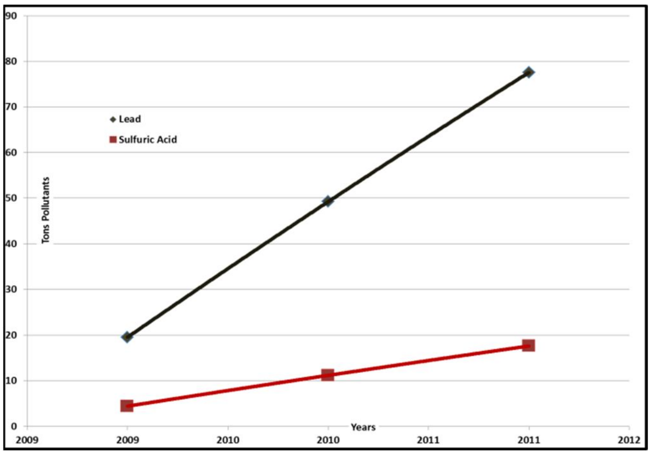

Fig. 2 Accumulated amount of lead pollution and waste of sulfuric acid in Sulaimaniya during the period from 2006 – 2011

TABLE 5

ACCUMULATED AUTOMOBILE PROFILE IN DUHOK THROUGH THE PERIOD FROM 2006 - 2011

Vehicle Type	2006	2007	2008	2009	2010	2011
Private	6313	9706	13894	22386	39829	57769
Taxi	1466	3469	7657	9067	11566	13859
Tracks	2257	4144	7120	9820	20063	27076
Motorcycle	0	0	0	0	10	18
Agricultural	24	70	77	119	424	574
Constructio n	114	156	171	366	596	844
Total	10174	17545	28919	41758	72488	10013 8

TABLE 6
ACCUMULATED AMOUNT OF SCRAP BATTERIES IN DUHOK THROUGH THE PERIOD FROM 2006 - 2011 IN TONS

Years	Tons of battery Scrap	Tons of Lead	Tons of waste sulfuric acid Sp Gr 1.2
2006	7	5	1
2007	13	9	2
2008	22	16	4
2009	31	23	5
2010	54	39	9
2011	75	54	12

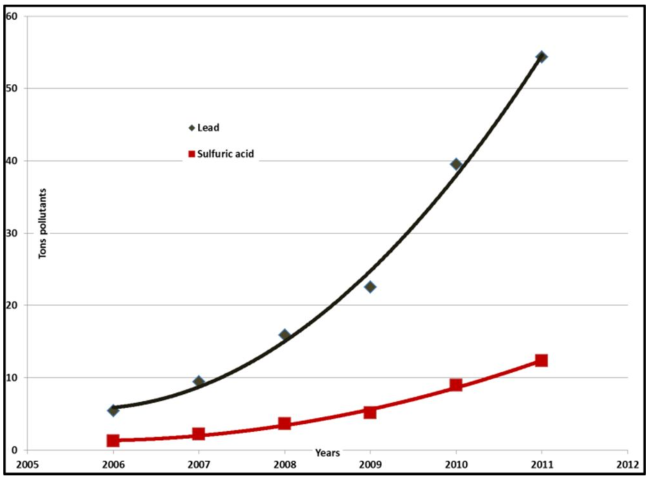

Fig. 3 Accumulated amount of lead pollution and waste of sulfuric acid in Duhok during the period from 2006 – 2011

TABLE 7
TOTAL ACCUMULATED VEHICLES IN KRG DURING THE PERIOD FROM 2006 - 2011

Vehicle Type	2006	2007	2008	2009	2010	2011
Private	36158	71740	112217	171850	268699	373267
Taxi	7930	15632	25713	38161	55501	109530
Tracks	7908	16230	32013	61536	115193	194682
Motorcycle	1	474	4354	8469	12668	15719
Agricultura l	50	117	226	1184	2213	3351
Constructio n	278	362	794	2367	3931	6032
Total	52325	10455 5	175317	283567	458205	702580

TABLE 8
ACCUMULATED AMOUNT OF SCRAP BATTERIES IN KRG THROUGH THE PERIOD FROM 2006 - 2011 IN TONS

Years	Tons of battery Scrap	Tons of Lead	Tons of waste sulfuric acid Sp Gr 1.2
2006	443	322	73
2007	909	660	150
2008	1523	1107	251
2009	2186	1589	361
2010	3204	2329	529
2011	5098	3705	841

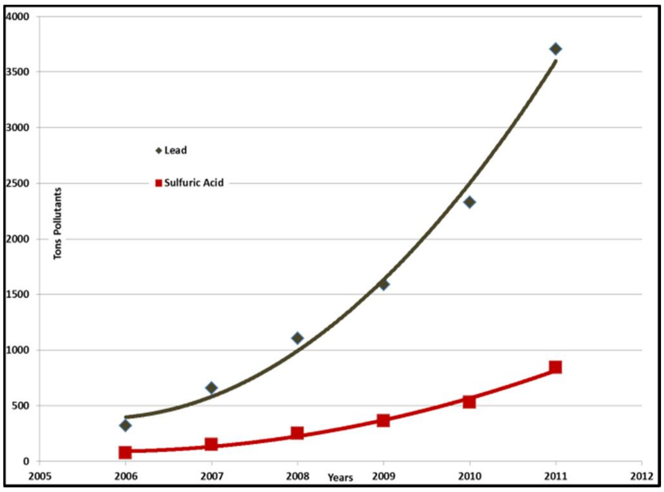

Fig. 4 Accumulated amount of lead pollution and waste of sulfuric acid in KRG during the period from 2006 – 2011

B. *Lead pollutions due to gasoline*

Assumption: Half of the trucks powered by gasoline fuel and half by light gasoil.

TABLE 9
ACCUMULATED NUMBERS OF VEHICLES IN KRG CLASSIFIED ACCORDING TO POWERED FUEL

Automobile Fuelling	2006	2007	2008	2009	2010	2011
Gasoline Automobile	48043	95961	158291	249248	394465	595857
Gasoil Automobile	4282	8594	17069	35348	64901	106994

One barrel =		36	gallons
One gallon contains 2 - 4 gm of TEL [5]	»	2	gm
So one barrel content of TEL	»	72	gm

Assumption: gasoline car consumes 10 liter of gasoline daily, Since 1 U.S. gallon = 3.785 litres, which means that the daily car's Gasoline consumption is 2.64 gallons. This leads to an average daily liberation of lead per car = 5.2 gm. With an assumption of annual usage of cars = 330 days (other days are for car maintenance), the following table will give the total accumulated emitted lead pollution per year:

TABLE 10
ACCUMULATED EMITTED LEAD POLLUTION IN KRG DUE TO VEHICLES FUEL DURING THE PERIOD FROM 2006 – 2011

Year	Erbil	Sulaimaniya	Duhok	Total in KRG
2006	67	0	15	82
2007	139	0	26	165
2008	229	0	43	272
2009	316	49	62	428
2010	444	127	105	677
2011	673	204	146	1022

TABLE 11
(1)DATA OF PRODUCTION OF LEADED GASOLINE IN KRG

Months	Amount Gasoline Barrel	Amount TEL (Kg)	Amount TEL in Tons
May-12	1117862	80486	80
June-12	1296358	93338	93
July-12	1491374	107379	107
August-12	1691299	121774	122
September-12	1882294	135525	136
October-12	2060369	148347	148
November-12	2157278	155324	155
December-12	2373358	170882	171
January-13	2581815	185891	186
February-13	2753833	198276	198

(1) Reference: Local data

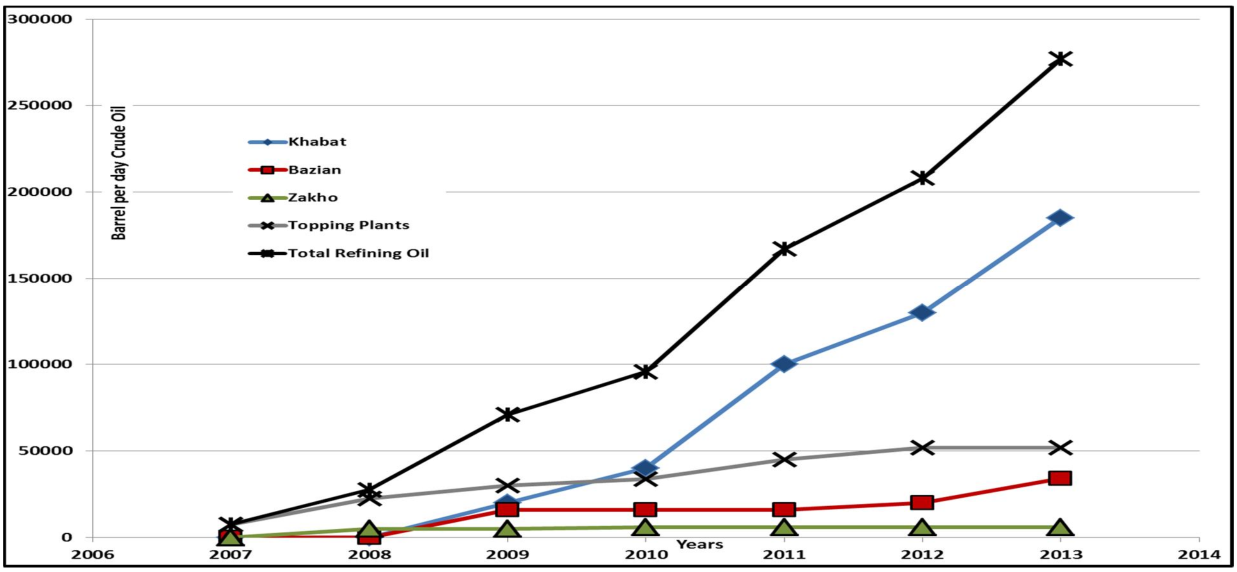

Fig. 5 Production of gasoline from the refiners in KRG in barrel per day during the period from 2006 2013

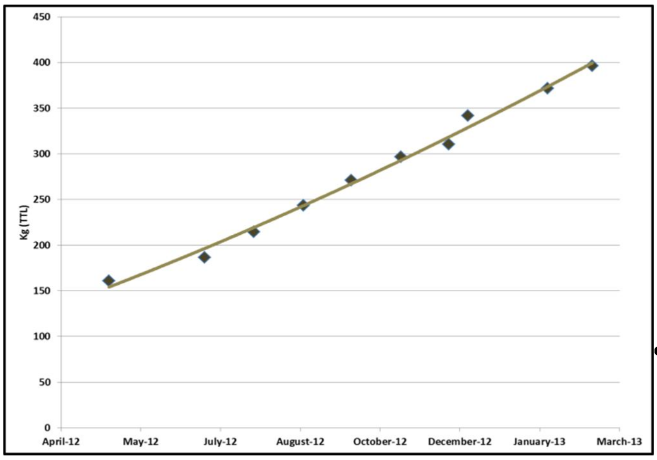

Fig. 6 Amount of lead emission from gasoline which was produced from refineries in KRG during the period from April 2012 – March 2013

II.CONCLUSIONS

This research has come up with the following conclusions:

- It was found through some historical reports and researches, such as those referred to in the previous introduction how fatal lead could be for the health and human beings safety. Previous works referred to large numbers of poisoning and death incidents caused by lead. This is why we think that the issue of pollution due to lead presence in the air, soil and underground water resources should be taken seriously and measures should be taken to reduce or abolish the dangers of pollution through lead.

- Kurdistan Region has witnessed an explosion in the number of vehicles during the past few years leaving a big impact on the environment. Our research has shown an increase in the production of pollutants due to the increase in the number of vehicles by an amount of 13.42 times between the years 2006 and 2011, whereby the total number of vehicles in Kurdistan reached 702580 in 2011.

- The big increase in the numbers of vehicles which are registered and used in Kurdistan Region generally, which is accompanied by a comparable increase in the used scrap batteries and the connected increase in the production of lead pollutant as a very hazardous and poisonous matter was in the order of 11.51 times between 2006 and 2011, whereby the amount of lead produced from scrap batteries reached an amount of 3705 tons in the year 2011.
- In addition to these amounts of lead pollution from scrap batteries which are left on the ground surface, another pollution due to Sulphuric Acid (H_2SO_4) as a component of these left scrap batteries was recorded during that period but to a lesser extent. The increase of pollution due to this acid increased by 11.52 times between 2006 and 2011. The recorded amount of this pollutant acid reached 841 tons in 2011.
- The increase in the capacities of oil refining in Kurdistan Region, which indicated an overall increased level of consumption of TEL (Tetra Ethyl Lead) by the order of 12.4 times between 2006 and 2011, is accompanied by an imminent increase of the risk of lead pollution in the same order during that period, whereby the amount of pollution due to lead from such source reached an amount of 1039 tons during 2011.

III.RECOMMENDATIONS

- Finding the appropriate place is one of the most important factors of the landfill waste management system for big cities in Kurdistan with a population of over 4,000,000 inhabitants. The choice of landfill sites has to be based on studies by environmental experts taking every parameter in consideration.
- Establishing an effective and an efficient environmental protection programme and encouraging scientific studies and researches in the field of environmental protection and increasing the budget which is allocated for such purposes and organizing more seminars, workshops and international conferences on the environment in Kurdistan.
- We think that the issue of pollution due to lead presence in the air, soil and underground water resources should be taken seriously, whereby effective measures should be taken to reduce or abolish the dangers of pollution through lead and acids.
- The relevant authorities and KRG have to legislate laws and strict regulations concerned with the environmental protection issues by not allowing car batteries or any other harmful substances to be thrown on the ground surface in the solid waste sites but recycling them in the proper manner. Legislations for phasing out Leaded Gasoline and prohibiting the use of TEL have to be legislated and securing ways to enforce them. These steps have been taken a long time ago by most of the western and more developed countries and it's high time that we follow their steps for a better and cleaner environment.
- Strict monitoring and observation of all factories, refineries, refill stations and oil change stations has to be adopted in order to make sure that they abide by all laws and regulations concerning environmental protection and reducing the amount of pollution to the air, land and water.
- The municipal authorities should cooperate with the Ministries of Environment, Trade and Industry to provide and install big classified garbage bins for various environmentally harmful wastes like batteries, acids, oils, glass, metal cans, etc. in proper locations of the residential areas and industrial zones and making sure of collecting them regularly in order to recycle the wastes in the proper manner and get rid of their pollution hazards. They have also to raise enough and adequate awareness campaigns to the public for the importance and the proper use of these classified garbage bins.

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