Taseiko Olga

INHALATION CANCER RISK ASSESSMENT IN KRASNOYARSK CITY

Taseiko Olga, Potilitsyna Elena
Siberian State Aerospace University, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, Russia, taseiko@gmail.com

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1. Introduction

The many changes in how people live and work, including the development of industry and transport, the increase in energy consumption and the leap in urbanization, have led to increases in environmental pollution which influence human health, diseases, and mortality. Urban air is an important factor that impacts population health and human adaptive capacity.

The evidence that air pollution increases the risk of cancer has been growing. Cancer rates in general are increasing in many countries, because of adoption of unhealthy western lifestyles such as smoking and physical inactivity and consumption of calorie-dense food. Cancers that were once known as diseases of industrialized countries, such as lung, colon, and breast cancers, are now commonly occurring in economically transitioning and less developed countries. Most of these countries also continue to be disproportionately affected by cancers related to infectious agents, such as cervix, liver, and stomach cancers, which are potentially preventable (Jemal A. et al., 2010). Over the past 20 years the nature of cancer has changed. In the early 1990s, people were less likely overall to get cancer than they are today, but also less likely to survive it.

The aim of this study was to examine the association between cancer mortality and air pollutant concentration in Krasnoyarsk city, an industrial city in eastern Siberia. Such statistical relationship does not provide conclusive evidence that the presence of atmospheric aerosols is the leading factor responsible for lung cancer occurrence, but suggests that some causal relationship is possible. We evaluated the time lag by using a statistical correlation, set up for a 0 – 16-year delay factors.

2. Methods and results

2.1 Analysis of air pollution tendencies in Krasnoyarsk city

To study the air pollution levels in Krasnoyarsk city, we used data from GU «Krasnoyarsk CGMS-R», which monitors the urban air quality by eight stationary posts located throughout the city (Statistical bulletin, 2013). We analyzed concentration of 21 pollutants for the period from 1982 to 2013. Among these pollutants there are a number of “cancerogenic to human” substances, “likely to be cancerogenic to human” and non cancirogenic substances.

We used one dimensionless parameter that is usual for practice in Russian environmental management system. It equals concentration divided by maximum level for this pollutant according national standards.

Annual dynamics of some cancerogenic pollutants are shown in Figure 1. The concentrations of ethylbenzene fluctuated slightly during last 10 years. The concentration of benzene didn’t change significantly. The concentrations of formaldehyde decreased by a factor of 4 over the same period. It reached the level of 80-xx years, when our industry was working at full capacity. But now it is caused by vehicle exhaust mostly.

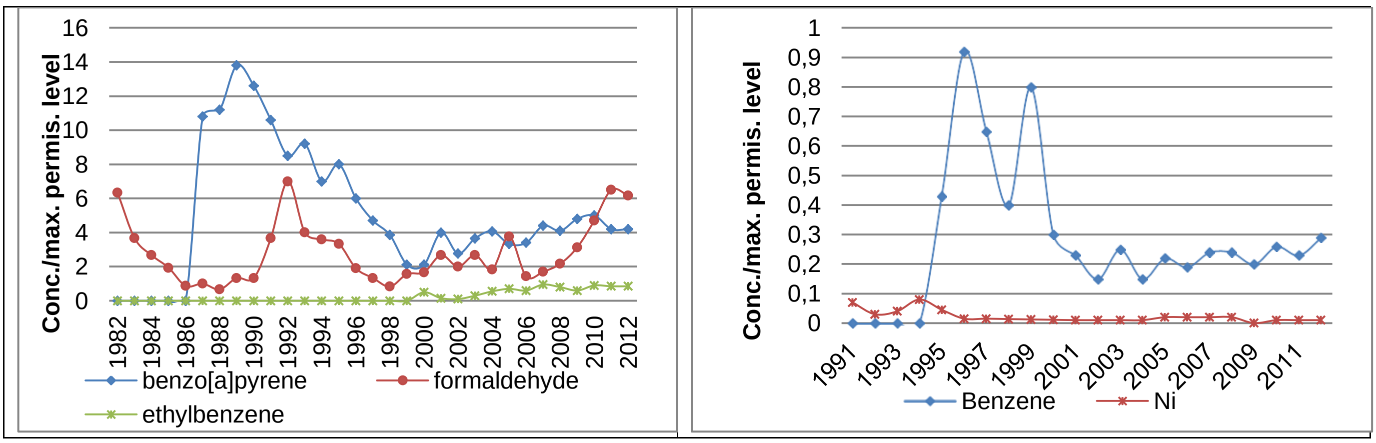

Figure 1: Average annually dynamics of some substances in Krasnoyarsk city

Today the main sources of air pollution in Krasnoyarsk are emissions from the aluminum plant, the electro power stations, which are located within city limits, and widespread vehicle exhaust. The main sources of benzo[a]pyren in the air are the aluminum factory, of nickel are the electro power station. So it is difficult to blame a single source as being responsible for the high levels of air pollution in Krasnoyarsk.

2.2 Cancer mortality dynamics in Krasnoyarsk city

In terms of incidence, the most common cancers worldwide (excluding non-melanoma skin cancers) are lung (12.3% of all cancers), breast (10.4%) and colorectum (9.4%). But death from cancer depends often on effectiveness of intervention. For example, appropriate intervention can help to avoid a fatal outcome following diagnosis of breast cancer. Hence, three major causes of death from cancer are cancers of the lung (17.8% of all cancer deaths), stomach (10.4%) and liver (8.8%) (World cancer report, 2003).

In Krasnoyarsk city the highest mortality rates from cancer are lung and trachea (23%), stomach (15%) and colorectum (13%).

All categories of cancer death was combined in functional groups (Table 1). It is seen that digestive system (including stomach) and respiratory system (including lung and trachea) have the most contribution to the number of cancer death and their contribution not change significantly during last 12 years.

Year	Number of death from cancers, % from total mortality	Number of deaths for some groups of cancer, % from cancer mortality			
		digestive system	respiratory system	reproductive system	Hemato-poietic system
2000	14.5	20.6	23.0	12.1	2.3
2001	15.0	24.4	21.9	12.7	2.9
2002	13.9	21.0	23.9	12.0	2.5
2004	16.4	21.3	19.7	13.1	2.9
2006	17.4	19.9	20.3	15.2	3.4
2008	18.5	20.7	20.1	14.0	2.5
2010	18.5	21.5	20.4	14.0	2.7
2012	18.9	19.7	19.6	13.8	3.2

Table 1: Annual dynamics of cancer mortality in Krasnoyarsk city

It is well known, that respiratory and gastric cancers are sensitive to elevated levels of air pollution. Other kinds of cancer depends on many other reasons: food intake, work and living conditions, genetic factors. In this work we estimate only connection the level of air pollution with all group of cancer death.

We have calculated and analyzed the correlation (in the probability level 0.99) between air pollutant concentrations numbers of death from different kinds of cancer with no time lag. There are many studies confirms our results about associations between air pollutants and some kind of cancer (Table 2). In this step we excluded some pollutants and cancer from our research, because we have not found correlation for its.

Pollutants	Organ targets (calculated data)	Organ targets (published data)
Benzo[a]pyrene	breast, lungs, stomach, prostate, esophagus	breast (Vernigorova et al., 2005), lungs, stomach, thyroid (Mun et al., 2006), prostate, esophagus (Rashitov et al., 2010)
Formaldehyde	leukemia, larynx	larynx, nasopharynx, leukemia (Revich, 2006)
Ni	lungs, stomach, larynx	nasopharynx, lungs (Smola, 2013), stomach, larynx (Bingam, 1993)
Benzene	lymphoma	lymphoma
Ethylbenzene	larynx, liver, ovary	nasopharynx, liver, lungs, kidney, thyroid, ovary (IARC, 2010)
Cr	lungs	lungs
Pb	larynx, leukemia, lymphoma esophagus	immune system, lung, stomach, kidney, brain of nervous system, endocrine function, hematopoietic system (Zadov et al., 2013)

Table 2: Correlation between some kind of cancer death and cancerogenic substances

In this step we excluded some pollutants and cancer from our research, because we have not found correlation for its.

2.3 Time lag estimates

The formation of a tumor is a complex process, and tumor progression occurs by a sequence of randomly occurring changes in genetic material that alter cell functions to overcome the normal barriers to becoming malignant.

Obviously, latency period depends on category of cancer. Cancer latency ranges from 2.2 years (for chronic lymphocytic leukemia) to 57 years (for cancer of the transverse colon). For the solid cancers it was found a range of latencies from 6.6 years up to 57 years. For the lymphoproliferative and hematopoietic cancers, a range of latencies is 2.2 – 35.7 years. Tumors of the pancreas take nearly 18 years to become clinically evident after the first cancer initiating mutations (J. Howard, 2015).

In epidemiologic studies time lag is obtained usually by statistical modeling of the association between exposure to an agent and a type of cancer. But time lag can be greater than latency period. Time lag includes latency period and clinical phase. Unfortunately, the scientific literature assessing time lags for specific types of cancer is scarce.

The estimation of time lag for all substances measured in Krasnoyarsk is presented in Table 3. These estimates were obtained by using of cross-correlation function on the confidence level 0.99.

Pollutants	**CANCER MORTALITY OF**						
	respiratory system (lungs, larynx)	**hemato-poietic system (leukemia)**	**digestive system (stomach, liver, pharynx)**	**immune system (limphoma)**	**brain and nervous system**	**reproductive system (prostate)**	**bones**
"Cancerogenic to human"							
benzo[a]pyrene			0 – 1 and 14 – 16	0 – 1	15 – 16		15 – 16
benzene			7	3 – 7	7		9
formaldehyde	7		0 and 16		12		
Cr	2		2 and 10	3	13		11
Ni	2		2				11
"likely carcinogenic to humans"							
ethylbenzene	3		0 – 5	0		0 – 1	
Pb	4	14	0 – 3	0			14
"likely carcinogenic to animals"							
toluene			0	0			
"non cancerogenic"							
phenol	8	6	5 – 9	5 – 9		7	
xylene	3	6	3			7	
Fe			0 – 5	0 – 4		0 – 2	
Zn			0 – 1	0	13	0 – 1	
Mn			0 – 7	0 – 6	14	0 – 2	13
Cu			1 – 5, 11 – 12	1 – 3	11 – 12		11 – 12
SO_2	1		1				
NO	11		2 – 3	2		2	
NO_2			2 – 6	2 – 5		3 – 4	14

Table 3: Time lags between air pollutants and mortality from different types of cancer

The digestive and immune systems are more sensitive to air pollution than others. The time lags for both systems are less than for other system and its vary in the range from 0 to 5 years.

It is shown the digestive system reacts to air pollution faster than other system. It doesn't mean that air pollution is the main reason of cancer. It means only that these factors can reduce pre-clinical and clinical phases for cancer of those organs as a stomach, colorectum, esophagus and liver. Usually cancer of digestive system is explained by food and drinks, but our results show that the influence of air pollution has a great contribution to mortality from this type of cancer. Unfortunately we have no enough data about quality of food and water to estimate this contribution numerically.

Time lags were estimated for all types of substances: "cancerogenic to human", "likely to be cancerogenic to human" and non-cancerogenic substances. The results of this study show that substances from all of these groups have influence on cancer mortality. Because, even if pollutant has non cancerogenic effect, it can be indicator of not measured pollutant, that can be cancerogenic.

3. Summary

The analysis of air pollution dynamic shows that the air quality in Krasnoyarsk city has deteriorated last years. The concentration of some pollutants increased by a factor of 2 and 4.

It was selected 17 air pollutants that have influence on numbers of cancer mortality and 16 types of cancer that have connection with specially pollutants by using correlation analysis.

Using cross correlation functions it was shown that air pollution has the greatest influence on digestive and respiratory system.

Lag analysis revealed a continued increase in cancer mortality years after air pollution impact on nervous system, hematopoietic system (including leukemia) and bones. The time lag for digestive system is less than for other system and it varies in the range from 0 to 5 years.

Our study is not finished now but in this stage we can predict some tendencies. For example, we can expect the increasing of the numbers of cancer death from digestive and immune systems caused by increasing concentration of benzo[a]pyren, formaldehyde, ethylbenzene after 6-8 years.

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