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AIR TEMPERATURE AS A METEOROLOGICAL FACTOR AFFECTING LEVEL OF ATMOSPHERIC POLUTION BY FORMALDEHYDE

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Abstract: This article describes trends of changes and existential distribution of formaldehyde concentrations in Almaty city's atmosphere over the past four years. Its been revealed that the level of city's air pollution varies depending upon the season and particular adverse meteorological conditions of the given urban area. The results of exploring the air temperature's impact to changes in the level of formaldehyde in the city atmosphere shows a direct correlation between the two parameters.

Key words*:* atmosphere, pollution sources, pollutants, the level and extent of contamination

Introduction

Air pollution in large cities recently has become one of the major environmental problems in Kazakhstan and in the world as well. High industrial growth and increasing number of motor vehicles leads to rise of emissions and air quality deterioration [1]. Among the many harmful substances which can be found in the different cities atmosphere, we should pay a special attention to the substance known as formaldehyde. With the atmospheric temperature rising over the past years its very important to clarify the role of air temperature in the formation of formaldehyde concentrations. As a rule, formaldehyde is formed from incomplete combustion of liquid fuel, during the process of manufacturing synthetic resins, plastics, tanning, etc. Formaldehyde is also emitted into the atmosphere from motor vehicles [2]. Studies carried out by a number of authors have shown [3,4] that formaldehyde not only is coming from industrial and natural sources, but is formed as a result of complex photochemical reactions in the interaction with methane, nitrogen oxides and other catalysts.

Over the past years there has been a marked increase of formaldehyde concentration in Almaty city. According to the news-bulletin [5] the average concentrations of formaldehyde in Almaty increased in recent years. Thus, in 2010 in Almaty the air pollution index on five substances (further API5) was 11.7. Most of it has been observed on formaldehyde - 47% (fig 1).

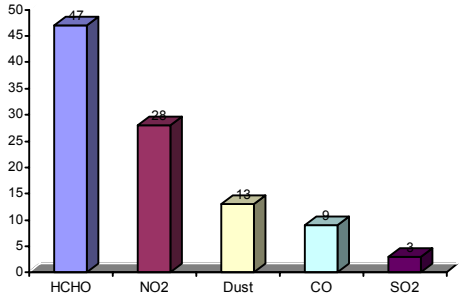

Figure. 1. The atmospheric concentration of pollutants that determine air pollution index (API), of Almaty city in 2010

Such data gives us enough reasons to analyze situation, conduct research and find the determining factors of formaldehyde's high concentrations.

Materials and methods of research

The state of formaldehyde air pollution in Almaty is the object of investigations. Methods of research are comparative-analytical, physico-chemical, physicostatistical, statistical analysis of empirical data.

The standards of GOST 17.2.3.01-86 "Nature Preservation. Atmosphere. Norms of air quality regulations in settlements." have been used as a basis for organizing observations regarding levels of city's atmospheric pollution. Air synoptic material has been used as an initial data. Fixed positions and selected research locations have been used for monitoring the air pollution level.

Depending on the street area's load by various vehicles, location of industrial factories, heating sources, main streets, area relief and other factors, several fixed stationary observation posts have been set-up in the city. The ones below have been used as center points for monitoring environmental pollution:

- Post №1, located in the central part of city, near the intersection of Satpayev street and Seifullin prospectus;
- Post № 12 on corner of Raiymbek avenue and Nauryzbai Batyr street is the site with highest traffic load;
- Post № 16, Ainabulak-3 microraion. Here most of pollution is observed in winter and summer mostly from household waste, although large movement of air currents is observed on this site;
- Post № 25, on corner of Marechka street and B.Momysh-uly street. This site is contaminated by boiler plants of western thermal complex.
- Post №26, Tastak-1 microraion, Tole- By Street 249 (in the site of city polyclinic № 4).

Results

The average life expectancy of formaldehyde in the atmosphere is approximately three hours. It depends on weather conditions and it may be longer in sunny and clear weather conditions and is less in overcast and cloudy weather conditions [3].

Also atmosphere has a large number of non-methane hydrocarbons, which may contribute to formaldehyde's formation. Our research shows that in most of observed cases, the maximum concentrations of formaldehyde can be found during warm season of the year. Thus, the annual course is clearly expressed, and the peaks are observed during the period from May till

September. Table 1 shows annual course of formaldehyde concentration during the years 2007 -2010.

The table shows that during the four-year period the highest concentrations of formaldehyde have been observed in 2008 and in 2010, especially in July, and made-up 0,017 mg/m^3. Another peak was observed in June-July 2009 and equaled to 0,015mg/m^3. Its obvious by looking at the trend of formaldehyde's distribution that most of pollution's high-points take place in warm season mostly in summer time. During the period of summer maximum the highest concentrations are in 0,016-0,017 mg/ m^3. During winter period concentrations vary between 0,009-0,013 mg/ m^3. Such changes occur almost every year. The only exception is January 2007 when average concentrations of formaldehyde were 0,016mg/m^3. If we observe highest maximum points of formaldehyde concentration most of them also take place during warm season and range from 0,043 to 0,055mg/m^3. During winter season these values are significantly lower: from 0,028 to 0,044mg/m^3 with January 2008 as an exception when the formaldehyde concentration reached 0,053mg/m^3.

Months	Quantity of formaldehyde in mg / m^3 in various years							
	2007		**2008**		**2009**		**2010**	
	Average concentration (qav) mg / m^3	Maximal concentration (qm) mg / m^3	Average concentration (qav) mg / m^3	Maximal concentration (qm) mg / m^3	Average concentration (qav) mg / m^3	Maximal concentration (qm) mg / m^3	Average concentration (qav) mg / m^3	Maximal concentration (qm) mg / m^3
1	0,016	0,046	0,014	0,053	0,013	0,041	0,009	0,031
2	0,012	0,039	0,014	0,044	0,010	0,028	0,011	0,038
3	0,010	0,032	0,013	0,047	0,012	0,043	0,0108	0,052
4	0,009	0,032	0,011	0,041	0,014	0,050	0,009	0,033
5	0,010	0,038	0,012	0,037	0,015	0,050	0,010	0,031
6	0,012	0,044	0,012	0,050	0,015	0,050	0,013	0,043
7	0,013	0,037	0,017	0,053	0,016	0,052	0,017	0,055
8	0,015	0,042	0,015	0,042	0,011	0,060	0,010	0,045
9	0,013	0,052	0,012	0,043	0,010	0,060	0,012	0,040
10	0,013	0,053	0,012	0,043	0,010	0,044	0,009	0,040
11	0,012	0,053	0,012	0,047	0,011	0,060	0,010	0,040
12	0,010	0,030	0,009	0,030	0,010	0,030	0,010	0,035

Table 1. Annual course of formaldehyde concentration during the years 2007-2010.

Let's consider in more detail how the level of formaldehyde's distribution in the air depends from the air temperature. We took the average concentrations of formaldehyde during four years (Table 1) and air temperature values from the same period (Table 2). Based on these indicators we've made a chart showing the direct dependence of formaldehyde concentrations from the air temperature (Figure 2).

Figure 2 clearly shows correlation of rising formaldehyde concentration values and air temperature from

winter season to summer season. The noticeable summer maximum can be explained as an aftereffect of chemical reactions due to high air temperatures during summer and intensive solar radiation. In other words, during the summer there is an activity of photochemical processes which leads to the formation of formaldehyde in the atmosphere. Also the city atmosphere receives large amounts of different hydrocarbons emissions, which boost the reactions [7]. Besides, the city atmosphere contains high concentrations of nitrogen dioxide that indicates the undergoing reaction. Winter peak is rarely observed, it is less vivid than the summer one, and is associated with industrial emissions of this substance because the emissions of factories and industrial complexes such as thermal power stations have a high temperature and contain hydrocarbon gases, nitrogen oxides and other substances that may contribute to the photochemical process. As a result, we have made an assumption that high concentrations of formaldehyde are

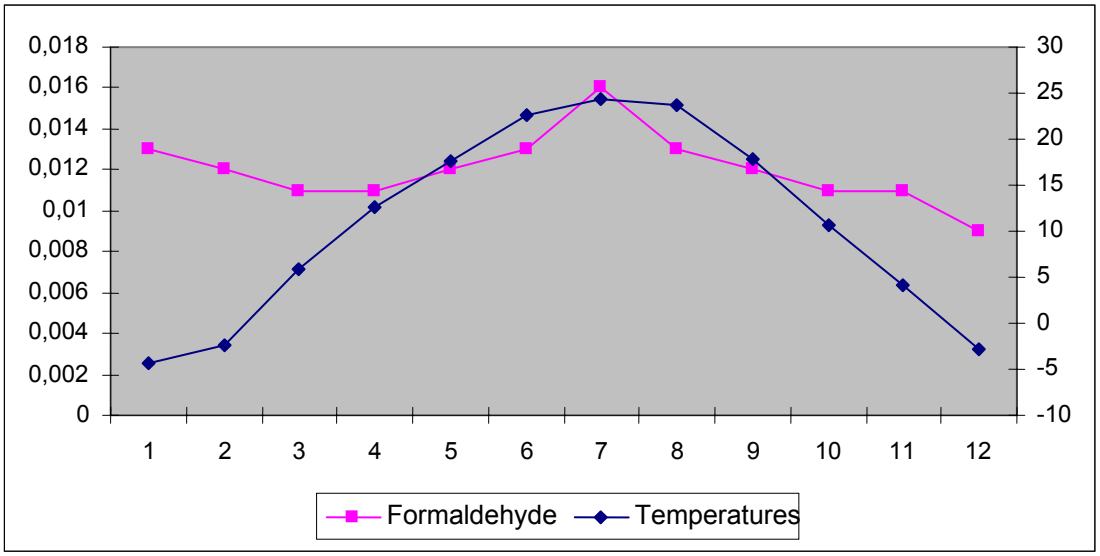

Figure 2 Annual course of formaldehyde values in mg/m^3 and temperature values in ^{0}C (years 2007-2010)

not necessarily related to emissions of the substance, but may be formed in the atmosphere by photochemical reactions in conditions of city's very high level of air pollution.

By taking a look at the average multi-year values of air temperature (Table 2) and comparing them with table values of average and maximal one-time concentrations of formaldehyde (Table 1), we observe the following difference.

Table 2 – Monthly average air temperature during years 2007-2010 in Almaty city [6]

Months	Temperature in various years	Norm

	2007	2008	2009	2010	
January	-2,8	-10,4	-2,6	-1,6	-5,5
February	0,5	-4,3	-0,9	-4,8	-4,2
March	3,7	9,2	6,4	4	1,8
April	15	12,9	10,8	12,1	11,4
May	17,5	20,7	16,4		16,1
June	22,9	24,8	21,3	21,7	21,1
July	24,5	25,8	24	23,6	23,8
August	23,4	25,2	22,5	23,5	22,5
Septem-ber	19,5	18,4	16,5	17,5	17,2
October	9,3	10,6	11,4	11,8	9,5
Novem-ber	5,2	3,7	2,3	5,8	2,1
Decem-ber	-4,4	-2,2	-2,2	-2,4	-2,7

In Almaty, the average winter temperature usually reaches -2,2 ° C and below, but can drop up to -10 ° C and raise to 0 ° C and above. We have found that at temperatures below freezing point in winter concentrations of formaldehyde are low, rarely exceed 0,012 mg/ m^3, and don't dependent on air temperature. And since in half of cases the air temperature is above 0 ° C, the concentrations of formaldehyde are also higher. In spring with air temperature increasing to 10 ° C, the formaldehyde concentration also starts to increase.

In order to determine the dependence of the phenomena and processes we've applied a statistical method of studying these interactions, namely the linear correlation coefficient, which characterizes the degree of close connection between the studied variables. The linear probability dependence of random variables is based on the principle that if one random variable tends the increase the other one has a tendency to decrease or increase by the linear principle just like in our case. The results of the observations during the warm period of 2007 and 2010 have been used for analysis. Only concentrations exceeding 0,008 mg/ m^3 have been used to eliminate the errors taking place while determining low concentrations of impurity. At the same time all data relevant to air temperature below 10°C, which is possible at the beginning and end of the warm season, has been excluded from analysis.

To process the data we have chosen months with highest temperatures such May, June, July, August, September. As a result of processing data the value of linear coefficient (r) correlation ranged within $-1 < r_{xy} < 1$ and a qualitative assessment of close connection of these quantities has been found by applying correlation analysis scales Chedoke.

From figure 3 we can see that tight connection between the values is considered as high, with

correlation coefficient value r = 0,849543. Thus, correlation analysis showed the existence of significant ties between concentration of polluting substances in the atmosphere and a

meteorological parameter such as the temperature.

Conclusions

With positive air temperature present there is a noticeable connection between air temperature and the concentration of formaldehyde. The higher the temperature, the higher the concentration of formaldehyde. There's a linear connection between the specified parameters, and at temperatures above 10 ° C formaldehyde begins to form. The correlation coefficient between the concentration and the air temperature is 0,84.

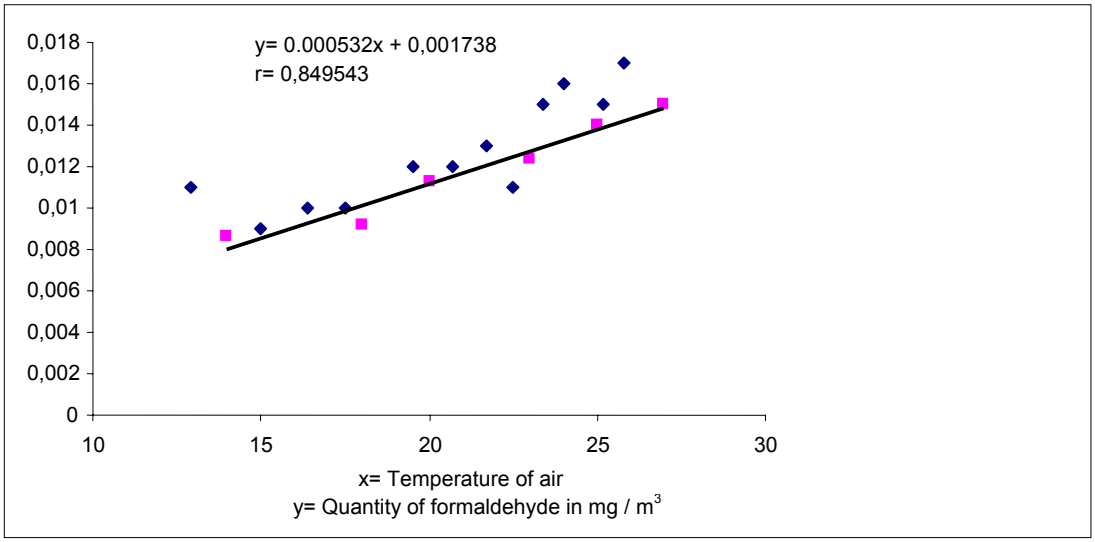

Figure 3. The regression line of correlation between the level of air pollution by formaldehyde and air temperature during the warm period of years 2007- 2010, Almaty city

However, although there is a dependency of the formaldehyde concentration from the air temperature, it is not as close, as it could be because it has been noted that most of low concentrations of formaldehyde varies only slightly under the thermal influence. The reason for this is that the temperature of 20-25 ° C is still not sufficient for the reaction to occur.

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