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INFLUENCE OF FOG ON THE LEVEL OF ATMOSPHERIC POLLUTION IN EAST KAZAKHSTAN FOR THE PERIOD 2014-2024

Annotation. The article presents a spatiotemporal analysis of the recurrence of fogs according to data from Kazakhstan, in the East Kazakhstan region for the period 2014-2024. The influence of fogs on air pollution in the cities of the region is also considered. Fogs in East Kazakhstan are observed throughout the year. A large number of foggy days are recorded during the cold season of the year. In Ust-Kamenogorsk, fog occurs in the X, XI, and II months out of the twelve. The synoptic conditions during fog include a low-gradient field, a warm sector, and a high-pressure center. A certain percentage (80%) is accounted for by the synoptic period during which fogs are observed. Air pollution occurs very frequently during fogs. The level of atmospheric pollution decreases towards the southwestern periphery of the anticyclone. In the case of fog, the maximum permissible concentration is often determined primarily in accordance with the MPC. For example, the amount of H2S (hydrogen sulfide) accounts for almost half of all impurities.

Keywords: fog; urban fog; Ust-Kamenogorsk; atmosphere; pollution; synoptic situation; environment; water evaporation; reservoir; Irtysh; toxic air.

Introduction

Fogs over land and water bodies are a fairly common occurrence. The national economy, especially air and sea transport, needs both information about the distribution of fogs and their forecast. As atmospheric physics develops, it becomes possible to solve the problem of artificial fog dispersion. But the physical essence of the processes of fog formation and dispersion cannot be considered fully clarified, because there are a number of still unsolved problems in this matter.

East Kazakhstan is one of the largest and most picturesque regions of Kazakhstan, located at the crossroads of Europe and Asia. The region includes several administrative

districts and cities, such as Ust-Kamenogorsk, Ridder, Zyryanovsk and Semey. The territory of the East Kazakhstan region is approximately 283,300 square kilometers. The territory of East Kazakhstan is characterized by a variety of landscapes, including mountain ranges, valleys, forests, rivers and lakes. The main mountain ranges include the Altai Mountains, the Tarbagatai Range and the Sauyr-Tarbagatai Mountains. The region is also famous for its nature reserves, such as the Katon-Karagay and West Altai Nature Reserves, home to rare and endangered species of animals and plants. The region is rich in natural resources, such as gold, silver, copper, zinc and lead. The mining industry plays an important role in the economy of East Kazakhstan.

The relevance of the study is the local recurrence of fog. In parallel with the study, the task is to count the days with fog and record the amount of atmospheric air pollutants. The The main water basin is the Irtysh, which divides the city into two parts [1]. Therefore, the Irtysh is the main body of water that contributes to the formation of fog, as fog itself consists of 90-100% humidity [2]. Evaporation fogs from reservoirs can be considered as one of the types of fogs in cold advection, in which the main process of saturation of air with water vapor is evaporation. Evaporation fogs most often form in the cold season near the shores of non-freezing reservoirs. A significant process is represented by data on the daily course of fog duration. Night and early morning fogs prevail until August – September, and in October the winter daily course of fogs is established, again daytime and evening fogs prevail. As special studies of the daily course of fog duration have shown based on frequent observations, in winter, during anticyclonic weather, fogs most often occur between 7:00 and 11:00 hours, when in populated areas the heating of furnaces is intensified and the number of condensation nuclei in the air increases. During the summer period, fogs typically occur between 02:00 and 06:00 hours during the period of greatest radiation cooling of the underlying surface. After sunrise, these fogs quickly dissipate. Wind speeds during fogs are usually low, and calm or winds with speeds of 3-6 m/sec are often observed. Information on the temperature and relative humidity of the air during fogs is very scarce, and only fragmentary data are available for some areas [3]. Based on frequent observations, it was possible to obtain some idea of the relationship between temperature and humidity with fog. In winter, fogs occur in 40-50% of cases at temperatures of -10, -150C and relative humidity of 90-95%. In winter, fog occurs at relative humidity of 75-80% and air temperature of -20 -25%. The distribution of fogs in the eastern part of Kazakhstan is similar to their distribution in the west of the republic: in the steppe regions, up to 15 days with fog are noted per year, and in the mountainous part - up to 50. The mountainous regions of Eastern Kazakhstan are represented by the Kalba, Altai and Saur-Tarbagatai ranges, they are surrounded by hilly plains [4]. The ridges, individual mountains, valleys and gorges of Altai and Sayan create a very varied picture of the distribution of the number of days with fog, typical for mountainous regions. Altai and Sayan mountains differ noticeably in the distribution of fogs. In The main number of foggy days is observed in the main part of the Irtysh River valley, ranging from 30-75 days to 90 days. A significant increase in the number of fogs in the upper part of the Irtysh valley is explained by its openness to westerly and north-westerly winds, which contributes to the condensation of moisture as air currents rise along the valley [5]. On the slopes of individual ridges and in closed mountain valleys of

Altai, the number of foggy days per year decreases to 20 or less. In winter, the duration of individual fogs is usually longer than in summer. In 40-50% of cases, winter fogs last from 2 to 5-7 hours in a row. In 2-3% of cases, the duration of continuous winter fogs reaches 24-48 hours. In summer, fogs are usually short-lived, in 50-70% of cases their duration does not exceed 3 hours, and only in very rare cases fogs lasting up to 6-12 hours are possible. On the northern and north-eastern slopes of the Eastern Sayan ridge, mainly in the valleys of mountain rivers, from 20 to 50 days with fog per year are observed. In foggy conditions, the composition of atmospheric air is very complex and diverse. In urban environments, fog is often detrimental to various sectors of the economy, including transportation, human mobility, and well-being. [6]. Non-ferrous metallurgy is developed in Ust-Kamenogorsk. The number of enterprises in Ust-Kamenogorsk is very large relative to the number of people living there. According to data for 2002, there are about 169 firms in the city. Most of them are industrial enterprises that work on the extraction and processing of raw materials and, mainly, heavy metals. Meteorological conditions for fog formation: inversion, calm or light wind, and high humidity. These conditions contribute to the accumulation of impurities in the prism layer, which are also absorbed by the droplets. Instead of being absorbed by the droplets, the impurities remain in the surface layer of the air [7]. A similar process also occurs in the production of sulfuric acid, when water is used in the absorption tower to absorb sulfur oxide. In this case, sulfuric acid is formed in the form of a fog consisting of tiny droplets. In places of strong focal pollution of the atmosphere under unfavorable weather conditions, as a result of the interaction of pollutants and atmospheric oxygen under the influence of ultraviolet rays, toxic fog can form - photochemical smog. In this case, a synergistic effect is observed - two polluting components as a result of the reaction form more toxic substances, such as chlorine, hydrogen sulfide, carbon monoxide, mercury, many metals and organic compounds [8]. A number of toxic substances, especially chemical plants, are discharged in large quantities. for example, sulfur dioxide, sulfuric acid fog, chlorine, hydrogen chloride, nitrogen oxides, and others. Sulfur dioxide. Photochemical transformations of sulfur dioxide lead to the formation of aerosols, and the scattering and absorption of radiation by aerosols in the atmosphere cause a decrease in visibility. An accumulation of small water droplets or ice crystals in the surface layer of the atmosphere, which reduces horizontal visibility from 1 km to several meters. Sometimes fog is observed at a height of several hundred meters [9]. And the greater the concentration of large droplets at the earth's surface, the denser the fog becomes, and visibility sometimes decreases to tens of meters or even less. Therefore, fog is considered a very dangerous weather phenomenon and poses a threat to air, sea, and land transport. Fogs are formed as a result of the condensation of water vapor on aerosol (liquid or solid) particles contained in the air. According to their physical genesis, fogs are divided into cooling fogs and evaporation fogs. Water vapor can be considered one of the main greenhouse gases on Earth. It influences the formation of the planet's radiation balance and chemical reactions in the atmosphere. According to synoptic conditions of formation, there are intra-mass fogs, which form in homogeneous air masses, and frontal fogs, the appearance of which is associated with atmospheric fronts. Fogs are more common in populated areas than far from them due to the increased content of hygroscopic condensation nuclei in urban air.

Materials and methods

Knowledge of the climatic conditions of the territory is of great practical importance. Fogs are abnormal meteorological conditions, under which the danger of air pollution increases significantly. For the analysis, the data of Kazhydromet (National Hydrometeorological Service of Kazakhstan) observations of fog at 6 meteorological stations of East Kazakhstan for the period 2014-2024 were used. The data bank made it possible to calculate the days with more than 8 observations of fog. All observations were conducted at weather stations according to the established Greenwich time. Air pollution was calculated using forms issued by Kazhydromet, but these data describe the local locations of the posts. Observations of impurity concentrations in Eastern Kazakhstan are conducted in three cities: Ust-Kamenogorsk, Ridder, and Semey.

Results and discussion

In the East Kazakhstan region, the frequency of fog differs between warm and cold periods. Out of the 28-31 days of the month, fog is most common during the cold season, and sometimes during the transitional season (autumn and spring).

Table 1 - Average number of days with fog in East Kazakhstan (2014-2024)

Weather station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Cold period X-III	Warm period IV-IX	Year
Ust-Kamenogorsk	3,4	3,8	4,8	5,6	0,2	0,3	0,1	0,2	3,1	8,7	**8,9**	8,8	38,4	9,5	41,8
Ridder	**2,1**	2,0	3,3	3,5	0,2	0,1	0,1	0,2	3,3	6,2	6,8	6,8	27,2	7,4	34,6
Semey	0,3	0,3	0,8	0,6	0,2	0,3	0,3	0,6	1,7	0,6	0,4	**0,2**	2,6	3,7	6,3
Zaysan	3,4	2,1	3.5	3,6	0,2	0,3	0,1	0,2	3,1	6,3	7,4	7,8	30,5	7,5	38,0
Kurchum	3,4	3,0	2,8	4,5	0,5	0,1	0,1	0,3	1,1	5,7	5,3	6,5	26,7	6,6	33,3
Katon-Karagay	0,4	**2,8**	3,8	3,6	0,1	0,1	0,1	0,2	3,1	6,2	7,3	6,8	27,3	3,4	7,2

The areas with the highest average number of foggy days (Table 1) are located in areas of elevated terrain. First of all, this is the eastern area, where the average number of foggy days is 8.9 days. We can also highlight the extreme northeastern and mountainous eastern areas of the region, where the average number of foggy days is 2.1–2.8 days. The lowest average number of foggy days is observed in the central areas and in the southwest of the region, and ranges from 0.2 to 1 day. In the rest of East Kazakhstan,

the average number of foggy days is from 1.1 to 1.7 days. The distribution of fog frequency by month is also characterized by heterogeneity.

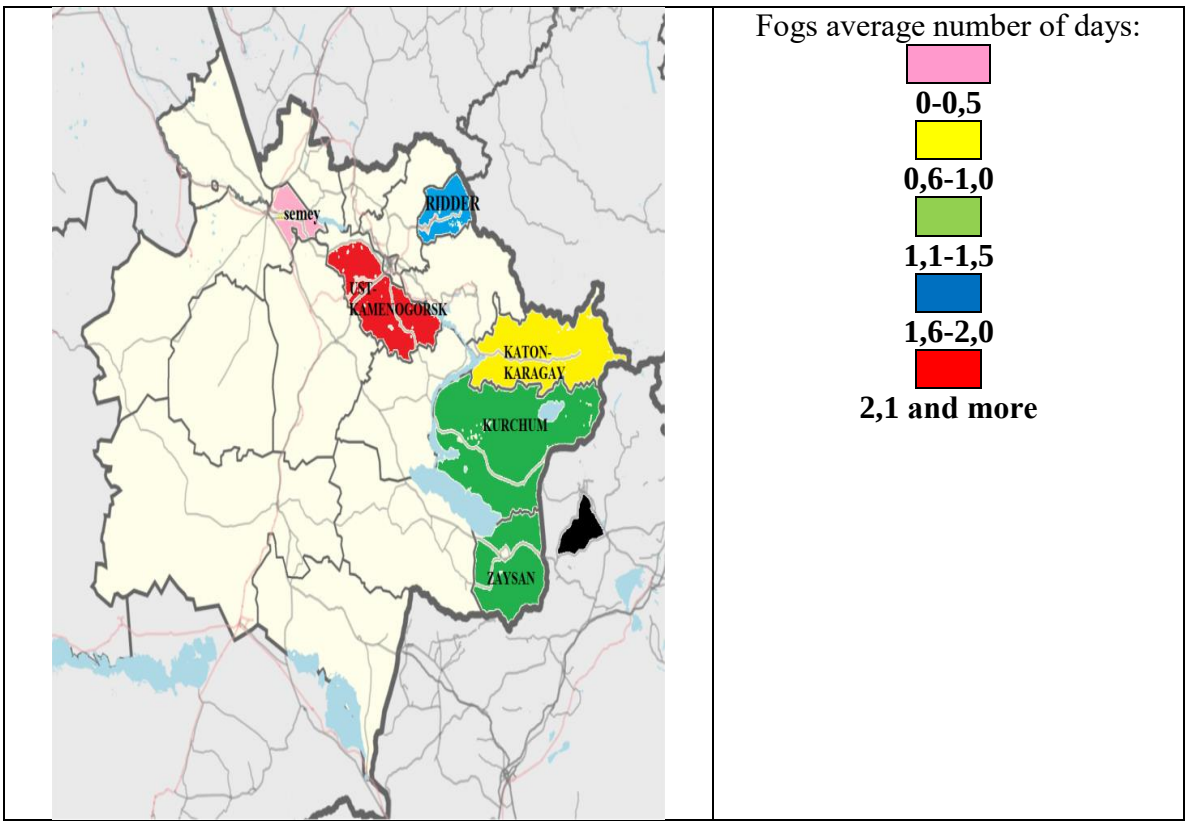

Fig 1 - Distribution of fog frequency by month

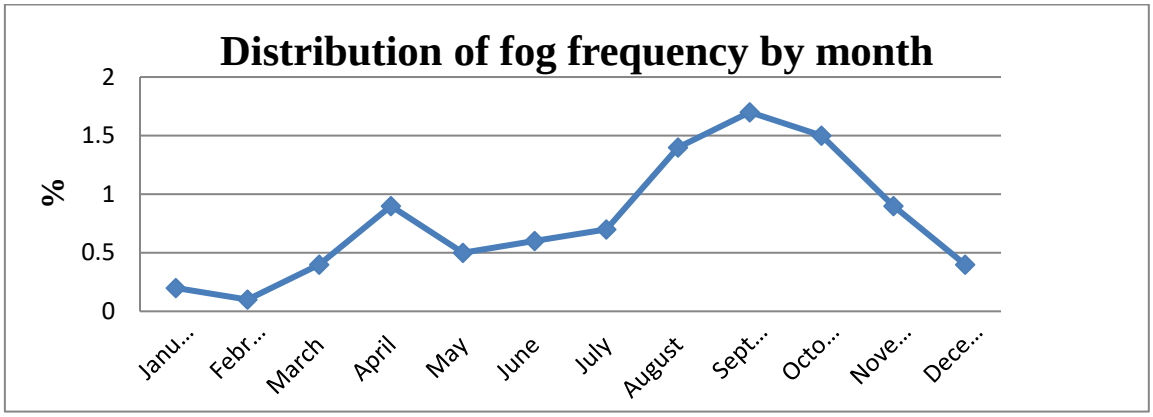

Fig 2 - Average frequency of fogs by month in East Kazakhstan for the period 2014–2024

Fog is most frequently observed in August (an average of 1.4% of the total number of hours), September (1.7%) and October (1.5%), which is associated with the highest values of relative air humidity in these months. The lowest frequency of fog is observed

in January (0.2%) and February (0.1%), which is associated with low values of relative air humidity. Next, a study was conducted to determine the synoptic situations in which fog is observed. The frequency of fog in various synoptic situations in the studied cities of the region for the period 2014-2024 is presented in Table 2. The synoptic situations in which fog is most frequently observed in the region include a low-gradient field, a warm sector of a cyclone and the center of an anticyclone. They account for more than 70% of all synoptic situations in which fog was observed. Fog was least frequently observed at various peripheries of anticyclones and cyclones. No fog was observed in the synoptic situations of “cyclone center” (Semey), “northern part of the cyclone” (Ridder), “northeastern periphery of the anticyclone” (Kurchum, Zaysan), “eastern periphery of the anticyclone” (Katon-Karagay), “western periphery of the anticyclone” (Ust-Kamenogorsk).

An analysis of the literature data showed that in Kazakhstan, among the environmental stress zones, The first place in terms of atmospheric air pollution is occupied by East Kazakhstan – Ust-Kamenogorsk. According to the World Health Organization, over the past decade, more than 2.5-3 million people have died worldwide from diseases caused by environmental pollution [11,12]. In the Republic of Kazakhstan, every person who actively lives and works is faced with the fact that due to industrial regions with an unfavorable ecosystem, they suffer from cardiovascular diseases of varying severity. Ust-Kamenogorsk is one of the largest industrial centers in the Republic of Kazakhstan, as it is home to the non-ferrous and ferrous metallurgy industries of the nuclear industry [13,14].With very weak wind and inversion temperature distribution, fuel combustion products are not dispersed over a large area, but spread over a short distance around the source. Low location of chimneys and lack of wind contribute to the accumulation of hydrogen sulfide in the surface layer. The atmosphere under these conditions is characterized by high stability: due to the lack of turbulent mixing and weak dispersion, its self-purification does not occur, and all industrial emissions remain in the surface layer. Such unfavorable meteorological conditions contribute to the accumulation of impurities and form high and very high levels of air pollution in the region [15,16]. The study used the bulletin of the RSE (National Hydrometeorological Service of Kazakhstan) "Kazhydromet" on the state of the Ust-Kamenogorsk air basin as of November 25, 2024. The bulletin states that the MPC (Maximum Permissible Concentration) of H2S (hydrogen sulfide) is 2.013 mg/m3, which means that the amount of this substance in the air that is considered normal for health is more than twice as high. Hydrogen sulfide is a colorless gas that is dangerous to humans (hazard class II). The gas enters the body through inhalation and transdermal (through the skin). When inhaled, hydrogen sulfide paralyzes the olfactory nerves, and a person stops smelling the gas, which has a lethal effect. This often leads to severe poisoning due to the inability to promptly recognize and stop contact with the toxic source. Being very toxic, H2S primarily affects the nervous system, causing severe headaches, convulsions, and can lead to a coma. The lethal concentration of hydrogen sulfide is approximately 1000 mg/m3. At a concentration of 6 mg/m3, headaches, dizziness, and nausea begin. Since from November 22-25, 2024 there were windless days, that is, calm, fog formed unfavorable meteorological conditions that contributed to the accumulation of pollutants in the

atmosphere of Ust-Kamenogorsk. The formation of fogs in Central Asia is often an interesting topic for study. Climatologists extensively research the synoptic part of the occurrence of fogs in various places, both near and without bodies of water. The general pattern of fog formation is the same, but there is a nuance worth noting: the relative and absolute humidity in the air layer [17].

Conclusion

Thus, over the past 10 years, in comparison with previous long-term periods, the average annual and seasonal number of days with fog in Ust-Kamenogorsk has remained virtually unchanged, but throughout all three periods considered there is a decrease in their annual and seasonal duration, a decrease in the share of cold period fogs in the total annual duration of fogs, a decrease in the duration of one fog both on average per year and during the cold period. An increase in air temperature leads to a decrease in fog formation. A climatic analysis showed that last year, the average air temperature was within the normal range, with no prolonged frosty days. This was one of the reasons for the decrease in fog during the cold season. Hydro-meteorological phenomena, such as heavy rainfall, contributed to the dissipation of fog. The results of the analysis of synoptic maps of the intracontinental territory of Eurasia within Kazakhstan and Russia made it possible to obtain the following results: to study the atmospheric processes leading to the appearance of certain cloud structures and the relationship of large-scale cloud formations with baric systems of a synoptic scale. The results of numerous studies have significantly expanded our knowledge of the movement of air masses and their energy changes and have shown that the forecast of urban fog is made on the basis of taking into account the general factors of fog formation (radiation, advection, evaporation, proximity of open water bodies) with the introduction of local adjustments for city conditions. Frosty (village stove, airfield) fogs occur during severe frosts if an additional source of water vapor appears (furnace heating, operation of an airplane engine, a steam locomotive). Research has shown that urban fogs are usually singled out as a separate type due to the fact that fog in a large industrial city is often observed even when it is absent in the city's outskirts. This is especially true for winter conditions. Generally speaking, urban fog is either radiation, or advective, or any other type of fog. The specificity lies, firstly, in the fact that in a large city the regime of all the main meteorological elements (wind, temperature, humidity) differs from the regime of these same elements in the city's outskirts; secondly, in the fact that there are always additional sources of water vapor and smoke in the city. Sometimes urban fog spreads beyond the city in the direction of the wind. Pollution of urban air by industrial waste contributes to a significant deterioration in visibility and the formation of fog.

In conclusion, it should be noted that the increase in the concentration of pollutants can be adjusted by regulating industrial sectors in terms of technical aspects (such as filter replacements, timely maintenance, and cleaning of equipment) to accurately measure the maximum permissible level. The results directly indicate that fog is detrimental to human life, especially for the national economy, which may have negative consequences in the socio-economic sector of the Republic of Kazakhstan.

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Алдабергенова А.М., Б.А. Капсалямов Б.А., Харламова Н.Ф., Идришева Ж.К., Сейлхан А.

2014-2024 ЖЫЛДАРДАҒЫ ШЫҒЫС ҚАЗАҚСТАНДАҒЫ АТМОСФЕРАНЫҢ ЛАСТАНУ ДӘРЕЖЕСІНЕ ТҰМАННЫҢ ӘСЕРІ

Аңдатпа. Мақалада Қазақстанның мәліметтері бойынша, Шығыс Қазақстан облысында 2014-2024 жылдар кезеңінде тұман қайталануының кеңістіктік-уақыттық талдауы ұсынылған. Шығыс Қазақстанда тұман жыл бойы байқалады. Суық мезгілде тұманды күндердің көп саны байқалады. Өскеменде он екі айдың ішінде X, XI және II айларда тұман байқалады. Тұман кезіндегі синоптикалық жағдайларға төмен градиентті өріс, жылы сектор және жоғары қысымды орталық жатады. Белгілі бір пайыз (80%) тұман байқалатын синоптикалық кезеңге келеді. Тұман кезінде ауаның ластануы өте жиі кездеседі. Атмосфераның ластану деңгейі антициклонның оңтүстік-батыс шетіне қарай төмендейді. Тұман жағдайында шекті рұқсат етілген концентрация көбінесе ШРК сәйкес анықталады. Мысалы, H2S (күкіртсутек) мөлшері барлығының жартысына жуығын құрайды.

Кілт сөздер: тұман; қалалық тұман; Өскемен, атмосфера; ластану; синоптикалық жағдай; қоршаған орта; судың буланууы; су айдыны; Ертіс; улы ауа.

Алдабергенова А.М., Капсалямов Б.А., Харламова Н.Ф., Идришева Ж.К., Сейлхан А.

ВЛИЯНИЕ ТУМАНОВ НА СТЕПЕНЬ ЗАГРЯЗНЕНИЯ АТМОСФЕРЫ В ВОСТОЧНО-КАЗАХСТАНЕ ЗА ПЕРИОД 2014-2024Г.Г.

Аннотация. В статье представлен пространственно-временной анализ повторяемости туманов по данным из Казахстана, в Восточно-Казахстанской области за период 2014-2024 гг. Также рассматривается влияние туманов на загрязнение воздуха в городах региона. Туманы в Восточном Казахстане наблюдаются в течение всего года. В холодное время года отмечается большое количество туманных дней. В Усть-Каменогорске туманы наблюдаются в X, XI и II месяцах из двенадцати. Синоптические условия во время тумана включают в себя поле с низким градиентом, теплый сектор и центр высокого давления. Определенный процент (80%) приходится на синоптический период, в течение которого наблюдаются туманы. Во время туманов очень часто происходит загрязнение воздуха. Уровень загрязнения атмосферы снижается по направлению к юго-западной периферии антициклона. В случае тумана предельно допустимая концентрация часто определяется в первую очередь в соответствии с ПДК. Например, количество H2S (сероводорода) составляет почти половину всех примесей.

Ключевые слова: туман; городской туман; Усть-Каменогорск; атмосфера; загрязнение; синоптическая ситуация; окружающая среда; испарение воды; водоем; Иртыш; токсичный воздух.