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G. A. Sainova[1], M. O. Baikhamurova[2],
A. D. Akbasova[1], Zh. Zh. Yessenbayeva[1], Ali Ozler Mehmet[3]

[1]International Kazakh-Turkish University named after Khoja Ahmed Yasawi, Turkistan, Kazakhstan,
[2]Kazakh National Agrarian University, Almaty, Kazakhstan,
[3]Mugla Sitki Kochman University, Mugla, Turkey.
E-mail: ecolog_kz@mail.ru

ENVIRONMENTAL ANALYTICAL CHARACTERISTICS OF GAS EMISSIONS FROM THE SOLID DOMESTIC WASTE LANDFILLS OF TURKISTAN OBLAST

Abstract. The work is devoted to the study of the state of 2 urban and 22 rural landfills of Turkistan oblast (Turkestan and Otyrar districts). Based on the conducted morphological analysis of SDW, it was determined that about 50% of waste in the landfills of Turkistan and Kentau towns can be attributed to a potential source of secondary raw materials. Chemical and analytical studies have been carried out to identify the content of harmful gas components in the atmospheric air on the territory of landfills under normal conditions and under ignition of solid domestic waste (SDW). Al hazard classes' compounds presence was detected in the composition of landfill gas. A significant part of the urban landfills' territories in contrast to rural areas, can be attributed to the fire hazard zone. It has been determined that during fumigation or fire, the content of toxic compounds in gas emissions is higher many times than the maximum permissible concentrations both in the working area and outside the landfills.

Keywords: solid domestic waste, urban and rural landfills, ignition, gas emissions, toxic compounds.

Introduction. At the present time the destiny of solid domestic waste (SDW), the quantity of which is increasing with speed, anticipating their recycling and utilization, belongs to pending important problems in all countries [1, 2]. The main part of generated solid domestic wastes are stored in the landfills of various type and numerous unauthorized landfills. They mainly adjoin the settlements or are located in the territory of residential areas.

Ownerless accumulation of SDW has huge environmental, economic and social damages. Such waste management can be referred to one of the main factors, which hinders stable development of the cities and villages.

Permanent growth of generated waste quantities leads not only to littering, but also to increase of recallable valuable lands under SDW disposal landfills in the economic respect. SDW consists of toxic gases and not less toxic products of their decomposition, representing various harmful substances in the form of gaseous, solid and liquid connections. Accordingly places of SDW accumulation acts as the essential pollution sources of environmental medium, more specifically of atmosphere, soil, surface and underground water. which in turn have a negative impact on the biological resources, including population [3, 4].

For protection and enhancement of the environment, ensuring environmental safety it is necessary to focus on solution of a problem with minimization of SDW impact on the environment and population health, decrease of accumulated SDW volume by implementing effective measures on collection, sorting, treatment and recycling with obtaining valuable market products, reclamation and rehabilitation of disturbed lands. Occupied under landfills and unauthorized landfills. In light of specified problems, a solution of the problem, ensuring environmental improvement on a broad scale and in a concrete region is topical.

The objective of this work was to identify existing landfills and landfills of Turkistan oblast (for example, Turkistan and Otrar districts) and conduct chemical and analytical studies to determine the ecological condition of atmospheric air under normal conditions of storage of SDW and their fire.

Objects and methods of study. 24 polygons of Turkistan oblast, namely, in two districts (Turkistan and Otrar) and in the towns - Turkistan, Kentau (table) served as objects of research. Apart from that, several hundreds of unauthorized landfills located in the studied areas were examined.

The landfills under study of Otyrar district (Akkol, Akkum, Arys, Baltakol, Bestam, Bestorangyl, Koksarai, Kosterek, Mayakum, Otyrar, Syrdarya), the area occupied by them is 60 ha (17 922 people). Total quantity of waste in the landfills of Otyrar district (actual) is 41 355,144 tons. Total area occupied by 10 rural landfills of Tukistan district (Zhibek zholy, Ushaiyk, Shornak, Sauran, Zhuynek, Zhana Ikan, Eski Ikan, Babaikorgan, Orangai) is 22 ha (87 957 people). Total quantity of buried waste in the landfills of Turkistan district (actual) is 155 780,662 tons. Urban lanfdfill of Turkistan occupies 18 ha (263 000 people). Quantity of waste of Kentau town (actual) is 239 175 tons. Area of the landfill of Kentau town is equal to 33 ha (7115 people), total quantity of waste in it is 20 020 tons. Average quantity of SDW for 1 person is from 200 to 250 kg/year.

In order to perform the foreseen works, a comprehensive analytical analysis of landfills' condition, determination of SDW morphological composition in different periods of the year, the study of gaseous products' composition released under normal conditions and spontaneous combustion were carried out. Measurement of gas composition above the landfill surface was carried out in favorable meteorological conditions, in particular, on a windless day and in the absence of precipitation. And to establish the distribution of gas flows in space and their effects on environmental objects, measurements were taken both in calm and in windy weather, but in the absence of precipitation.

As is known, the value of gas flow from the body of waste into ground air of landfill surface in different sections are different [5, 6]. Irregularity is observed not only in area, but also in depth. It is connected with heterogeneity of solid domestic waste both in composition and capacity of landfill masses. In this regard, to establish the intensity of the gas flow from the landfill masses and SDW morphological composition in them, the sampling was carried out using a well-known "envelope" method [7]. Used "envelope" method for sampling by us was not difficult, since SDW in the studied landfills and disposal fields are in piles (no more than 2-3 meters high) and there are free passages between them.

All analytical studies were carried out in an accredited laboratory of "Environmental Control and Chemical Analysis" by certified methods, and field observations were conducted in the territories of landfills using well-known classical methods [8-10].

Using the universal gas analyzer ГАНК-4 (measurement height up to 2 meters from the ground), we regularly measured emissions of harmful gaseous substances. While using the gas analyzer "ГАНК-4" the chemical cassettes or a built-in sensor are used. The cassette is designed for approximately 1000 counts for working area air and/or for atmospheric air. The built-in pump sucks in analyzed air through the inlet piece of a gas analyzer and passes it through the sensor or tape of a chemical cassette. Changing the cassette is done manually and takes at most 1 minute.

Results and discussion. The outcomes of monitoring studies in the territories of districts under consideration show that there are not only 24 landfills, but also hundreds of unauthorized landfills, about 20 landfills in the territory of Turkistan and Kentau towns. It is impossible to determine an exact number of unauthorized landfills, as they are like mushrooms after rain, appear in unpredictable places especially in rural areas. SDWs are piled in the ravines, pit places and areas adjacent to private solid fuel-heated houses (about 70% of ash and construction waste).

The studied 24 landfills of Turkistan oblast on average occupy a total area equal to 133 hectares. Only 5% of these landfills meet the requirements of sanitary standards. The most common method of waste management is depositing the solid domestic waste at disposal fields and landfills in the territory under consideration. The results of field surveys (visual assessment) showed that the waste is disposed systemless in many SDW landfills (at least 80%). Waste is delivered to the entire area without mapping and observing the established sequence for waste. Proper compaction and backfilling of waste with soil is also not performed.

As the results of on-site surveyы have shown, over time, the geometric characteristics of landfill sites is changed with accumulated waste. Namely, there is a subsidence of SDW and sometimes, on the

contrary, a height increase of burials due to refill of heaps with new batches of various wastes. It accordingly leads to a change not only in shape, but also to a change in the mechanical, chemical, biochemical, and other characteristics of SDW. Changing the areal and volumetric configuration of the landfill body requires periodic monitoring of atmospheric gas pollution state in the territories of a landfill and in the territories of a residential part adjacent to the landfill. The data from monitoring studies will allow establishing the impact of landfills on natural environmental objects' state in both normal and extreme (fire, smoke, etc.) conditions.

One of the important indicators characterizing the SDW composition is their morphological composition. These data are necessary not only for identifying the landfill impact on the environment, but also for effective selection of decontamination technology, methods of SDW disposal and recycling [11]. In connection with this, we have conducted studies on establishment of a morphological composition in all existing landfills and dumps of the studied area.

Table presents an average morphological composition of SDW at various types of landfills, depending on season (2018).

An average morphological composition of solid domestic waste located in rural and urban landfills of Turkistan oblast (12 landfills of Turkistan district, Kentau town, 11 rural landfills of Otyrar district)

Name of components	Average content of SDW components in rural and urban landfills by seasons of a year, %					
	winter-spring			summer-autumn		
	rural	Turkistan	Kentau	rural	Turkistan	Kentau
Food waste	5-7	23-30	15-20	8-10	36-37	35-45
Paper, cardboard	9-12	13-16	10-12	7-9	20-22	5-6
Tree	~0,4	2-3	0,5-1	~0,5	3-4	1-2
Ferrous and nonferrous scrap metal	≤1	≤3	до 1	≤2	≤3	1-3
Textile	4-6	4-5	3-5	4-6	4-5	2-4
Bones	5-7	6-8	1-2	4-6	5-6	1-2
Glass	3-5	7-8	2-5	10-12	10-15	9-11
Leather, rubber	6-9	2-5	10-11	5-7	2-5	2-3
Construction materials: stone, plaster, asbestos sheeting and others	8-9	19-23	5-7	10-15	20-26	6-8
Polymers	7-10	20-24	10-20	20-25	26-29	15-20
Manure, poultry droppings, wool and others	10-15	2-3	5-10	8-10	2-3	1-2
Other waste (ash, coal, residue)	Remaining			Remaining		
SDW physical and mechanical composition for urban landfills						
Ash content to working mass, %					10-21	
Ash content to dry mass, %					20-32	
Organic substance to dry mass, %					48-60	
Humidity, %					15-20	
Density, kg/m^3					190-200	
Heating value as fired, kJ/kg					5000-8000	
Agrochemical factors, % to dry mass (rural landfills)						
Total Nitrogen					0,8-1	
Phosphorus (P_2O_5)					0,7-1,1	
Potassium (K_2O)					0,5-0,7	
Calcium (CaO)					2,3-3,6	

As can be seen from the data presented in Table 1, solid domestic waste is a complex heterogeneous mixture, determined by living standard of population, degree of home improvement, habits and characteristics of residents. The content of food waste is unstable, their content in the total waste stream increases in the summer-autumn period, which is associated with an increase in consumption of vegetables and fruits, preparation for storage and absence of the need to use them as food for animals and birds. Food waste is not thrown away in the winter-spring period, because it used for feeding animals. An increase in the content of glass and plastic containers is associated with an increased use of various beverages in hot summer months. An increase in construction waste by almost 2 times is due to the intensified repair and other construction works in summer-autumn months. The remaining fractions are practically little changed. Many waste components belong to IV and V hazard classes, average waste density is ≤ 0.2 t/m^3.

Based on a deep morphological sorting, solid domestic waste can be divided into the following 3 groups: biodegradable (food, wood, sawdust, textiles, leather), inert (stone, sludge, resuduals) and recyclable (paper, cardboard, polymeric materials, metal, glass).

Morphological analysis of waste of Turkistan and Kentau towns showed that at least 50% of SDW are potential secondary raw materials. Under the existing waste management system, about 100 000 tons of SDW are placed annually in two town landfills, including over 7 thousand tons of glass, ~ 4-6 thousand tons of polymeric materials, at least 8 thousand tons of paper and cardboard and about 5 thousand ton of metal. There is a constant increase in the content of non-ferrous and ferrous metals in SDW composition. It is connected with additional recharge of non-ferrous metals due to emergence of aluminum cans from beer, water and other beverages, as well as iron packaging cans. The content of plastic packaging materials, including bottles made of polyethylene terephthalate, is also increasing every day in all landfills.

The survey results of landfills' state show that the construction materials, large furniture, refrigerators, microwave ovens, other kitchen appliances, car tires, chemical current sources (batteries, batteries) and similar household items constitute a significant part in the structure of waste stored at landfills and dumps. The disposal of these materials is not only a significant force on the environment, but also the loss of valuable materials and energy contained in them.

Involvement of such valuable components as paper, cardboard, glass, polymeric materials, metals in the secondary circulation will lead to a significant reduction in the need for material and energy resources, as well as to reduce their negative impact on the environment. In addition, an extraction of recycled materials from waste and their sale, use of biogas energy will allow for additional income.

Recycling of organic waste will provide an opportunity to return carbon to the circulation of substances, naturally increasing soil fertility through the production of compost, vermicompost and use the waste energy value through use of energy and heat produced.

Since 2019, taking into account the feasibility of reusing the valuable components of SDW as a secondary raw material, Kazakhstan has banned the export and deposit of paper, cardboard, plastic bottles and other polymeric materials, glass in landfills [12].

Considering the experience of Germany and other countries in collection and sorting of waste [13-15] the implementation of pre-sorting has commenced in Turkistan with active participation of students, undergraduates, doctoral students and staff of International Kazakh-Turkish University named after Khoja Ahmed Yasavi. At the same time the following is used for separate collection of waste: *yellow* containers designed for plastic packaging and plastic films; *red* - for food and other biological waste; *blue* - for waste paper; *brown* - for glass products; *black* - for collecting other waste.

Sorted waste from special containers having different colors will fall under further processing. This approach allows not only to obtain an economic effect, but also to improve the environment by reducing the amount of waste which does not fall under biodegradation.

But, unfortunately, used batteries and accumulators that have a multicomponent chemical composition get into the composition of other waste. There are practically no enterprises involved in their processing in Kazakhstan as in many other countries [16–19]. In this regard, they have to be disposed of in landfills along with other waste. In a mixed environment, they enter into chemical reactions, are destroyed and begin to act as a dangerous source of environment contamination.

Worries in the cities are caused by food waste, their collection and separate storage in containers does not solve the environmental problem. They quickly decompose with release of bad smelling compounds, and are also a cumulative environment for rapid development of harmful microorganisms and

other representatives of biota. Their destroying by burning does not solve the problem, although this method is used in many countries [20-22].

A perspective and strenuously developing method of biochemical transformation of organic waste with production of useful products - compost or biohumus serves as an alternative to the burning method. But, however, to recommend their use in agriculture is limited, which is associated with possibility of heavy metals in their composition. They can only be suitable for fertilizing lawns and industrial crops that are not used to produce food.

At the present, there is no option of comprehensive optimal solution of SDW disposal issues, which would allow processing of secondary raw materials and energy resources in a significant amount both economically and environmentally efficient. The system for SDW management that exists in Kazakhstan and in local regions requires further improvement based on development and implementation of more rational ways to minimize the SDW impact on the environment and public health.

The presented paper provides the observation results of atmospheric air state directly in the territories of 24 polygons under consideration and in nearby areas up to 1 km. Field observations made it possible to note elevated concentrations of greenhouse gases (methane and carbon dioxide) and toxic gases — hydrogen sulfide, sulfur dioxide, nitrogen oxides and carbon in the surface air on the landfill body during fumigation moments. It has also been determined that significant air pollution of the landfill working area and the adjacent territory with carcinogenic compounds - benzpyrene, formaldehyde, benzene and other hazardous substances is as a result of waste ignition (figure).

The quantity of these of those gases in the surface air over different parts of the landfill sections was very different from each other. Such uneven content of gases in the atmospheric air first of all, during the fire, apparently, is related to the heterogeneity of composition and capacity of the waste landfill masses. And under normal conditions, the value of emission and the dynamics of gas volume changes over time depend on the nature of processes occurring in the landfill body.

Fumigation or fire development, especially during summer periods at the landfill, is more associated with artificial burns and, probably, to a lesser degree with facts of spontaneous combustion.

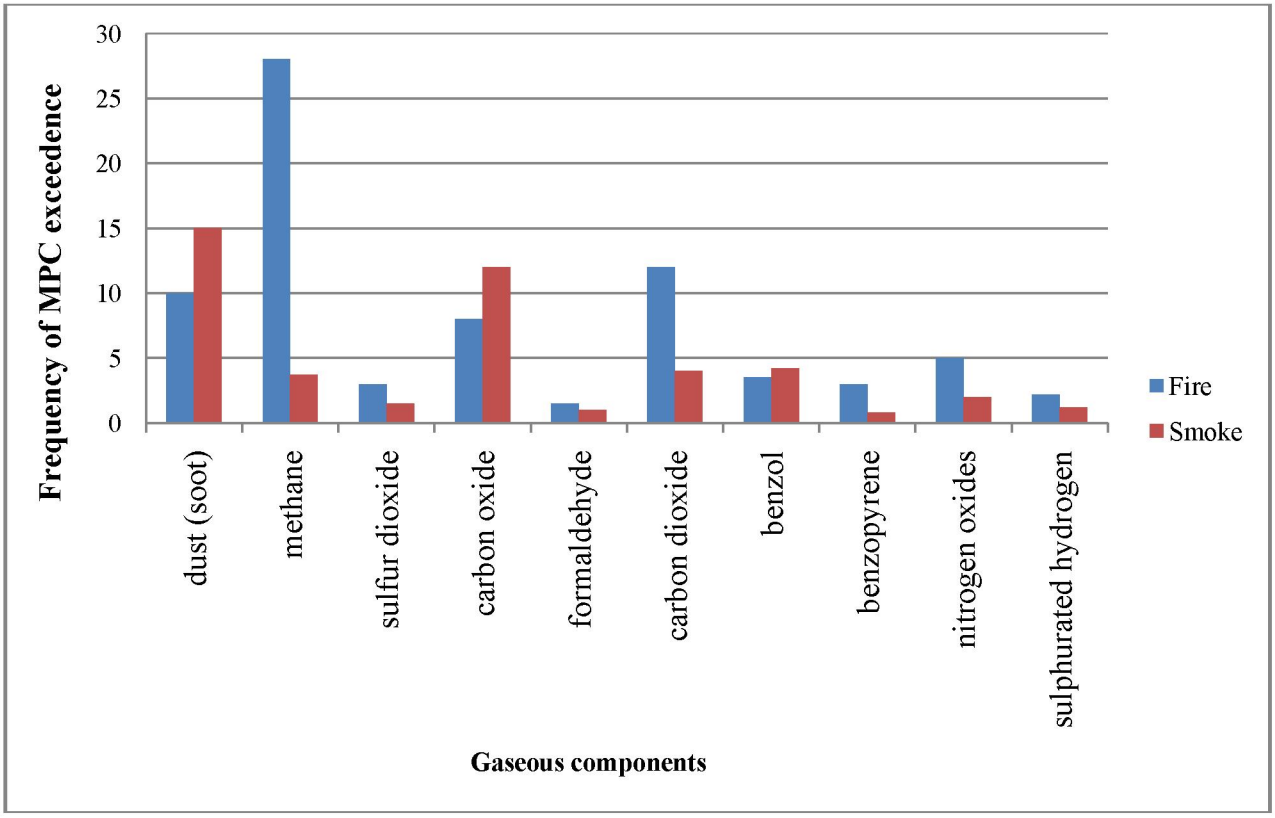

Figure 1 – Frequency of exceeding the maximum permissible concentration of individual compounds content in the composition of gas emissions (gas emissions) generated during fire

The results of experimental studies on determination of gas components released into the atmospheric air during ignition indicate to possibility of deterioration in the quality of population life in the nearby territories.

The presence of substances of all hazard classes was detected in the landfill gas composition. In addition, in urban landfills as opposed to rural areas, a significant part of the landfill territory belongs to the potentially fire-hazardous zone.

The considered qualitative and quantitative composition of landfill gas emissions testifies to presence of hazardous, fire-hazardous, toxic and carcinogenic gases of all hazard classes in the composition of gas emissions. In nature of impact on the human body, harmful substances can be divided into groups: irritants (chlorine, ammonia, hydrogen chloride, etc.); suffocative (carbon monoxide, hydrogen sulfide, etc.); narcotic (nitrogen under pressure, acetylene, acetone, carbon tetrachloride, etc.); somatic, causing organism disorder (lead, benzene, methyl alcohol, arsenic).

Thus, in order to reduce a negative impact on the environment and human health, it is necessary to take measures to minimize the risk of fires or fumigation on time.

Conclusions.

1. Monitoring studies on the state of 24 solid waste landfills in Turkistan oblast were carried out. It has been determined that, until now, the priority method of waste disposal from Turkistan and Kentau towns, as well as from the villages of Otrar and Turkistan districts is their removal for burial to landfills.

2. A morphological composition of waste deposited at the landfills was studied and, based on the results of these studies, the SDW components were classified into 3 groups: biodegradable (food, wood, sawdust, textiles, leather), inert (stone, sludge, residues) and recyclable (paper, cardboard, polymeric materials, metal, glass).

3. On the basis of experimental studies, generation of toxic compounds has been determined, the contents of which in gas emissions from fumigation or fire are many times higher than the maximum allowable concentrations both in the working area and outside the landfills (or disposal fields).

4. To enable the operation of solid waste landfills without a negative impact on the environment, it is proposed to carry out a regular analysis of entering waste. This will make it possible to identify types of waste that cannot be buried in ordinary SDW landfills, for example, availability of radioactive substances, hazardous medical and other wastes, and also to identify the sources of their generation.

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Г. А. Саинова[1], М. О. Байхамурова[2], А. Ж. Ақбасова[1], Ж. Ж. Есенбаева[1], Али Озлер Мехмет[3]

[1]Қожа Ахмет Ясауи атындағы Халықаралық қазақ-түрік университеті, Түркістан, Қазақстан,
[2]Қазақ Ұлттық Аграрлық университеті, Алматы, Қазақстан,
[3]Мугла Сыткы Кочман университеті, Мугла, Түркия.

ТҮРКІСТАН ОБЛЫСЫНЫҢ ҚАТТЫ ТҰРМЫСТЫҚ ҚАЛДЫҚ САҚТАҒЫШТАРЫНАН БӨЛІНЕТІН ГАЗ ШЫҒАРЫНДЫЛАРЫНЫҢ ЭКОЛОГИЯЛЫҚ-АНАЛИТИКАЛЫҚ СИПАТТАМАЛАРЫ

Аннотация. Мақала Түркістан облысының (Түркістан және Отырар ауданы) 2 қалалық және 22 ауылдық полигондарының жағдайын зерттеуге бағытталған. Қатты тұрмыстық қалдықтарға жүргізілген морфологиялық талдау нәтижелері көрсеткендей, Түркістан және Кентау қалалық полигондарында орналастырылған қалдықтардың шамамен 50% екінші реттік шикізат көзі ретінде қолданысын таба алады. Полигондардағы жинақталған қатты тұрмыстық қалдықтардан қалыпты жағдайда және де олардың өртенетін кезінде атмосфералық ауаға бөлінетін уытты газдардың құрамын анықтау мақсатында химиялық-аналитикалық зерттеу жұмыстары жүргізілген. Қоршаған ортаға бөлінетін газдардың құрамында барлық қауіптілік

сыныпқа жататын қосылыстар болатыны айқындалды. Ауылдық қалдық сақтағыштармен салыстырғанда қалалық полигондардағы қалдықтардың ауқымды көлемі өрт қауіптілігі жоғары екені анықталды. Өртеніп немесе түтіндеп жататын кезеңдерде полигондардың жұмыс аймағында да санитарлық шекарасының сыртында да улы қосылыстардың мөлшері шектік рауалы мөлшерден анағұрлым асып жататыны дәлелденді.

Түйін сөздер: қатты тұрмыстық қалдықтар, қалалық және ауылдық полигондар, өртену, газ шығарындылары, уытты қосылыстар.

Г. А. Саинова[1], М. О. Байхамурова[2], А. Д. Акбасова[1], Ж. Ж. Есенбаева[1], Али Озлер Мехмет[3]

[1]Международный казахско-турецкий университет имени Ходжи Ахмеда Ясави, Туркестан, Казахстан,
[2]Казахский Национальный Аграрный Университет, Алматы, Казахстан,
[3]Университет Мугла Сыткы Кочман, Мугла, Турция

ЭКОЛОГО-АНАЛИТИЧЕСКАЯ ХАРАКТЕРИСТИКА ГАЗОВЫХ ВЫБРОСОВ С ПОЛИГОНОВ ТВЕРДЫХ БЫТОВЫХ ОТХОДОВ ТУРКЕСТАНСКОЙ ОБЛАСТИ

Аннотация. Работа посвящена исследованию состояний 2 городских и 22 сельских полигонов Туркестанской области (Туркестанский и Отрарский районы). На основе проведенного морфологического анализа ТБО установлено, что около 50% отходов в полигонах городов Туркестан и Кентау можно отнести к потенциальному источнику вторичного сырья. Проведены химико-аналитические исследования по определению содержаний вредных газовых компонентов в атмосферном воздухе на территории полигонов при обычных условиях и при возгорании твердых бытовых отходов (ТБО). В составе свалочного газа обнаружено присутствие соединений всех классов опасности. Значительная часть территорий городских полигонов в отличие от сельских можно отнести к пожароопасной зоне. Установлено, что при задымлении или пожаре содержание токсичных соединений в газовых выбросах многократно превышают предельно допустимые концентрации как в рабочей зоне, так и за пределами полигонов.

Ключевые слова: твердые бытовые отходы, городские и сельские полигоны, возгорание, газовые выбросы, токсичные соединения.

Information about authors:

Sainova Gaukhar Askerovna, Doctor of technical sciences, Professor, Chief Researcher of the Scientific Research Institute of "Ecology" at Khoja Akhmet Yassaw International Kazakh-Turkish University, Turkistan, Kazakhstan; ecolog_kz@mail.ru; https://orcid.org/0000-0002-0709-7453

Baikhamurova Moldir Orazalievna, Phd, Kazakh National Agrarian University, Almaty, Kazakhstan; https://orcid.org/0000-0002-2098-7960

Akbasova Amankul Dzhakanovna, Doctor of technical sciences, Professor, Director of the Scientific Research Institute of "Ecology" at Khoja Akhmet Yassawi International Kazakh-Turkish University, Turkistan, Kazakhstan; https://orcid.org/0000-0002-0842-4647

Yessenbayeva Zhanar Zheniskizi, Master of technical sciences, Junior Researcher of the Scientific Research Institute of "Ecology" at Khoja Akhmet Yassawi International Kazakh-Turkish University, Turkistan, Kazakhstan; https://orcid.org/0000-0002-7737-548X

Ali Ozler Mehmet, Doctor, Mugla Sitki Kochman University, Mugla, Turkey; https://orcid.org/0000-0001-7547-0080

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