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ANALYSIS OF EMISSIONS OF POLLUTANTS INTO THE ATMOSPHERE FOR THE FACILITIES OF TENGIZCHEVROIL LLP IN ATYRAU REGION

Abstract. The article analyzes the volume of emissions of pollutants from flare installations of Tengizchevroil LLP facilities. The facilities of Tengizchevroil LLP include 4 main groups: production and transportation facilities of the extracted products; oil and gas treatment facilities; a second-generation installation and TCO maintenance and life support facilities. Sources of production facilities of Tengizchevroil LLP in 2019-2021 emit pollutants of 99 hazard class 1-4 names into the atmospheric air, of which 11 substances have a summing effect when they are present in the atmospheric air together. According to the analysis, the dominant pollutants in the total emissions from TCO facilities are Carbon monoxide and sulfur dioxide. The maximum values of carbon monoxide emissions are characteristic of flare installations for pumping crude gas and oil production and an Integrated processing line. Emissions of sulfur dioxide from flare installations for pumping crude gas and oil production are tens and hundreds of times higher than emissions of other pollutants from other installations. In second place are the volumes of sulfur dioxide emissions from flare installations of the Integrated Production Line. In third place are sulfur dioxide emissions from Second-generation flare installations, where the volume of emissions is about 700-800 tons/year, which is 20 times less than emissions from flare installations for pumping crude gas and oil production. An analysis of the total volume of all pollutants from TCO flare installations shows that the main suppliers of pollutants are a flare installation for pumping crude gas and oil production. Emissions of the total volume of all pollutants from Second-generation flare installations are approximately 2 times less than from flare installations of the Integrated Process Line. The lowest values are typical for emissions from external objects and are more than a hundred times more than from flare installations for pumping crude gas and oil production.

Key words: emissions, pollutants, flare installations, carbon monoxide, sulfur dioxide.

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АТЫРАУ ОБЛЫСЫНДАҒЫ «ТЕҢІЗШЕВРОЙЛ» ЖШС НЫСАНДАРЫНАН АТМОСФЕРАҒА ШЫҒАТЫН ЛАСТАУШЫ ЗАТТАРДЫҢ ШЫҒАРЫНДЫЛАРЫН ТАЛДАУ

Аннотация. Мақалада «Теңізшевройл»ЖШС объектілерінің алау қондырғыларынан ластаушы заттар шығарындыларының көлемі талданады. «Теңізшевройл» ЖШС объектілері 4 негізгі топты қамтиды: өндірілген өнімді өндіру және тасымалдау объектілері; Мұнай және газ дайындау объектілері; екінші буын қондырғысы және ТШО-ның техникалық қызмет көрсету және тіршілікті қамтамасыз ету объектілері. «Теңізшевройл» ЖШС өндірістік объектілерінің көздері 2019-2021 жылдары 1-4 қауіптілік дәрежесінің 99 атауындағы ластаушы заттарды атмосфералық ауаға шығарады, олардың 11-і атмосфералық ауада бірге болған кезде жиынтық әсер етеді. Талдауға сәйкес, ТШО нысандарының шығарындыларының жалпы көлемінде басым ластаушылар көміртегі тотығы және күкірт диоксиді болып табылады. Көміртегі тотығы шығарындыларының максималды мәні шикі газды айдауға, мұнай өндіруге және интеграцияланған технологиялық желіге арналған Алау қондырғыларына тән. Шикі газды айдауға және мұнай өндіруге арналған Алау қондырғыларынан күкірт диоксидінің шығарындылары басқа қондырғылардан басқа ластаушы заттардың шығарындыларынан ондаған және жүздеген есе асып түседі. Екінші орында біріктірілген өндірістік желінің алау қондырғыларынан күкірт диоксиді шығарындыларының көлемі. Үшінші орында екінші буынды алау қондырғыларынан күкірт диоксидінің шығарындылары тұр, мұнда шығарындылар көлемі жылына шамамен 700-800 тоннаны құрайды, бұл шикі газды айдауға және мұнай өндіруге арналған Алау қондырғыларынан шығарындылардан 20 есе аз. ТШО алау қондырғыларынан шығатын барлық ластаушы заттардың жалпы көлемін талдау ластаушы заттардың негізгі жеткізушілері шикі газды айдауға және мұнай өндіруге арналған Алау қондырғылары болып табылатынын көрсетті. Екінші буынды алау қондырғыларынан барлық ластаушы заттардың жалпы шығарындылары біріктірілген Технологиялық желінің алау қондырғыларына қарағанда шамамен 2 есе аз. Ең төменгі мәндер сыртқы нысандардан шығарындыларға тән және шикі газды айдауға және мұнай өндіруге арналған Алау қондырғыларынан жүз есе көп.

Түйін сөздер: шығарындылар көлемі, ластаушы заттар, алау қондырғылары, көміртегі тотығы, күкірт диоксиді.

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АНАЛИЗ ВЫБРОСОВ ЗАГРЯЗНЯЮЩИХ ВЕЩЕСТВ В АТМОСФЕРУ ДЛЯ ОБЪЕКТОВ ТОО «ТЕНГИЗШЕВРОЙЛ» В АТЫРАУСКОЙ ОБЛАСТИ

Аннотация. В статье анализируется объем выбросов загрязняющих веществ от факельных установок объектов ТОО «Тенгизшевройл». Месторождение Тенгиз, открытое в 1979 году, является одним из самых глубоких и крупных нефтяных месторождений в мире - сверхгигантом, верхний нефтяной пласт которого залегает на глубине около 4000 метров. Основными видами деятельности ТШО являются добыча и продажа углеводородов и серы. Лицензионная площадь проекта включает огромное месторождение Тенгиз и меньшее, но со значительными запасами, Королевское месторождение. Нефть Тенгизского месторождения характеризуется как легкая, сернистая, малосмолистая, малопарафинистая. Объекты ТОО «Тенгизшевройл» включают 4 основные группы: объекты добычи и транспортировки добытой продукции; объекты подготовки нефти и газа; установка второго поколения и объекты обслуживания и жизнеобеспечения ТШО. Источники производственных объектов ТОО «Тенгизшевройл» в 2019-2021 годах выбрасывают в атмосферный воздух загрязняющие вещества 99 наименований класса опасности 1-4, из которых 11 веществ оказывают суммирующее действие, когда они присутствуют в атмосферном воздухе вместе и образуют 11 суммирующих групп. К этим веществам относятся: Диоксид азота (IV), Оксид азота (II), Углерод, Диоксид серы, Сероводород, Окись углерода, Метан, 1-Бутантиол, Метантиол, Пропан-1-тиол, Этанол. Согласно проведенного анализа видно, что доминирующими загрязняющими веществами в общем объеме выбросов с объектов ТШО являются Окись углерода и Диоксид серы. Максимальные значения объемов выбросов окиси углерода характерны от факельных установок для закачки сырого газа и добычи нефти и интегрированной технологической линии. Выбросы окиси углерода от факельных установок для закачки сырого газа и добычи нефти постепенно увеличиваются, начиная с 2018 года от 2079,094689 т/год до 4118,536538 и 4102,958838 т/год в 2020 и 2021 годах соответственно. Выбросы окиси углерода от факельных установок Интегрированной технологической линии наоборот характеризуются тенденцией уменьшения объема с 3678,4869 т/год в 2018 году и 3903.0645 т/год в 2019 году до 3345,7597 в 2020 году и 3412,2803 т/год в 2021 году соответственно. Выбросы окиси углерода от факельных установок Второго поколения не имеют системности и находятся около 1589,9833 т/год в 2021 году до 1887,9457 т/год в 2020 году. Выбросы окиси углерода от установок внешних объектов находится на одном уровне в пределах около 200-220 т/год. Выбросы диоксида серы от факельных установок для закачки сырого газа и добычи нефти в десятки и сотни раз превышают выбросы других загрязняющих веществ и от других установок. Объем выбросов диоксида серы увеличивается с каждым годом и составляют от 17265,88055 т/год в 2018 году и 34722,9255 т/год в 2021 году. Самые минимальные значения характерны для выбросов внешних объектов и составляют от 247,0662877 в 2020 году до 275,3908474 т/год в 2019 году, что более чем в сто раз больше, чем от факельных установок для закачки сырого газа и добычи нефти.

Ключевые слова: объем выбросов, загрязняющие вещества, факельные установки, окись углерода, диоксид серы.

Introduction. In fact, air pollution in Kazakhstan caused by many factors. The first is the recent increase in mining and processing of minerals. The second cause of air pollution is the combustion of gases during the extraction of oil and natural gas. This accompanied by soot emissions. Manufacturers have found that the cost of burning gas is lower than the cost of cleaning gas, which leads to air pollution with carbon dioxide. The next factor is the dispersion of emissions from industrial enterprises in the production process during the combustion of industrial products [1].

The Tengiz field, discovered in 1979, is one of the deepest and largest oil fields in the world - a supergiant, the upper oil layer of which lies at a depth of about 4000 meters. The Tengiz reservoir stretches for 19 km in length and 21 km in width. The capacity of the oil column is 1.6 km.

In 1993, the Government of the Republic of Kazakhstan established Tengizchevroil LLP (TCO) together with Chevron. To date, four companies are already partners: JSC NC KazMunayGas (20%), Chevron Overseas (50%), ExxonMobil (25%) and Lukarko (5%).

The main activities of TCO are the extraction and sale of hydrocarbons and sulfur. The licensed area of the project includes the huge Tengiz field and the smaller, but with significant reserves, the Royal field [2].

The oil of the Tengiz field is characterized as light, sulfurous, low-tar, low-paraffin.

The objects of Tengizchevroil LLP in Atyrau region can divide into 4 main groups:

- Oil production facilities of the Tengiz field and the Royal field
- Production and transportation of the extracted products;
- Gas Processing Plant - oil and gas treatment;
- Second-generation installation (SGI) - oil and gas treatment;
- External facilities – TCO maintenance and life support facilities.

External facilities also include boiler rooms designed for heating the central office, hotel and residential complex in Atyrau.

Tengizchevroil LLP includes 2 oil fields – Tengiz and Korolevskoye.

At the Tengiz and Royal oil fields, the configuration of the wellhead equipment is identical.

The system for collecting produced products at the Tengiz and Korolevskoye fields can divide into 2 groups: the basic oil collection system (BOCS) and the new generation collection system (NGCS).

The basic oil collection system includes 9 GZU at the Tengiz field, collecting oil fluid from 56 wells, and 1 GZU at the Korolevskoye field (KGZU 1), collecting extracted products from 3 wells.

Sources of production facilities of Tengizchevroil LLP in 2019-2021 emit pollutants of 99 names of hazard class 1-4 into the atmospheric air, of which 11 substances have a summing effect when they are present in the atmospheric air together and form 11summation groups [3].

Salvo emissions are intended short-term emissions that are many times higher in power than average production emissions. Their presence is provided by the technology of work and is due to the conduct of certain stages of certain technological processes.

Materials and methods. The inventory of existing sources of emissions is the first stage of the development of the draft standards of maximum permissible emissions, the need for which arose in connection with the clarification of the number of sources of emissions of pollutants into the atmosphere, the operating mode of the facilities of Tengizchevroil LLP, which is due to the constant development of the Tengiz and Korolevskoye fields.

The paper identifies and analyzes the characteristics of the sources of emissions and emissions of pollutants into the atmosphere at the time of the inventory for all objects of Tengizchevroil LLP.

When carrying out dispersion calculations for the normal operating mode, backup and salvo sources of pollutant emissions were excluded [4].

On flare installations, for this mode, the combustion of purge and pilot gas is taken into account, as well as the combustion of raw gas, desulfurized gas and dry gas.

The calculation was carried out for a rectangle with the parameters: length (on the X axis) = 55000 m, width (on the Y axis) = 65000 m, with a grid step = 500 m. Coordinates of the center of the calculated rectangle X= 90300 m, Y= 112475 m.

Of all pollutants, as well as groups of substances that have a summation effect when they are present together, the highest concentrations at the SPZ boundary are observed for Carbon dioxide and Sulfur oxide and, respectively, for summation groups.

Results and discussion. The list of summation groups with the indication of substances having a summing effect is presented in Table 1.

Table 1 - Summation groups and substances with summative effect

Summation group number	Pollutant code	Name of the pollutant
1	2	3
03, 04, 05	0303	Ammonia
03, 04, 30, 39	0333	Hydrogen sulfide
04, 05, 24, 39	1325	Formaldehyde
24	0301	Nitrogen (IV) dioxide
24	0326	Ozone
27, 28, 30, 31, 35, 81	0330	Sulfur dioxide
28, 40	0322	Sulfuric acid
35, 71	0342	Fluoride gaseous compounds
40	0302	Nitric acid
40	0316	Hydrochloride
71	0344	Fluorides are poorly soluble

During the operation of the facilities of Tengizchevroil LLP, volleys of SV emissions into the atmosphere are possible due to the discharge of gas to flare systems during maintenance and failure of technological equipment, deviation from normal operation and complete purging of equipment and pipelines. Gas will discharge to flare systems only in cases stipulated by the Associated Gas Processing Development Program at the fields of Tengizchevroil LLP for the period 2019-2021 for the safety of personnel and environmental protection, that is, in cases of technologically unavoidable gas combustion. The volume of technologically unavoidable gas combustion is individual for each field and depends on the specific technological and geometric parameters (diameter, length) of gas pipelines for various purposes, the technological mode of operation of equipment and installations, technical characteristics of equipment, as well as operating conditions described in the regulations and operating instructions of installations used by subsoil users at all stages of the technological process of extraction, transportation, preparation, processing and combustion of gas. Such incineration includes various options for the combustion of reservoir, crude, acidic, desulfurized, dry, fuel gas, as well as LPG - propane and butane. Examples of such incineration include, but are not limited to the following [5]:

- The supply of desulfurized gas to the flare due to a temporary deterioration in gas purification (an increase in the H_2S content above 20 ppm), which may be caused by technological reasons. In order to avoid the leakage of H_2S into the main gas pipeline, an automatic termination of the supply of substandard desulfurized gas and its redirection to the flare system provided;
- Discharge of the fuel gas of the gas cushion of the tank of substandard oil T-200 to the flare. Maintaining the gas cushion in the steam space ensures the presence of an explosion-proof environment in the tank, and also minimizes the evaporation of gas components from oil;
- Discharge of gases to the torch due to short-term technical problems, when the multi-stage automatic protection system installed by the project stops the equipment upon reaching the lockout setting. For example, this happens for the following reasons:

* Power outages;
* stopping the supply of raw materials;
* Termination of the KIP air supply;
* Termination of supply of technical, cooling, technological hot water;
* Termination of steam supply;
* stopping of the equipment when the lock is triggered;
* Failure of controls and regulation.

In such situations, to prevent the creation of overpressure, the gas discharged onto the torch to protect technological equipment, personnel and the environment. Discharge of gases to the flare from installations due to the stoppage of gas supply to external consumers due to external reasons beyond the control of the enterprise.

Reducing the pressure of liquefied gas from the filling hoses allows safely disconnect them after the completion of the filling process of tanks. As well as any discharges of raw, dry, desulfurized or fuel gases for the Injection of raw gas.

Discharge of instantaneous evaporation crude gas from a closed drainage system: When hydrocarbons drained from equipment and pipelines into a closed drainage system, the pressure decreases from the operating value in the apparatus/pipelines to the pressure of the closed drainage system, resulting in degassing of hydrocarbons and the released gas flared [6].

Discharge of butane and propane caused by technological reasons, such as: temporary deterioration of changes in the purification of propane/butane at installations or during the drainage of butane from the bulites of the Goods Fleet.

During the commissioning of the equipment after repair, short-term technical problems may occur and a multi-stage automatic protection system stops the equipment upon reaching the lockout setting. In such situations, to prevent the creation of overpressure, the gas discharged onto the torch to protect the process equipment.

When the compressor stops and the multi-stage automatic protection system triggered during shutdown/start-up after major repairs and during maintenance, which carried out on various equipment and installations, selectively, throughout the year.

The inevitability of such discharges confirmed by the statistical data of the OREDA database, based on the experience of large oil and gas companies, in which all cases of technical failures and their frequency recorded during the operation of oil equipment of large fields. Ensuring safety is due to the need for technologically unavoidable flaring of gas and none of the above scenarios is an accident and does not lead to accidental emissions and/or accidental pollution of the environment.

Since 2008, the field pipelines and discharge lines have replaced at the Tengiz field [7]. When performing these repairs and during the cleaning of pipelines, as well as in other cases of salvo emissions, the field gas will discharge to the fuel storage and CPM flares. Based on the above, a certain amount of emissions of pollutants into the environment during incineration attributed to salvo emissions, since: these emissions are necessary for the normal operation of the equipment of the enterprise, will be carried out in accordance with technological regulations and technical instructions for the safe production of repair and commissioning works [8]. While emergency emissions are sudden, unintended and uncontrolled emissions that occurred because of explosions, fires, destruction of buildings, structures and mechanisms. Based on the above, for sources of pollution – flare installations of the existing KTL, ZVP/ZSG, External facilities and Fishing – emissions of pollutants resulting from routine and volley combustion of hydrocarbon gases are proposed for rationing.

Multiple sources of emissions also include exhaust pipes of generators for backup power supply and fire pumps installed at technological sites.

To reduce the risk of industrial accidents and to minimize their damage company developed a set of measures to ensure the security, suppression and containment of accidents [9].

The total volume of emissions of pollutants into the atmosphere from TCO flares presented in Figures 1-4.

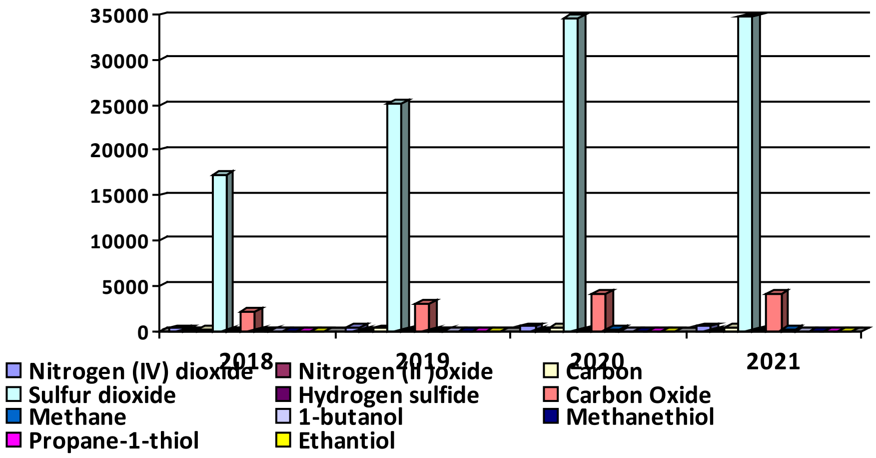

Figure 1 - Emissions of pollutants from Crude Gas Injection flares and Oil Production

As can be seen from Figure 1, among the 11 pollutants entering the atmosphere from Crude Gas Injection flares and Oil Production, the maximum emissions are characteristic of sulfur dioxide (from 17265.88055 tons/year in 2018 with an annual increase to 34722.9255 tons/year in 2021), and the lowest in the amount of less than 0.1 tons/year of pollutants for 1-Butanethiol, Methanethiol, Propane-1-thiol and Ethanethiol. In second place in terms of emissions is carbon monoxide, whose emissions range from 2079.094,689 in 2018 to 4118.536,5538 tons/year in 2020 [10].

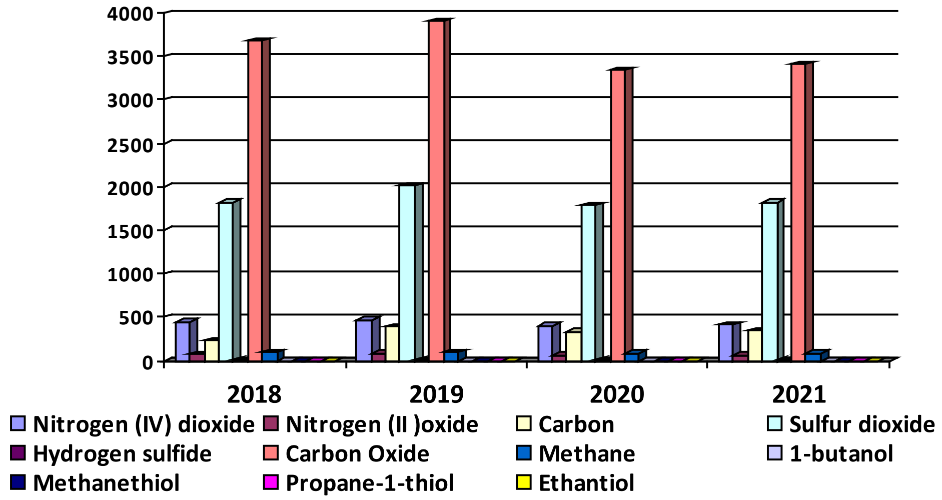

Figure 2 - Emissions of pollutants from the flares of the Integrated Process Line

Figure 2 shows the volume of pollutant emissions from the flares of the Integrated Process Line, where Carbon Monoxide and Sulfur dioxide are also the dominant pollutants, but here, unlike the previous installation, the maximum values are characteristic of Carbon Monoxide in the range of 3345.7597 t/year in 2020 and 3903.0645 t/year in 2019. The volume of Sulfur dioxide emissions is almost twice less than Carbon Monoxide at the level of 1784.8329 tons/year (in 2020) to 2012.2975 tons/year in 2019. Minimum values of less than 0.1 t/year are also typical for 1-Butanediol, Methanethiol, Propane-1-thiol and Ethanediol [11].

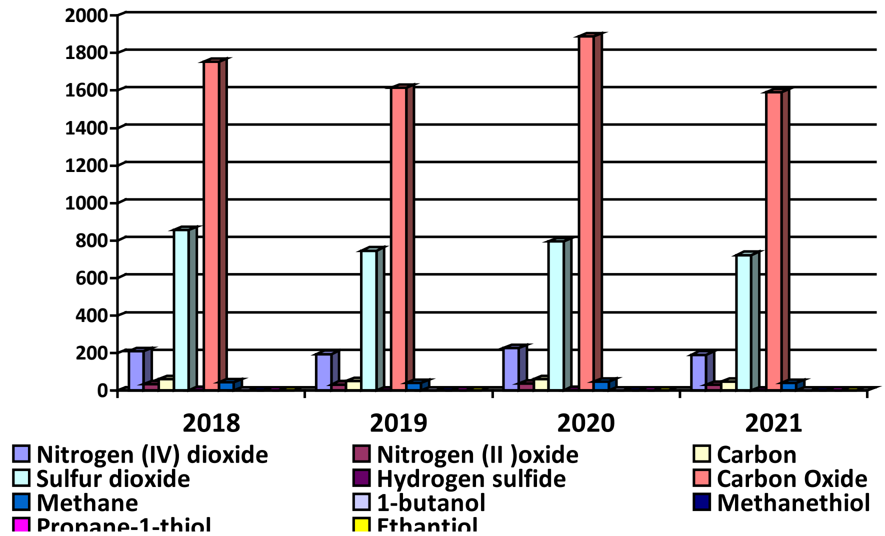

Figure 3 - Emissions of pollutants from flares of the Second Generation Plant

According to Figure 3, the same pollutants are dominant in the volume of pollutant emissions from Second-generation flare installations: Carbon Monoxide and Sulfur dioxide. The volume of Carbon Monoxide emissions (ranging from 1589.9833 tons/year in 2021 to 1887.9457 tons/year in 2020) as well as from the Integrated Process Line flares is more than twice the volume of Sulfur dioxide emissions (722.0831863 tons/year in 2021 to 856.336213 tons/year in 2018). The volume of emissions of 1-Butanediol, Methanethiol, Propane-1-thiol and Ethanediol is about 0.1 and less tons per year [12].

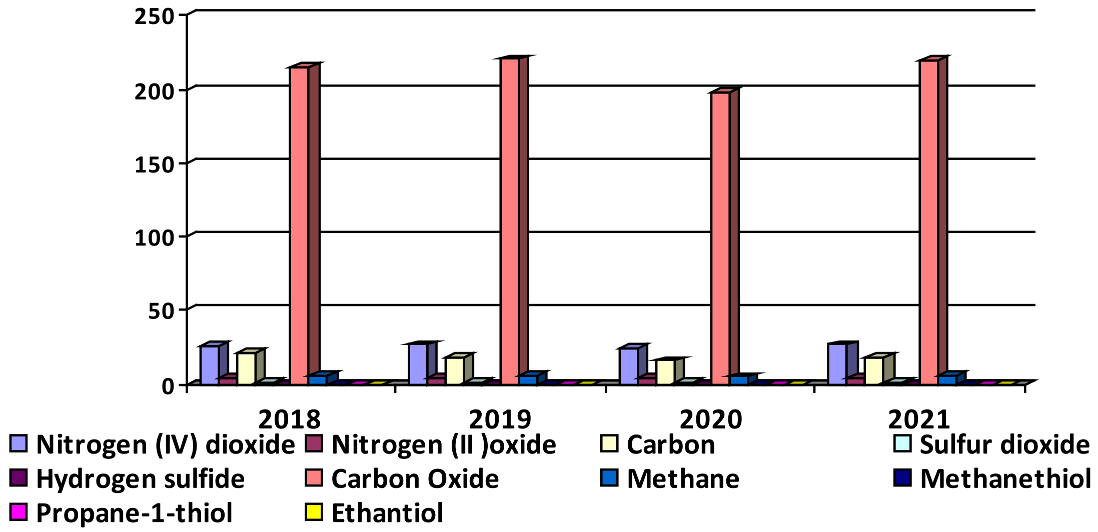

Figure 4 - Emissions of pollutants from flares of External objects

Figure 4 shows the emissions of pollutants from the emissions of external facilities, where Carbon Monoxide emissions prevail by more than 10 times the volume of Nitrogen Dioxide and Carbon emissions and by more than 200 times the remaining pollutants. The volume of Carbon Monoxide emissions ranges from 198,0033 tons/year in 2020 to 220,4712 tons/year in 2019. The volume of emissions of Methanethiol, Propane-1-thiol and Ethanediol is less than 0.001 t/year, and in terms of Propane-1-thiol emissions, the volume of emissions has been zero in the last three years.

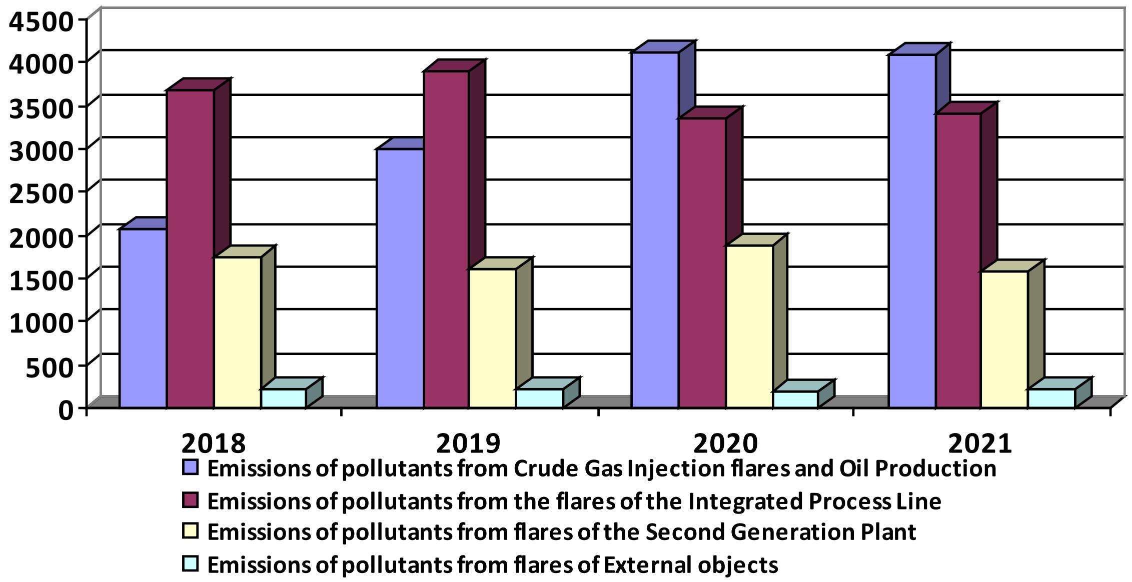

Figure 5 - Emissions of Carbon Oxide from TCO flares

According to the first four figures, we see that the dominant pollutants in the total emissions from TCO facilities are Carbon Monoxide and Sulfur Dioxide, which analyzed in Figures 5 and 6. In Figure 5, we will look at Carbon Monoxide emissions from all TCO facilities. The maximum values of Carbon monoxide emissions are characteristic of flare installations for crude gas injection and oil production and an Integrated Process Line. Emissions from flare installations for crude gas injection and oil production are gradually increasing starting in 2018 from 2079,094,689 tons/year to 4118,536,538 and 4102,958838 tons/year in 2020 and 2021, respectively. Emissions from flare installations of the Integrated Process Line, on the contrary characterized by a tendency to decrease in volume from 3678.4869 tons/year in 2018 and 3903.0645 tons/year in 2019 to 3345.7597 in 2020 and 3412.2803 tons/year in 2021, respectively. Emissions of pollutants from second-generation flare installations have no consistency and range from 1589.9833 tons/year in 2021 to 1887.9457 tons/year in 2020. Carbon Monoxide emissions from installations of external facilities are at the same level in the range of about 200-220 tons/year and does not have a systematic change in emissions [13].

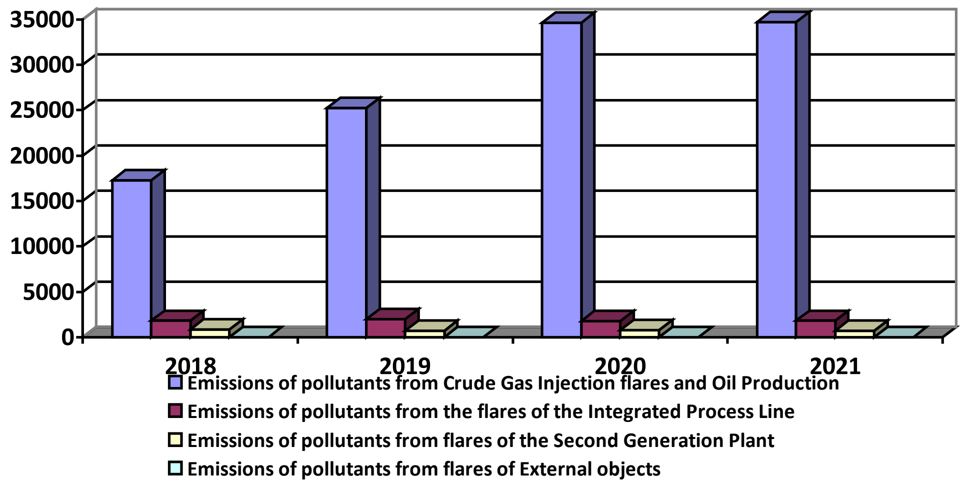

Figure 6 - Emissions of Sulfur dioxide from TCO flares

Sulfur dioxide emissions from TCO flare installations, shown in Figure 6, show that the dominant emissions are pollutants from flare installations for pumping crude gas and oil production, which are tens and hundreds of times higher than emissions of other pollutants from other installations [14]. The volume of emissions increases every year and ranges from 17,265,88055 tons/year in 2018 and 34,722,9255 tons/year in 2021. In second place are the emissions from flare installations of the Integrated Process Line, the volume of which is on average about 1800 - 2000 tons /year, which is 10 times less than at the previous installation. In third place are emissions from Second-generation flare installations, where the volume of emissions is about 700-800 tons/year, which is 20 times less than emissions from flare installations for pumping crude gas and oil production. The minimum values are typical for emissions of external objects, the volume of which is about 1.0 t/year.

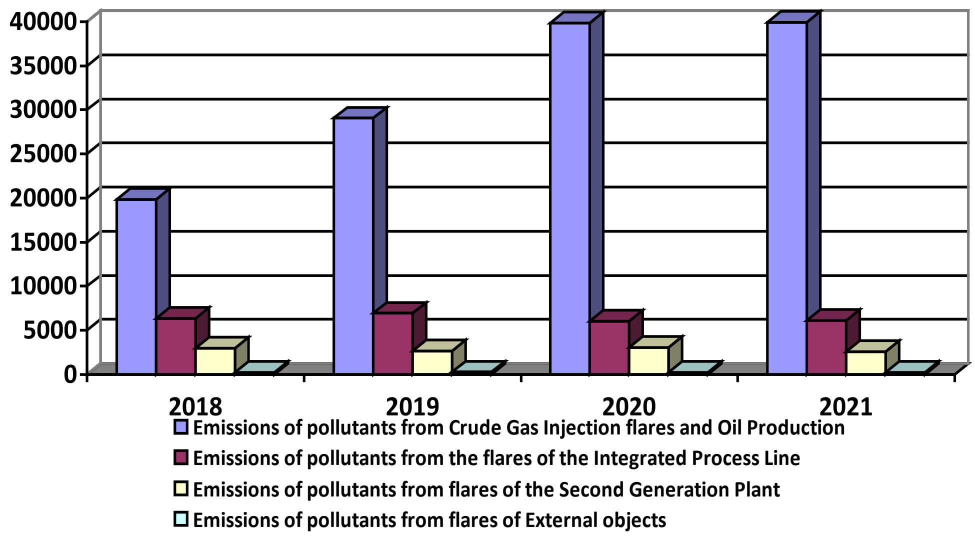

Figure 7 - Emissions of the total volume of all pollutants from TCO flare installations

The analysis of the total volume of all pollutants from the TCO flare installations presented in Figure 7 shows that the main suppliers of pollutants are a flare installation for pumping crude gas and oil production, the total volume of all pollutants of which is more than 19 thousand (19826.05934) tons/year in 2018 – and about 40 thousand (39927.87828) tons/year in 2021, with an annual increase in the volume of emissions of pollutants. The total volume of all pollutants from flare installations of the Integrated Process Line is less than from flare installations for pumping crude gas and oil production by more than 3 times and on average amount to more than 6 thousand tons/year, being approximately at the same level from 6017,074691 tons/year in 2020 and 6949,446184 tons/year in 2019. Emissions of the total volume of all pollutants from Second-generation flare installations are approximately 2 times less than from flare installations of the Integrated Process Line and are at the level of 2621.352511 tons/year in 2021 to 3053.588875 tons/year in 2020. The lowest values are typical for emissions from external facilities and amount to more than two hundred tons/year (from 247.0662877 in 2020 to 275.3908474 tons/year in 2019), which is more than a hundred times more than from flare installations for pumping crude gas and oil production [15].

Conclusion. The analysis carried out by the volume of emissions of all pollutants from TCO flare installations shows that of the eleven pollutants, only two pollutants account for the main volume, these are Sulfur dioxide and Carbon oxide. In terms of sulfur dioxide emissions, emissions from flare installations for pumping crude gas and oil production are dominant, while the volume of emissions from other installations is tens and hundreds of times less. In terms of Carbon monoxide emissions from two flare installations, such as for crude gas injection and oil production and an Integrated Process Line, they are at the same level, with slight changes over the years, and from Second-generation flare installations they are almost at the same level and the minimum values are characteristic of emissions from external objects. The most minimal values for all installations are typical for pollutants: 1-Butanethiol, Methanethiol, Propane-1-thiol and Ethanethiol. Of all flare installations, the main volume of pollutants falls on the flare installation for pumping crude gas and oil production.

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