Ensuring environmental safety at Garabogaz transport and industrial complex by identifying environmental risks

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Abstract. The authors of the article propose a number of measures to optimize the production process of “Garabogazcarbamide” factory in order to increase its environmental safety. The factory and the newly equipped berth in Garabogaz (Bekdash) have a negative impact on the ecological situation of the Caspian Sea, in particular, Garabogazgol Bay. The fragile balance between economic activity and preservation of the ecosystem and its biodiversity is broken. Potential accidents at drilling rigs and oil-gas transport and industrial complex can lead to extreme consequences and desertification of the region. The threat of environmental degradation in the Caspian region and the depletion of its natural resources are especially great due to the overdevelopment of the fuel and energy industry, the lack of legal regulations for environmental protection, the limited use of energy and environmental technologies and a primitive environmental culture; all these factors increase the risk of technological disasters. According to the authors’ opinion, the organization of a system of continuous environmental monitoring over the technological updating of the factory equipment; the use of a closed JW system (including desalting unit); the construction of its own power plant for the needs of the factory; purification systems for atmospheric emissions; improving smart technologies to reduce natural gas consumption can help to improve the environmental situation in Garabogaz.

1. Introduction

The modern urea factory “Garabogazcarbamide” with deep processing of gas and oil products was built by the order of the Turkmenchemistry Group of Companies in the city of Garabogaz (formerly Bekdash). The production of not only urea for the manufacture of mineral fertilizers, but also synthetic detergents and ammonia is provided for at this factory. The project was implemented by two mega corporations: the Japanese “Mitsubishi Corporation” and the Turkish “Gap İnşaat”. Construction was completed in September 2018. Two warehouses for urea of 50 thousand tons each, warehouses for 10 thousand tons of liquid ammonia, as well as a workshop for its production, water and gas supply systems, water treatment, packaging and loading and other infrastructural objects are located on the area of 60 hectares. The plant produces 1.155 million tons/year or 3.5 thousand tons/day of products. These products are obtained from natural gas, which is produced in the Turkmen fields of Garabogazgol Bay. The location of the plant in Garabogaz was determined by the fact that there is the Khazar gas compressor station nearby with a capacity of 2 billion m\textsuperscript{3}/year of gas; this station collects associated petroleum gas from offshore platforms. There is a mega-petrochemical processing complex with the necessary infrastructure for the supply of raw materials to “Garabogazcarbamide” 120 km to the south in the city of Turkmenbashi (formerly Krasnovodsk) (fig. 1).
Many scientists emphasize that the scientific basis for the development of sustainable natural-technical systems involves ensuring the environmental safety of industrial facilities [1-8]. The terms of the possible exhaustion of various types of minerals are quite visible [9]. Articles and reports emphasize with concern that any production, and even more so toxic, should be environmentally friendly, energy-efficient, resource-saving, bio-positive to create favorable living conditions for the population [10-13].

The purpose of the article is to identify environmental risks and mitigate them in favor of environmental technologies at the advanced enterprise of Turkmenistan “Garabogazcarbamide” factory in Garabogaz. Ideally, energy efficiency in industry and construction should be nature-like and must develop with maximum environmental safety. As in nature, energy efficiency should lead to the predominance of consistent goals for the sake of the entire community. In this regard, the authors put the following tasks: to conduct a comprehensive analysis of the ecological situation in Garabogaz area and the adjacent waters, establish the nature of anthropogenic impact on the Caspian ecosystem as a whole, identify environmental risks (desertification, pollution of the aquatic environment, harm to the fish productivity of the sea and biological resources in general, and etc.) that threaten this region, finally, indicate measures to correct production technology in Garabogaz, in order to ensure the environmental safety of the enterprise in close connection with the real protection of the ecosystem of the Caspian Sea and Garabogazgol Bay.

2. Materials and Methods

Today, advanced countries are gradually making the transition to comprehensive environmental safety without the use of hydrocarbon energy sources, without sufficient fresh water reserves and without other resources which are exhausted on the planet. Imitation and approaching nature turns out to be the main requirements for operation of technical means, because nature is self-sufficient, nourishes people's health, it is predictable and reliable in general, unsophisticated, simple even in its most complex creations (for example, an eye, a human hand, etc.). The practice of “green” construction implies such construction of industrial facilities as if they would have emerged independently and without human intervention, like seeds in the earth, grew out of the natural environment, i.e. their construction should be bionic. The perfection and harmony of such structures with the environment, their simplicity, reliability and energy efficiency are associated with certain expediency: in nature, reducing the cost of one animal to maintain life leads to the benefit and prosperity of the entire
community - species diversity, which increases the stability of the entire ecosystem. Nature is perfect. Emergence of extreme situations due to neglect of environmental safety compromises the natural course of events, introducing changes that are alien to the ecosystem. Activities that transform the environment should be carried out with extreme caution; any unnatural changes in the ecosystem inevitably lead to irreversible changes. One way or another one has to pay for developments that do not ensure the environmentally safe state of natural-technical systems. Authors follow the methodology developed by Meadows [14]. According to the Meadows dynamic model, the self-sufficiency of Earth's ecosystems is disrupted due to population growth. Favorable environmental and economic equilibrium scenarios have become unattainable. The consumption of natural resources and the destruction of the environment more and more unpredictably lead to an extremely gloomy (basic) scenario. Time to implement favorable scenarios is irretrievably lost. Meadows emphasizes that without significant changes in the consumption of natural resources by people, catastrophic changes will inevitably occur in the near future. [15]. The sustainability model supported by the authors permits the depletion of resources and environmental degradation, but the potential of natural resources should not be lower than the level of resource withdrawal or the rate of change in people's living conditions. It is necessary not to violate the law of redistribution of natural elements that make up the closed cycle in the ecosystem (producers, decomposers, consumers). Hazardous chemicals that are not found in nature (DDT, polypropylene, polyethylene, etc.) do not enter into the natural process of redistribution and are extremely dangerous for human health [16]. The authors believe that disasters such as the spill of diesel fuel on the Norilsk Nickel are the consequence of the self-intensifying destruction of the natural environment and its degradation due to negative anthropogenic impact. Various industrial enterprises have created a total threat directly to human life. The author's model of sustainable development [17-18] takes into account the rationale of N.F. Rejmer's nature's safety margin [19], as well as the fundamental importance of the second biogeochemical law of V.I. Vernadsky [20]: the migration of chemical elements occurs in the biosphere with the obligatory direct or indirect participation of living organisms; any loss in the composition of living substance will cause exponential waves of destruction of the entire biogeochemical system. Thus, the quality of construction of industrial facilities directly depends on the correct formulation and solution of environmental problems, calculation of environmental risks and constant assessment of environmental impact at all stages of the life cycle of a construction project [21].

3. Results
Garabogazgol Bay is rich in sodium sulfate, glauber salt and other useful minerals. This is truly a “chemical pantry” of Turkmenistan, in which almost all the elements of the Mendeleev periodic table are present. Since the project is an export one, 2/3 of the products are supposed to be delivered abroad. A related decision was the construction of a new port in Garabogaz. It is also planned to open a new automobile bridge across the bay on the Turkmenbash-Garabogaz-Kazakhstan road section. Although during the construction of the factory a great emphasis was placed on ensuring environmental safety, nevertheless, putting it into operation gave an additional negative burden on the ecological system of the Caspian Sea, which leaves a lot to be desired. To be honest, with the introduction of petrochemical complexes along the entire Turkmen coast of the Caspian, the ecosystem has become catastrophic. Numerous oxygen-free dead zones have been formed in the shelf zone, where neither fish (especially valuable sturgeon breeds) nor other representatives of the marine flora and fauna (seals) can be found. The areas of fish spawning grounds are declining at a threatening pace, there are almost none left, since the rivers are blocked by hydraulic structures. But in this sea 300 thousand tons of fish are caught only from the side of Russia (30% of its total catch of fish in inland waters). The same is referred to Krasnovodsk Bay. It is a sturgeon fishing ground of global importance, but for how long? The large-scale development of offshore mineral reserves undermines the production of black caviar, although with a rational approach to nature management, the economic income is incomparably higher and the effect is associated with the breeding and preservation of sturgeon fish [10].
Due to the construction of hydraulic structures, dams, reservoirs, water does not flow from rivers flowing into the sea to the extent that makes the level of the Caspian Sea constant. It is clear from this fact why the area of its water surface and the shelf zone has been reduced. The Volga river - an ancient iconic river in the history of many peoples - has turned into the main effluent channel of Russia. Despite the fact that plants for the artificial breeding of sturgeons were built near Astrakhan and other places, 60% of fish released into the sea is caught by poaching. Sturgeon catches decreased from 16 thousand tons to 4 thousand tons per year [6]. The Caspian Sea is a closed ecosystem, and the violation of the ecological balance in one region leads to the irretrievable death of the entire unique environment. Thus, excessive anthropogenic impact and unreasonable nature management resulted in the rapid destruction of the Aral Sea ecosystem and its almost complete disappearance. Since until 1992 the Garabogazgol bay was blocked by a dam, its water surface area was also significantly reduced and the coastal zone was subjected to desertification. In general, 60% of agricultural land is not used in the region, as it is saline and boggy.

Industrial development of the region and large-scale development of oil and gas fields on the Caspian shelf pose a potential danger of unpredictable emergencies that are fatal for all living organisms. It is almost deserted in waters of the gulf not only because of the excessive salinity of water, but primarily because of the pollution of water by oil, oil products and other toxic substances that come into the sea during transportation of goods. According to the most optimistic forecasts, more than 132 thousand tons of oil comes into the Caspian Sea per year. [13]. However, only the Volga River produces 35 thousand tons of oil along with domestic water and wastewater. Petroleum hydrocarbons are found in bottom sediments throughout the Caspian Sea. Hidden oil leaks during well abandonment become a source of oil dispersion for a long uncontrolled period and represent an unpredictable technological anomaly in nature. The oil concentration exceeds 100 times or more the maximum permissible concentration (MPC) of the established water quality standard [22]. It should be noted that during normalized oil production, each drilling rig discharges into the sea 30-120 tons of oil, 150-400 tons of drilling sludge, 200-1000 tons of drillings [12]. Technical imperfections in the oil fields have resulted in the formation of vast oil and water lakes up to 2 km in size, which are absorbed by the surge wave during sea level fluctuations. Man-made disasters occur more and more often. An open oil fountain burned for 398 days at the Tengiz (Kazakhstan) field. During the gushing process, 3.5 million tons of oil and 1.7 billion m$^3$ of gas burned out in the air, of which 516 thousand tons of hydrogen sulfide. About 900 thousand tons of soot was formed. The concentration of sulfur dioxide at the wellhead reached 1.100 MPC, at a distance of 500 m - 46 MPC, 45 km - 42 MPC, 100 km - 1 MPC. The main pollutants are carbon dioxide, carbon monoxide, hydrocarbons, dust, sulfur, nitrogen dioxide. Phenols, a number of highly toxic heavy metals: mercury, lead, cadmium and arsenic, nickel, vanadium, barium, copper, zinc were found in Garabogazgol Bay. Their concentration exceeds all permitted standards. Mercury and cadmium are classified as toxic metals and are persistent pollutants in the environment, which remain in the system and are accumulated in food chains [23-24]. The maximum values of pollutants in bottom sediments were found along the coast of the industrial “belt” of Garabogaz-Turkmenbashli-Khazar. In shallow areas, bottom sediments are sources of secondary pollution. When sea levels rise under the influence of dynamic processes, additional pollutants enter the bottom layer of the sea. The oil and gas, chemical, metallurgical, energy, agricultural complexes of the economy of Turkmenistan cause significant damage to the ecosystem of the Caspian Sea (fig. 2).
Figure 2. Chart of anthropogenic impact on the Caspian ecosystem: potential environmental hazards in the Caspian Sea Region. https://farm1.staticflickr.com/447/31551218253_a57e5ef2d2_o.jpg.
Obviously, the pollution with pesticides violates the principles of environmental safety, but also in the course of construction of industrial facilities and even resort infrastructure (for example, “Awaza” and others) cement, asphalt concrete, chemical plants, enterprises for the production of expanded clay, brick, ready-mixed concrete, prefabricated reinforced concrete products, house-building plants, etc. turn into a powerful additional environmental pollutant and in fact sharply worsen the favorable living conditions of the population of this Caspian country. Environmental damage exceeds income from the exploitation of natural resources and negative technological changes cause an increase in morbidity and the death rate of people. The standard of living in this Caspian littoral state is 15-20 years lower than in developed countries. Already, the global economic costs of air pollution are gradually increasing and will reach 1% of world GDP by 2060, and the largest GDP losses are observed in China, Eastern Europe and the Caspian region. The impact of high concentrations of pollution on people's health leads to aging of population, premature deaths and high health care costs, which are putting aside other expenses and consumption [25].

Synthetic detergent production at Garabogazcarbamide factory is highly toxic to the Gulf ecosystem. According to sanitary standards, wastewater entering the storm and domestic and fecal sewage systems is so dangerous for the marine ecosystem that synthetic detergent manufacturing companies must strictly apply a closed cycle of water consumption and wastewater treatment systems. The risk of water pollution with synthetic surface-active reagents and petroleum products is not compatible with the operation of environmentally friendly natural and technogenic systems. In addition, the use of detergents and agricultural fertilizers results in the pollution of waters of the bay with nitrogen and phosphorus from wastewater. The low oxygen content in the deep layers of the sea led to the formation of a clearly defined intermediate maximum of nitrates. With the emergence of hydrogen sulfide in the bottom layers, nitrate reduction processes under these conditions caused a sharp increase in the concentration of ammonium nitrogen. Nitrogen and phosphorus are pollutants because their high concentration increases eutrophication. Chlorine is also discharged into the sea after disinfection of wastewater [26].

Large foci of technogenic desertification are located around such industrial cities as: Turkmenbashi (formerly Krasnovodsk), Khazar (formerly Cheleken), Balkanabat (formerly Nebit Dag). Intensive development of oil fields and increased traffic of large tankers annually lead to the release of more than 122 thousand tons of potentially harmful oil pollutants in the largest enclosed water basin in the world [23]. The source of 95% of pollution is the Caspian countries in the north and northwest - Russia, Kazakhstan and Azerbaijan, which account for the majority of offshore oil production. But recently, Turkmenistan has increased oil production on the shelf 5-7 times, which per se states about critical situation in the region [10]. According to the opinion of experts from UNEP (United Nations Environment Program), active exploration of oil and gas resources on the shelf, growing networks of pipelines and transport routes, industrial pollution from river and groundwater inflows, climate change and coastal desertification, as well as, in particular, loss of biodiversity due to poaching of fish stocks and the emergence of aggressive invasive species, the associated gas flaring - these are just a few of the environmental challenges that threaten the Caspian Sea. Although the water level in the Caspian Sea has remained relatively stable since 1995, further sea level rise can lead to emergencies in oil production areas, floods at drilling sites located in lowlands and the destruction of protective embankments and dams around them, the breakdown of field pipelines and groundwater pollution, which will subsequently contribute to additional pollution of the sea.

Now, there is a rapid disappearance of various types of living organisms under the influence of the construction activities of the Caspian countries. Moreover, this process is ten, and in some cases a hundred thousand times more intense than before. Species do not just disappear. The whole structure of the living matter of the Caspian ecosystem is changing under the influence of construction technologies. The forecast of various anthropogenic hazards (climate change, desertification of regions, malfunctions of the Le Chatelier-Braun system principle, “The Equilibrium Law”) showed that due to the exhaustion of natural resources and environmental pollution, a regional catastrophe is possible, which can be avoided by stabilizing the population and scope of industry, stimulating
agricultural development. Since the population of the region is 15 million people who depend heavily on the natural resources of the sea, protecting the environment of the Caspian Sea is not only a matter of environmental security, but also a prerequisite for reducing risks to the health of the coastal population and sustainable economic development. As most of the problems are cross-border in nature, these challenges require closer and more active cooperation between the Caspian countries.

As a result of the implementation of investment and construction projects without justifying their environmental safety, the energy properties of the bio-ecological system are also changing and this leads to desertification of the coastal zone of the Caspian Sea. This also destroys both the foundation of the immediate environment of our life and economic development of the region. If earlier socio-economic adaptation followed the changes in the environment, now it should precede them, since there is no margin of safety left in nature, including in humans as a biological beings. As you can see, the environmental situation in the Caspian region is more than alarming: as a result of construction activities, it worsens every year and is on the verge of catastrophic development. Vernadsky's law on living matter cannot be repealed. Its action begins with some single and small losses in the composition of living matter, but then dramatic destruction of the entire biogeochemical system will follow [20]. The conservation of natural bio-systems is declared as a strategic goal by Russia, Azerbaijan, Kazakhstan, Uzbekistan, Turkmenistan, Iran, but in fact protection is provided for only one of its elements - a human being who is no longer an element of the natural environment, but mainly its user. The regulation of environmental protection in industry is formal. Moreover, the plans of Turkmenistan and Azerbaijan to start construction of the Trans-Caspian Gas Pipeline “Nabucco” along the bottom of the Caspian Sea for gas supplies to Europe are conflicting in this matter.

In this regard, it is necessary not only to make state control over the implementation of measures for the restoration of disturbed lands and environmental protection by business more strict, which in itself meets the goals of the safety of human habitation, but also to direct significant capital investments to preserve all the surviving elements of natural biota. By 2025, the amount of about $ 160 billion will become socially justified expenses for saving the world's biodiversity. If we take into account that species disappear from the surface of the earth at a rate of 1 species per day, it turns out that now the global necessary costs for saving species are approximately $ 30 billion per year [19]. For the Caspian countries, the cost of saving species, which number about 150 species and subspecies of fish, sea animals (seals), crayfish, etc. can be $ 6 billion per year.

Let's try to assess the environmental risk in the Caspian region. To do this, it is necessary to consider the following data. Considering that more than 100 thousand km of pipelines have been laid on the transboundary shelf for pumping oil products, the probability of accidents on pipelines is estimated by the value of 6.3·10^{-4} km/year with one-off leaks up to 800 tons and total oil losses of about 50 thousand tons/year. In the case of a tanker accident, the average spill frequency is 1.5·10^{-2} per year. The probability of major accidents with a spill of 5 thousand tons of oil is 3.3·10^{-3} spills per year [27-28]. As a result of tanker accidents, 625 tons of spills per year enter the Caspian Sea, causing damage to the ecosystem of approximately 1 billion RUB. Next, we use the following matrix to assess risk (Table 1).

**Table 1.** The matrix for determining the risk of the territory by the criterion “frequency of implementation - financial damage”.

| Intensity of hazard implementation, cases/year | Financial damage, minimum monthly wage | Zone of strict control, an assessment of the appropriateness of risk reduction measures is necessary |
|-----------------------------------------------|----------------------------------------|------------------------------------------------------------------------------------------------|
| > 1                                          | > 200.000                              | Unacceptable risk zone, urgent risk reduction measures are necessary |
| 1 – 10^{-1}                                  | 20.000-200.000                         |                                                                                               |
|                                               | 2.000-20.000                           |                                                                                               |
|                                               | 200-2.000                              |                                                                                               |
|                                               | < 200                                  |                                                                                               |
According to this matrix and the above data, the Caspian region belongs to the zone of unacceptable risk with the necessary urgent measures to reduce it. This conclusion is confirmed by the results of an integrated assessment of the degree of environmental vulnerability of the Caspian shelf of Turkmenistan, given by I.V. Karabanova [29]. She says about high environmental vulnerability (14-21 points) and ensuring environmental safety should be carried out here with particular care. It should be added that the Caspian area is a zone of unacceptable risk in terms of social damage. It is shown by accidents statistics. So, in April 2000, a fire occurred at the Kalamkas and Karazhanbas fields, more than a hundred wells went under water as a result of large-scale subsidence of the earth’s surface. In spring and summer of 2000, after drilling a well at Kashagan (Kazakhstan), approximately 30 thousand seals died, several kilometers long oily spots were formed with a high content of highly toxic sulfur compounds. On November 10, 2000, the Russian cargo ship “Elena” sank. October 22, 2002 the ship “Mercury-2” sank with 44 dead. In 2004, 1383 oil wells with hidden leaks were discovered on the Kazakhstan shelf. On October 13, 2010 the tanker “Grigory Bugrov” was shipwrecked and as a result fuel oil spilled. On December 4, 2015, a fire occurred on oil platform No. 10 at the Azerbaijani Guneshli oil field (Azerbaijan), 31 people died. In November 2016, 2 people died as a result of the accident. On December 15, 2016, 10 oil workers went missing in an Azerbaijani port during a hurricane. On June 28, 2017, after an accident, 5 oil workers were injured of varying severity. On March 28, 2019, a large-scale fire occurred at the Kalamkas field, the derrick went under water and the oil spill area was formed to 1 km size. In May, 14 people were injured in an explosion on the “Israfil Huseynov” pipe-laying vessel in Azerbaijan. On October 29, 2019, a boat exploded, 1 was killed and 2 people were injured. On April 17, 2020, a boatswain died on the barge “Yuri Kuvykin”. Already this brief statistics allows us to reliably conclude that in relation to social damage, the Caspian Sea zone is an unacceptable risk area (Table 2).

Table 2. The matrix for determining the danger of the territory by the criterion “frequency of implementation - social damage”.

| Intensity of hazard implementation, cases/year | Social damage                                                                 |
|----------------------------------------------|-------------------------------------------------------------------------------|
| $10^{-1} - 10^{-2}$                           | Zone of acceptable risk, no risk reduction measures necessary                 |
| $10^{-2} - 10^{-3}$                           |                                                                              |
| $10^{-3} - 10^{-4}$                           | Zone of acceptable risk, no risk reduction measures necessary                 |
| $10^{-4} - 10^{-5}$                           |                                                                              |
| $10^{-5} - 10^{-6}$                           | Zone of acceptable risk, urgent risk reduction measures necessary             |

4. Discussion
Let’s come back to the factory in Garabogaz. The commissioning of a mineral fertilizer production factory will require additional gas reserves and, accordingly, will increase the amount of various emissions into a rather fragile ecosystem of the region. Environmental legislation requires building a complex and expensive water recycling and wastewater treatment system from waste. The city of Garabogaz is located on a cape, between the bay and the sea, and it is quite possible that the concentration of harmful substances in the effluents can be diluted with sea water and then drained into the sea. According to the Committee on Environmental Protection, Garabogassulfate factory does so by discharging 1.2 million m$^3$ of wastewater into the Caspian Sea annually. In order to improve the environmental situation in the region, it is necessary to increase the environmental safety of the enterprise, to minimize the damage caused by its emissions to the environment. For this, it is proposed, in addition to organizing a system of continuous environmental monitoring, training of technically competent employees for the maintenance and operation of the plant, to make a number of energy-saving technological changes in equipment that meet European standards for smart petrochemical factory [28-30].

Thus, the construction of circulating water filtration plants can prevent industrial effluents from entering the marine environment. The technology of lateral filtration is implemented in them; the essence of this technology is the diversion from the total flow of circulating water about (~ 10%) for filtration and its subsequent return to the general flow of circulating water supply. As a result, water quality is maintained at an acceptable level. The filtration module purifies up to 4400 m$^3$ of water as part of the plant’s recycling water supply (fig. 3).

Figure 3. Type of installation with lateral filtration of the recycled water of the enterprise.

Salt-saturated industrial effluents can cause significant damage to the gulf ecosystem. World experience shows that it is possible to process seawater for household needs through the use of solar energy. Modern technologies make it possible to use desalination plants even for cooling server equipment used for telecommunications (which is very important for Garabogaz, which has recently lost its city status due to population decline). In this case, after desalination, the obtained salt can be processed to prepare healthy products. Mobile desalination plants powered by solar energy, since the facility is essentially in the desert, can be provided for not only the Garabogazcarbamide factory and Garabogassulfate plants, but also for gas and petrochemical plants throughout the Garabogazgol region (fig. 4) [31].
It is also important to analyze the issue of building the own power plant by “Garabogazcarbamide” factory [32]. Power from 1 thousand to 10 thousand kW will cost the plant from 20 to 50 thousand RUB per kW. Own power station for “Garabogazcarbamide” enterprise is a promising business and meets the goals of developing sustainable natural-technical systems. The price of an autonomous mobile gas turbine (gas piston) power plant with a capacity of 3 thousand kW (3 MW) - from € 2 million EURO (see Table 3).

Table 3. Calculation of the cost of an autonomous power plant.

| Cost                                | % of the total project cost (approximately) |
|-------------------------------------|--------------------------------------------|
| Main generating equipment           | 70% (1610.000.0 €)                         |
| Design (in full scale)              | 7% (161.000.0 €)                           |
| Installation                        | 6% (138.000.0 €)                           |
| The rest                            |                                            |
| (erection of a building from easily |                                            |
| assembled metal structures, internal piping, chimney, etc.) | 17% (391.000.0 €) |

At the same time, the plant will receive up to 17.5 million kWh of electricity per year. The payback period is about 5 years. The enterprise will significantly reduce production costs. The advantage of such a power plant is that the enterprise will receive a significant amount of thermal energy for consumption needs, and the benefit will be more than € 300 thousand EURO. In any case, the cost of electricity from the own power plant will be several times lower than that offered by suppliers, which are adding to the price a sales premium of up to 60% of the final tariff for enterprises. A heat engineering calculation should be made (to determine the thermal and electrical loads, to correctly select the unit capacity of the equipment, etc.), carefully calculate the profitability of the installation using natural gas or associated oil, since with an increase of gas prices in the world, the cost of electricity will increase too. When constructing the own station, you need to evaluate the payment of the power reserve from an external supplier, the costs of its maintenance, the surplus generated
electricity for sale to other consumers, etc. Own power station for Garabogazcarbamide factory is a promising business and meets the goals of developing sustainable natural and technical systems.

The production process at the plant causes harmful emissions of various compositions; therefore, it is necessary to purify gas from $SO_2$ and reduce the concentration of hydrogen sulfide compounds due to corrosion of pipes and equipment, and to neutralize ammonia vapors harmful to health. Based on the tasks of the safe use of the complex, the factory should be equipped with modern purification and treatment plants (fig. 5). Sulfur oxide emissions are reduced by flushing gases with a solution of soda or lime. Chemical reaction of soda ($Na_2CO_3$) with sulphurous anhydrite ($SO_2$) produces sodium bisulfate ($NaHSO_3$).

$$2Na_2CO_3 + SO_2 + H_2O \rightarrow 2NaHCO_3 + Na_2SO_3$$

(1)

$$2NaHCO_3 + SO_2 \rightarrow Na_2SO_3 + 2CO_2 + H_2O$$

(2)

$$Na_2SO_3 + SO_2 + H_2O \rightarrow 2NaHSO_3$$

(3)

Figure 5. Gas scrubbing process. On the left there is a gas desulfurization diagram; on the right - the view of a modern wet scrubber.

As it is seen from the diagram, nitrogen, carbon dioxide, nitric oxide, sulfur dioxide enter the scrubber; chalk ($CaCO_3$) serves as an absorbent; nitrogen, water and carbon dioxide; pure synthetic gypsum ($CaSO_4$) is collected on the output into a hopper.

Flushing of gases by ammonia reagent is also used. First, ammonium bisulfate is formed and then it decomposes into sulfur and ammonium sulfate. Scrubbers with fillers of various properties are used to purify air from ammonia. Flushing with sulfuric or phosphoric acid gives good results. Based on the tasks of safe use of the complex, the plant should be equipped with modern facilities for the purification of atmospheric emissions. To clean air from sulfur dioxide and ammonia, scrubbers with fillers of various properties are used and this gives good results.

5. Conclusions

Thus, the threat of environmental degradation in the Caspian region and the depletion of its natural resources are especially great due to the overdevelopment of the fuel and energy industry, the limited use of energy and environmental technologies and a primitive environmental culture, which increases the risk of technological disasters. Drilling anthropogenic pollution of the marine environment is taking place. Wells were drilled in the Caspian Sea with water-based drilling fluids, the typical chemical reagents of which were barium and calcium sulfates, zinc and calcium chlorides, potassium chloride, zinc chromate, sodium and calcium carbonates, galena, potassium dichromate, bentonite, etc. In the process of drilling, waste drilling mud and sludge without preliminary treatment were directly discharged into the marine environment. Even the “zero discharge” technologies (as part of the waste continues to enter the environment: flare emissions from associated gas burning, drill cuttings from the
upper interval of wells’ drilling, hidden oil leaks from operating wells with abnormally high pressure, sewage effluents and solid food waste from activity at the rig) will not help to improve the environmental situation in Garabogaz area.

According to the matrix for determining the risk of the territory by the criterion “frequency of implementation - financial damage” and the matrix for determining the danger of the territory by the criterion “frequency of implementation - social damage”, the Caspian region belongs to the zone of unacceptable risk with the necessary urgent measures to reduce it. In order to improve the ecological situation in the region, it is necessary to increase the environmental safety of the enterprise, to minimize the damage caused by its emissions to the environment; it is necessary to make a number of energy-saving technological changes in equipment that meet European standards for smart petrochemical factory.

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