Торайғыров университетінің
ҒЫЛЫМИ ЖУРНАЛЫ

НАУЧНЫЙ ЖУРНАЛ
Торайгыров университета

ТОРАЙҒЫРОВ УНИВЕРСИТЕТІНІҢ ХАБАРШЫСЫ

Химия-биологиялық сериясы

1997 жылдан бастап шығады

TORAIGHYROV UNIVERSITY

ВЕСТНИК ТОРАЙГЫРОВ УНИВЕРСИТЕТА

Химико-биологическая серия

Издается с 1997 года

ISSN 2710-3544

№ 4 (2023)

Павлодар

НАУЧНЫЙ ЖУРНАЛ
Торайгыров университета

Химико-биологическая серия
выходит 4 раза в год

СВИДЕТЕЛЬСТВО
о постановке на переучет периодического печатного издания,
информационного агентства и сетевого издания
№ KZ84VPY00029266

выдано
Министерством информации и коммуникаций Республики Казахстан

Тематическая направленность
публикация материалов в области химии, биологии, экологии,
сельскохозяйственных наук, медицины

Подписной индекс – 76134

https://doi.org/10.48081/JQSZ6573

SRSTI 34.33.27

https://doi.org/10.48081/IXSV1515

K. N. Orazbayeva[1], *A. V. Ubaskin[2], K. I. Akhmetov[2], T. Zh. Abylkhassanov[2]
[1]Bogatyr Coal LLP,
Republic of Kazakhstan, Ekibastuz;
[2]Toraighyrov University,
Republic of Kazakhstan, Pavlodar
*e-mail: awupawl@mail.ru

ENVIRONMENTAL PROBLEMS OF SOLID FUEL HEATING PLANTS (ON THE EXAMPLE OF EKIBASTUZTEPLOENERGO LLP)

The article presents the ecological assessment of heating plants operating on solid fuel. Types of negative impact and sources of emission of pollutants from thermal power plants into the environment are given. The degree of air pollution in Pavlodar region is analyzed, including the share of emissions of the city of Ekibastuz. The article is devoted to the environmental assessment of solid fuel heating plants and the development of environmental protection measures on the example of Ekibastuzteploenergo LLP (Limited Liability Company under the laws of the Republic of Kazakhstan). The authors paid attention to the study of the system of operation, technology, and equipment of the Ekibastuz CHP. According to the obtained data, a comparative analysis of pollutant emissions and the dynamics of CO_2 emissions is made. Components released into the atmosphere during fuel combustion are nitrogen, sulfur, carbon oxides, soot, and ash. Incomplete combustion, in particular, leads to emissions of hydrocarbons like methane and ethane. Solving the negative environmental impact of heating plants necessitates a comprehensive approach that entails multiple measures. Measures to reduce emissions into the atmosphere are suggested.

Keywords: coal power, thermal power plants, environment, impact, atmosphere, emissions, measures.

Introduction

In contemporary times, coal power plays a crucial and consistent role [1]. Thermal power plants produce both thermal and electrical energy, with up to 75% of the world's total power generation stemming from this source. However, these plants have a notable impact on their environmental surroundings. The vast majority of fuel is converted into waste, manifesting in the form of gaseous and solid combustion products that enter the environment. Meanwhile, the volume of waste exceeds several times the mass of the fuel consumed. Environmental decline is correlated with the release of extensive amounts of contaminants, which spread over a span of 25 radii spanning several kilometers and result in respiratory and associated illnesses in people and animals. Moreover, it impacts photosynthesis in plants, mineral equilibrium, and the vital nutrients required by plants, while also affecting the structure of soils, buildings, and structures due to corrosive reactions [2; 3].

The detrimental effects of trace elements and radionuclides present in ash and slag wastes generated by coal-fired power plants, as well as the flue emissions of trace elements containing fly ash from TPPs, on the health of personnel working at coal-fired power plants and the surrounding environment are documented [4].

Climate change has a considerable effect on electricity demand and supply. Future projections indicate that climate change-induced efficiency reductions may lead to significant energy supply reductions. The closure of small and older units enhances generation efficiency but is insufficient to offset the decline in supply resulting from their closure. Given the rapidly growing need for electricity, ensuring stable and sustainable energy supply presents greater challenges [5].

In recent years, there has been a global interest in analyzing the environmental impact of fuel and energy complex (FEC) development. Additionally, attention has been focused on assessing the investment potential of energy efficiency programs and projects, which may involve reducing greenhouse gas emissions in accordance with the economic mechanisms of the Kyoto Protocol. Improving fuel and energy resource efficiency is crucial in the midst of increasing anthropogenic influence on the ecology and climate of territories. This is particularly relevant as more resources are being attracted into the sphere of economic activity. The state's energy policy ranks this objective among its highest priorities [6;7].

Kazakhstan possesses the largest thermal coal deposit in the world, which is conveniently located near the earth's surface, thus allowing for the lowest production costs worldwide. The energy sector in Kazakhstan emits the most greenhouse gases, as it accounted for 77.6 % (272.5 million tons of CO_2 equivalent) of all annual greenhouse gas emissions in the country during 2020, mainly due to the significant usage of fossil fuels. Although coal and its refined products account

for 29.4% (in comparable energy units) of fuel and energy resources utilized, their contribution to national net emissions exceeds 55.7%. Thus, gradually transitioning the Kazakh economy from reliance on coal is critical for low-carbon development and the achievement of carbon neutrality by 2060. Carbon capture and storage technology is expected to be utilized in capturing gases over the medium to long term. In this regard, a plan will be formulated to decommission coal-powered capacity with a lifespan of over 30 years and introduce carbon capture and storage technology for plants that will operate past 2035. Additionally, the deactivated coal plants will be granted priority access to implement renewable energy initiatives. Research, innovation, and education play vital roles in achieving low-carbon development, transitioning to carbon neutrality, and adapting to the impacts of climate change. In Kazakhstan, transforming the economic structure to align with these goals requires a well-equipped and highly skilled workforce that possesses scientific and technological knowledge [8].

Materials and methods

The article uses statistical data on the emission of pollutants from open sources. An analysis of current methods for assessing the patterns of distribution of pollutant emissions into the atmosphere from TEP sources was carried out. An analysis of the substances that are the main components emitted into the atmosphere during the combustion of various types of fuel was carried out. A statistical analysis of the relationship between the amount of greenhouse gas emissions and the volume of fuel combustion (coal and fuel oil) was carried out.

Results and discussion

The operation of many plants and units has an impact on the environment (Figure 1)

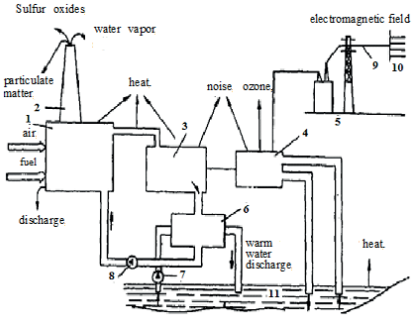

Figure 1 – Scheme of TPP impact on the environment:
1 – boiler; 2 – chimney; 3 – turbine; 4 – generator; 5 – substation;
6 – condenser; 7 – circulation pump; 8 – condensate pump; 9 – power line;
10 – electricity consumers; 11 - water body.

In general, the negative impacts of TPPs on the environment are classified into several types. These include:

- atmospheric pollution caused by suspended particles like soot, ash, and chemicals like SO_2, NO_x, CO, CO_2, etc.;
- greenhouse effect;
- consumption of oxygen, leading to a reduction in its concentration in the atmosphere;
- pollution of the lithosphere with solid waste materials such as slags and ash dumps, as well as the deposition of harmful emissions on the soil surface that can migrate deep into the lithosphere;
- excessive consumption of water and pollution caused by sewage;
- acid rains;
- thermal emissions;
- other negative impacts including noise and electromagnetic disturbances.

The thermal power industry emits over 300 types of substances into the environment, with sulfur dioxide, carbon oxides, nitrogen oxides, and various dusts comprising the majority.

Table 1 provides a comprehensive list of substances discharged by heating plants when using different types of fossil fuels.

Table 1 – List of substances discharged by heating plants when using different types of fossil fuels

Type of fuel	Gaseous substances	Aerosols	Impurity elements
Coal	NO, NO_2, SO_2, SO_3, CO_2, HCl, HF, Hg (fume), As (fume), H_2S, NH3	Fly ash, soot; formaldehyde, benzapyrene	As,Cd,Pb,Ti,Cr,Na,Ni, V, Cu, Zn, Mn, Mo, Sb, SiO_2,Al_2O_3,TiO_2, NO_3–, SO_4
Fuel oil	NO, NO_2, SO_2, SO_3, CO, CO2, Hg (fume), hydrocarbons	Ash (V_2O_5), formaldehyde, benzapyrene, soot	As, Cd, Pb, Ti, Cr, Na,Ni, V, Cu, Zn, Mn, Mo,Sb
Gas	NO, NO_2, CO, CO 2, traces of SO_2, hydrocarbons	Hydrocarbons	—

This substance list demonstrates that the primary components released into the atmosphere during fuel combustion are nitrogen, sulfur, carbon oxides, soot, and ash. Incomplete combustion, in particular, leads to emissions of hydrocarbons like

methane and ethane, polycyclic hydrocarbons such as benz(a)pyrene (C20H12), formaldehyde (NSON), and vanadium oxide (V) [9].

The quality of atmospheric air is crucial in terms of human health, and the well-being of flora and fauna is closely tied to air quality.

A significant number of pollutants is annually emitted into the atmosphere. Based on the Regional Environmental Protection Department's data, a comparative evaluation can be made regarding pollutant emissions into the atmosphere.

The air pollution near industrial centers such as Pavlodar, Ekibastuz, and Aksu has adverse impacts on vital activities of animals, plants, and microorganisms, besides causing immense economic damage to the urban areas.

For instance, the emission share in Ekibastuz is over 40 %. About one ton of harmful substances are emitted per person annually. This level of pollution is unacceptable. Despite a significant decline in production in the Ekibastuz industry during half of the last decade, Kazhydromet data showed that each analyzed substance exceeded the maximum concentration limit (MCL).

The city faces a challenging predicament due to the presence of nitrogen oxides and dust. Emissions from coal mines, thermal power plants, and transportation contain hydrogen sulfide, manganese oxides, silicon compounds, fluorides, and vanadium pentoxide. Moreover, 14.5 tons of dust are removed per year from 1 hectare of the operational section of the bulk ash disposal site with dust levels exceeding regulatory limits by 11.9 times [10].

An environmental impact assessment of Ekibastuz CHP (ECHP) revealed that in 2022, production decreased by 2.6 % and fuel consumption decreased by 10.4%. This resulted in a 19.9 % decrease in gross pollutant emissions. Specifically, emissions of sulfur oxides (SOx) decreased by 16.0 %, emissions of solid particles (coal ash) decreased by 17.0 %, and emissions of nitrogen oxides (NOx) decreased by 16.0 %. Accordingly, there has been a 13-15 % decrease in specific pollutant emissions, and greenhouse gas emissions were lower in 2022 than in 2021. This reduction can be attributed to lower fuel combustion (coal and fuel oil) caused by decreased production output (see Figure 2).

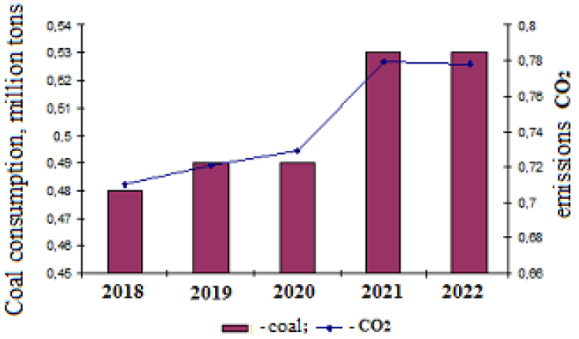

Figure 2 – Dynamics of carbon dioxide emissions from Ekibastuz CHP (correlation coefficient 0.996)

The Ekibastuz CHP of TOO Ekibastuzteploenergo is designed to produce hot water and steam for heating and technological purposes in Ekibastuz (Figure 3). Moreover, the ECHP generates electricity for its own consumption [11].

Figure 3 – The Ekibastuz CHP of TOO Ekibastuzteploenergo (https://ru.wikipedia.org/wiki)

- The primary fuel for the boiler units is Ekibastuz coal, and occasionally, fuel oil and diesel are used (including oil sludge). Sources of pollutants emitted into the atmosphere at ECHP are:
- Open coal storage;
- Fuel oil farm with fuel oil tanks;

- Steam boiler units BKZ-75-39FB - 5 pcs;
- Water-heating boiler units KVTK-100-150 - 5 units;
- Oil storage tanks;
- Overfilling units.

Steam boilers in the ECHP are fitted with second-generation "Panarin" system battery emulsifiers, while water-heating boilers have wet ash collectors. The ash collecting system can absorb up to 6% sulfur dioxide from flue gas when running on clarified water with alkalinity of 3.3 mg-eq/dm3. The fuel supply path is equipped with aspiration units which have coagulation wet dust collectors [11].

Minimizing pollutant emissions into the atmosphere is a crucial aspect of environmental preservation for heating plants. Thus, implementing ongoing environmental impact monitoring is essential to take measures that reduce emissions and prevent violations of environmental laws.

The replacement of outdated energy generating facilities with new ones that meet modern environmental protection requirements has the greatest impact on reducing emissions [12].

Thus, the goal of atmospheric protection should be to decrease emissions. This can be accomplished through the implementation of several measures, including:

1) the introduction of new fuel combustion technologies, such as fluidized bed combustion, which reduces the number of pollutants in exhaust gases;

2) the development of new methods for purifying fuel combustion products of sulfur compounds;

3) reducing the amount of sulfur in fuel to minimal values before combustion;

4) replacement of dust-cleaning equipment at thermal power plants (TPPs) with new, higher-efficiency equipment;

5) equipping TPP equipment and facilities with protective and shielding devices;

6) ensuring compliance with all environmental protection and regulatory acts in the design of facilities and structures.

Conclusions

In contemporary times, coal power plays a crucial and consistent role. The primary components released into the atmosphere during fuel combustion are nitrogen, sulfur, carbon oxides, soot, and ash. The Ekibastuz CHP of TOO Ekibastuzteploenergo is designed to produce hot water and steam for heating and technological purposes in Ekibastuz. The primary fuel for the boiler units is Ekibastuz coal, and occasionally, fuel oil and diesel are used. Greenhouse gas emissions were lower in 2022 than in 2021. This reduction can be attributed to lower fuel combustion (coal and fuel oil) caused by decreased production output. Solving the negative environmental impact of heating plants necessitates a

comprehensive approach that entails multiple measures. This includes equipping new thermal power plants with efficient methods of cleaning exhaust and pollutant emissions, waste management, and the use of environmentally safe fuels in their design and construction.

References

1 **Su, F.-Q.** Monitoring of coal fracturing in underground coal gasification by acoustic emission techniques / F.-Q. Su, K.-I. Itakura, G. Deguchi, K. Ohga // Applied Energy. – 2017. – V. 189. – P. 142–156.

2 **Pokale, W. K.** Effects of thermal power plant on environment // Sci. Revs. Chem. Commun.: – 2(3). – 2012. P. 212-215.

3 **Няшина, Г. С.** Анализ антропогенных выбросов при сжигании угольных топлив и отходов углепереработки [Текст] // Кокс и химия. – 2017. – № 4. – С. 40–46.

4 **Сидорова, Г. П., Крылов, Д. А., Якимов, А. А.** Экологическое воздействие угольных ТЭС на окружающую среду [Текст] // Вестник Забайкальского государственного университета. – 2015. – № 9 (124). – С. 28-38.

5 **Zhang H.** The impacts of climate change on coal-fired power plants // Energy & Environmental Science. – № 9, – 2021. P. 15-33. DOI https://doi.org/10.1039/D1EE01475G

6 **Ануфриев В. П.** Энерго-ресурсосбережение и Киотский протокол: возможности для регионов: монография [Текст]. – Екатеринбург, 2006. – 286 с.

7 **Нурмеев, Б. К.** Мероприятия по сокращению выбросов в атмосферу при сжигании топлива [Текст]. // Экология и промышленность России. – 2005. – № 10. – С. 32–33.

8 Об утверждении Стратегии достижения углеродной нейтральности Республики Казахстан к 2060 году [Текст]. – Указ Президента Республики Казахстан от 02 февраля 2023. – № 121.

9 **Краецкая, О. Ф., Прокопеня, И. Н.** Экология теплоэнергетики [Текст]. – Минск : БНТУ. – 2014. – 107 с.

10 **Гроза, М. М., Ермиенко, А. В.** Экологические проблемы Павлодарской области [Текст]. – Наука и техника Казахстана. – Павлодар, 2005. – № 2. – С. 7–15.

11 Пояснительная записка к проекту нормативов предельно допустимых выбросов в атмосферу (ПДВ) для Экибастузской ТЭЦ [Текст]. – Павлодар, 2018. – 38 с.

12 **Поддубная, А. А., Убаськин, А. В., Сатарова, С. Б.** Показатели загрязнения атмосферного воздуха и здоровья населения как индикаторы устойчивого развития [Текст]. «Химия и химические технологии в XXI веке» – Томск. – 2008.

13 **Ядутов, В. В., Петров, Т. И., Зацаринная, Ю. Н.** Воздействие ТЭС на окружающую среду [Текст]. – Казань. – 2013. – С. 78–79.

References

1 **Su, F.-Q.** Monitoring of coal fracturing in underground coal gasification by acoustic emission techniques [Text]. F.-Q. Su, K.-I. Itakura, G. Deguchi, K. Ohga // Applied Energy. – 2017. – V. 189. – P. 142–156.

2 **Pokale, W. K.** Effects of thermal power plant on environment [Text]. Sci. Revs. Chem. Commun.: 2(3), 2012, P. 212-215.

3 **Nyashina, G. S.** Analiz antropogennyh vybrosov pri szhiganii ugol'nyh topliv i othodov uglepererabotki [Analysis of anthropogenic emissions from combustion of coal fuels and coal processing waste] [Text]. Coke and Chemistry. – 2017. – No 4. – P. 40-46.

4 **Sidorova, G. P., Krylov, D.,A. Yakimov, A. A.** Jekologicheskoe vozdejstvie ugol'nyh TJeS na okruzhajushhuju sredu [Ecological impact of coal-fired power plants on the environment. «Energy and rational nature management»] [Text]. Vestnik of Zabaikalsky State University, No 124. 2015, 28-38.

5 **Zhang, H.** The impacts of climate change on coal-fired power plants // [Text]. Energy & Environmental Science, № 9, 2021, 15-33. DOI https://doi.org/10.1039/D1EE01475G

6 Anufriev, V. P. Jenergo-resursosberezhenie i Kiotskij protokol: vozmozhnosti dlja regionov [Energy and resource saving and the Kyoto Protocol: opportunities for the regions: monograph] [Text]. V.P. Anufriev. Ekaterinburg, 2006. – p. 286.

7 **Nurmeyev, B. K.** Meroprijatija po sokrashheniju vybrosov v atmosferu pri szhiganii topliva [Measures to reduce atmospheric emissions from fuel combustion] [Text]. Ecology and Industry of Russia. 2005. No 10. – P. 32-33.

8 On approval of the Strategy for achieving carbon neutrality of the Republic of Kazakhstan by 2060. [Text]. Decree of the President of the Republic of Kazakhstan dated February 2, 2023, No 121.

9 **Kraetskaya, O. F., Prokopenya, I. N.** Jekologija teplojenergetiki [Ecology of heat power engineering] [Text]. – Minsk, 2014. – p. 107.

10 **Groza, M. M., Ermienko, A. V.** Jekologicheskie problemy Pavlodarskoj oblasti [Ecological problems of Pavlodar region] [Text]. – Pavlodar, 2005. – p. 15.

11 Explanatory note of the draft standards of maximum permissible atmospheric emissions (MPE) for Ekibastuz CHP. [Text]. – Pavlodar, 2018. – P. 38.

12 **Poddubnaya, A. A., Ubaskin, A. V., Satarova, S. B.** Pokazateli zagrjaznenija atmosfernogo vozduha i zdorov'ja naselenija kak indikatory ustojchivogo razvitija [Indicators of air pollution and public health as indicators of sustainable development] [Text]. Chemistry and chemical technology in the XXI century – Tomsk, 2008.

13 **Yadutov, V. V., Petrov, T. I., Zatsarinnaya, Yu. N.** Vozdejstvie TJeS na okruzhajushhuju sredu [Impact of TPPs on the environmen] [Text]. – Kazan, 2013. – P. 78–79.

Accepted for publication on 04.12.23.

*К. Н. Оразбаева[1], *А. В. Убаськин[2],*
К. И. Ахметов[2], Т. Ж. Абылхасанов[2]
[1]«Богатырь Көмір» ЖШС,
Қазақстан Республикасы, Екібастұз қ.
[2]Торайғыров университеті,
Қазақстан Республикасы, Павлодар қ.;
Басып шығаруға 04.12.23 қабылданды.

ҚАТТЫ ОТЫН ЖЫЛЫТУ ҚОҢДЫРҒЫЛАРЫНЫҢ ҚОРШАҒАН ОРТА МӘСЕЛЕЛЕРІ (ЭКИБАСТУЗЖЫЛУЭНЕРГО ЖШС МЫСАЛЫНДА)

Мақалада қатты отынмен жұмыс істейтін жылу қондырғыларының экологиялық бағасы берілген. Жылу электр станцияларынан қоршаған ортаға теріс әсер ету түрлері және ластаушы заттардың шығарылу көздері келтірілген. Павлодар облысының атмосфералық ауасының ластану дәрежесі, оның ішінде Екібастұз қаласының шығарындыларының үлесі талданған. Мақала «Екібастұзжылуэнерго» ЖШС (Қазақстан Республикасының заңнамасы бойынша жауапкершілігі шектеулі серіктестігі) мысалында қатты отынмен жұмыс істейтін жылу қондырғыларының экологиялық сараптамасына және қоршаған ортаны қорғау шараларын әзірлеуге арналған. Авторлар Екібастұз ЖЭО-ның жұмыс істеу жүйесін, технологиясын, жабдықтарын зерттеуге назар аударды. Алынған мәліметтер бойынша ластаушы заттардың шығарындыларына және CO_2 шығарындыларының

динамикасына салыстырмалы талдау жасалған. Атмосферага шыгарындыларды азайту шаралары ұсынылады.

Кілтті сөздер: көмір энергетикасы, жылу электр станциялары, қоршаган орта, әсер, атмосфера, шыгарындылар, шаралар.

*К. Н. Оразбаева[1], *А. В. Убаськин[2],*
К. И. Ахметов[2], Т. Ж. Абылхасанов[2]
[1]«ТОО «Богатырь Комир»,
Республика Казахстан, г. Экибастуз.
[2]Торайгыров университет, Республика Казахстан, г. Павлодар,
Принято к изданию 04.12.23.

ЭКОЛОГИЧЕСКИЕ ПРОБЛЕМЫ ТВЕРДОТОПЛИВНЫХ ОТОПИТЕЛЬНЫХ УСТАНОВОК (НА ПРИМЕРЕ ТОО «ЭКИБАСТУЗТЕПЛОЭНЕРГО»)

В статье представлена экологическая оценка котельных, работающих на твердом топливе. Приведены виды негативного воздействия и источники выбросов загрязняющих веществ тепловых электростанций в окружающую среду. Проанализирована степень загрязнения атмосферного воздуха Павлодарской области, в том числе доля выбросов города Экибастуза. Статья посвящена экологической оценке твердотопливных котельных и разработке мероприятий по охране окружающей среды на примере ТОО «Экибастузтеплоэнерго» (Товарищество с ограниченной ответственностью по законодательству Республики Казахстан). Авторы уделили внимание изучению системы работы, технологии и оборудования Экибастузской ТЭЦ. По полученным данным произведен сравнительный анализ выбросов загрязняющих веществ и динамики выбросов CO_2. Предложены меры по снижению выбросов в атмосферу.

Ключевые слова: угольная энергетика, тепловые электростанции, окружающая среда, воздействие, атмосфера, выбросы, меры.

Теруге 04.12.2023 ж. жіберілді. Басуға 28.12.2023 ж. қол қойылды.
Электрондық басылым
2,14 МБ RAM
Шартты баспа табағы 8,28.
Таралымы 300 дана. Бағасы келісім бойынша.
Компьютерде беттеген З. Ж. Шокубаева
Корректорлар: А. Р. Омарова
Тапсырыс № 4244

Сдано в набор 04.12.2023 г. Подписано в печать 28.12.2023 г.
Электронное издание
2,14 МБ RAM
Усл. п. л. 8,28. Тираж 300 экз. Цена договорная.
Компьютерная верстка З. Ж. Щокубаева
Корректоры: А. Р. Омарова
Заказ № 4244

«Toraighyrov University» баспасынан басылып шығарылған
Торайғыров университеті
140008, Павлодар қ., Ломов к., 64, 137 каб.

«Toraighyrov University» баспасы
Торайғыров университеті
140008, Павлодар қ., Ломов к., 64, 137 каб.
8 (7182) 67-36-69
e-mail: kereku@tou.edu.kz
www.vestnik-cb.tou.edu.kz