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Generalized evaluation of oil and gas pollution in Mangystau region

The authors have developed a way to solve the inverse problem of integrated environmental assessment with the help of GIS technologies and models of the objective function on the basis of the available in the Atlas of Mangystau region maps with ready-made, integrated environmental assessment, take into account the effect of all sources of exposure. As previously published, oil and gas complex of Mangystau region in anthropogenic modification of the most important components of the environment are examples of its decision the review stage works are considered to estimate the contribution of activity – relief, soils and vegetation. The results of these calculations have shown that the oil and gas complex provides an additional contribution to the degradation of soil cover in excess of the average for all anthropogenic sources at the 19.31%, in relief degradation – 18.3%, vegetation – 16.7%. In this article, we consider the estimation of the impact of oil and gas complex in the groundwater.

In this article, we consider the assessment of the impact of oil and gas complex in the groundwater. Specificity of this evaluation is the need to detail the existing scale of the expert assessment of the level of anthropogenic disturbance of groundwater levels in three to five, as the necessary from the standpoint of ensuring sufficient accuracy of the environmental assessment in accordance with the recommendations of the environmental engineering, and from the standpoint of the possibility of “cross-linking” of all received solutions at integrated complex environmental Assessment. For a detailed map of the grading scale used natural protection of groundwater, published in the Atlas of the Mangystau region. Square contours combinations of 3 levels of anthropogenic disturbance with 4 levels of natural protection of groundwater, and then with hydrocarbons location areas defined in Arc GIS, the use of which components have greatly simplified the task, as after the procedure each loop sampling were received vector shapefiles, areal values are displayed automatically in the derivation of each circuit. The calculated objective functions have shown that the oil and gas complex creates an additional burden on the vegetation, exceeding the average of all anthropogenic sources by 9.9%. A summary of the assessment called because in the objective functions include numeric expression sums of squares of each level of anthropogenic disturbance, first across the region, and then for areas with the presence of oil and gas complex

Key words: Mangystau region, oil and gas complex, the degree of anthropogenic disturbance of groundwater, the natural protection of groundwater geographic information system, the objective function.

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Маңғыстау облысының мұнай газбен ластануын жалпылама бағалау

Маңғыстау облысының атласынан алынған барлық ластану көздері берілген дайын картаны пайдалана отырып, авторлар мақсатты атқарым моделімен ГИС-технологиясының көмегімен кешенді экологиялық бағалаудың кері шешім тәсілі өңделді. Рельеф, топырақ және өсімдік – табиғи ортаның ең маңызды құрамдас бөліктерінің антропогендік модификациясында Маңғыстау облысының мұнай газ кешенін бағалау мен оның мәселелері бұрынғы басылымға шыққан немесе рецензияланған жұмыстарда қарастырылған. Бұларды есептеу нәтижесінде мұнай газ өндіруші кешенінде антропогендік көздері бойынша топырақ жамылғысы бүлінудің қосымша 19,31%, рельефтің бұзылуы – 18,3%, өсімдіктер жамылғысының 16,7% үлесі бар екендігі анықталды.

Жерасты суларына мұнай газ өндіруші кешеннің әсері осы жұмыста берілген. Бұл бағалауды жүргізудің негізгі әдістемесі үштен бес деңгей бойынша антропогендік әсерден жер асты суларының бұзылысының деңгейінің сараптамалық бағалаудың шкаласының болуымен түсіндіріледі. Бағалауда Маңғыстау облысының атласынан жер асты суларының табиғи қорғау картасы алынды. Контурдың ауданы антропогендік бұзылыс 3 деңгеймен жер асты суларын табиғи қорғау 4 деңгеймен сәйкес. Содан кейін Arc GIS көмегімен көмірсутектер кен орны анықталып, әрбір контурды цифр көмегімен векторлық шейп-файлдар алынды, әрбір контурды жүргізгеннен кейін аудан аймағы автоматты түрде көрсетіледі. Мақсатты атқарым есеп нәтижелері мұнай газ өндіруші кешені өсімдіктерге ластанудың қосымша жүктемесін тудыратындығын көрсетті. Алынған бағалау жалпылама деп аталу себебі облыстың барлық территориясы бойынша антропогендік әсердің әрбір деңгейі ауданның есебінен мақсатты атқарым, содан кейін мұнай газ өндіруші кешеннің аймағы анықталады.

Түйін сөздер: мұнай газ өндіруші кешен, антропогендік әсер, жер

**GENERALIZED
EVALUATION OF OIL
AND GAS POLLUTION
IN MANGYSTAU
REGION**

Introduction

The region is located in the southwest of the Republic of Kazakhstan in the desert zone and includes Mangyshlak, Ustyurt plateau, the Peninsula Buzachi sors Dead Kuluk and Kaidak. The area is characterized by a continental dry desert climate, strong storms and winds.

The region recorded 559 industrial enterprises, including large and medium – 70. The raw material orientation of the economy of the region determined the priority of the mining industry, the state of development which are directly dependent on all other sectors of the economy. The area on the total volume of industrial output ranks third in the country. At the heart of the region's economy – oil and gas sector, where the volume of production occupies more than 90 percent of the total volume produced in industrial production region, which accounts related to oil and gas complex as the main source of anthropogenic disturbance of the natural environment components as oil and natural gas industry has traditionally been considered one of the most environmentally hazardous industries management [1, 2].

The specifics of climatic conditions of the region, taking into account the complete lack of a permanent river flow causes the acuteness of water scarcity problems in the first place, drinking water shortages. According to experts, the shortage of drinking water in the Mangistau region of 40,000 m³ per day and will reach 70,000 m³ / day in 2020 [3-5].

According to akimat, in the Mangistau region, there are 60 villages, of which the centralized water supply provided 17 settlements decentralized – 35. Due to the small size of the population and uneconomical construction of water supply systems in 9 rural settlements used imported bottled water. Aktau and Zhanaozen with surrounding towns, as well as oil-producing companies consume 93% of the total volume of water in the proportion of settlements accounted for 7% [3, 6].

Mangystau region is provided with water from three sources: LLP «MAEC-Kazatomprom» by desalinated seawater covers 47-50% of the demand in the region; Volga water supplied water pipeline «Astrakhan-Mangyshlak» provides about 40%; from groundwater

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**Обобщенная оценка
загрязнения нефти и газа
в Мангистауской области**

Авторами разработан способ решения обратной задачи комплексной экологической оценки с помощью ГИС-технологий и модели целевой функции на базе имеющихся в Атласе Мангистауской области карт с готовыми комплексными экологическими оценками, учитывающими влияние всех источников воздействия. В опубликованных ранее и находящихся на стадии рецензирования работах рассмотрены примеры ее решения для оценки вклада деятельности нефтегазодобывающего комплекса (НГДК) Мангистауской области в антропогенные модификации важнейших составляющих природной среды – рельефа, почв и растительности. Результаты этих расчетов показали, что нефтегазодобывающий комплекс создает дополнительный вклад в деградацию почвенного покрова, превышающий среднюю по всем антропогенным источникам на 19,31%, в деградацию рельефа – 18,3%, растительности – 16,7%. В данной работе рассматривается оценка влияния НГДК на подземные воды. Специфика проведения этой оценки заключается в необходимости детализации имеющейся шкалы экспертной оценки уровня антропогенной нарушенности подземных вод по трем уровням к пяти, необходимым как с позиции обеспечения достаточной точности экологической оценки в соответствии с рекомендациями инженерной экологии, так и с позиции возможности «сшивания» всех полученных решений в интегральной комплексной экологической оценке. Для детализации оценочной шкалы использовалась карта естественной защищенности подземных вод, опубликованных в Атласе Мангистауской области. Площади контуров сочетаний 3 уровней антропогенной нарушенности с 4 уровнями естественной защищенности подземных вод, а затем и с участками расположения месторождений углеводородов определялись в Arc GIS, использование компонентов которой значительно упростило задачу, т.к. после проведения процедуры оцифровки каждого контура были получены векторные шейп-файлы, площадные значения которых отображаются автоматически при выведении каждого контура. Результаты расчетов целевых функций показали, что НГДК создает дополнительную нагрузку на растительность, превышающую среднюю по всем антропогенным источникам на 9,9%. Обобщенная полученная оценка названа потому, что в целевые функции входят числовые выражение сумм площадей каждого уровня антропогенной нарушенности сначала по всей территории области, а потом для зон с наличием НГДК

Ключевые слова: нефтегазодобывающий комплекс, антропогенной нарушенности подземных вод, геоинформационная система, целевая функция.

deposits is possible to provide, according to various sources, from 11 to 13% of the total needs of the region [3, 5].

Total deposits of underground water Mangistau region is 65 units, the total reserves – 522 thousand cubic meters per day. The largest deposits of underground waters are: Tuyesu, Sauyskan, Kuyulus, Tonirekshyn, Janajol and Ketikskoe [3-5]. These fields allow for domestic needs of 17.5% of the population [3, 6-7].

Thus, the problem of shortage of drinking water quality resources is solved mainly due to water desalinated Caspian and the Volga water coming from the Russian Federation. All the water consumed by the city of Aktau and Zhanaozen with surrounding towns, as well as oil producers. Villages across the region are supplied from local groundwater deposits, so evaluation of their environmental state is highly relevant.

However, the financing of these activities It is also important to address the binding of pollution sources to implement the principle of «the polluter pays». This principle is implemented in the Republic of Kazakhstan on the basis of obtaining permits for enterprises emissions in the environment issued by the competent government authorities after their studies in the draft regulations, where they are calculated according to the industrial environmental control, taking into account all the planned changes in the enterprise.

On the other hand, any kind of environmental monitoring records the combined effect of the various sources of pollution on the natural environment components. Thus, the great theoretical and practical significance is the «inverse problem» integrated environmental assessment – determining the role of certain pollutants in the formation of the ecological situation in the region. The urgency of this problem is increasing also for the reason that the current mechanism of payments for emission formally approved in compliance with all emission regulations.

The results of calculations by the developed technique showed that oil and gas complex provides an additional contribution to the degradation of soil cover in excess of the average for all anthropogenic sources in the 16.51%, in the degradation of the relief – 16.73%, vegetation – 31.79%. In this paper we consider the assessment of the impact of oil and gas complex in the groundwater. Specificity of this evaluation is the need to detail the existing scale of the expert assessment of the level of anthropogenic disturbance of groundwater.

The purpose of this paper is to describe

the reception of detail and expert assessments of the scale of the inverse problem solution integrated environmental assessment to quantify the contribution of oil and gas complex in the anthropogenic transformation of groundwater Mangystau region using the method developed on the basis of the final expert private environmental assessment given to the traditional five levels of exposure.

Material and Methods

The authors have developed a way to solve the inverse problem of integrated environmental assessment with the help of GIS technologies and models of the objective function on the basis of the available in the Atlas of Mangystau region maps with ready-made, integrated environmental assessment, take into account the effect of all sources of exposure. The previously published and are at the stage of reviewing the works of the technique of realization of the method and examples of its decision to assess the contribution of the activities of oil and gas complex of Mangystau region in anthropogenic modification of the most important components of the natural environment -relief, soils and vegetation.

The technique consists of two parts. The first part – the procedure for obtaining the specific evidence in a form adapted for use in the target functions to implement a simplified method for solving the inverse problem of objectivity and sufficient justification of the objective functions. The second technique is based on the idea of constructing and comparing the generalized objective functions reflecting the average (weighted) assessment of human impact on the environmental components in the whole of Mangystau region of the Republic of Kazakhstan and for areas with the presence of oil and gas complex.

Pressures on the transformation of the levels in the target function takes into account the level of complexity of environmental activities for each component of the natural environment. Justification of the complexity of these measures is given in the legends maps or in the literature. A simplified approach is to obtain a comparison of generalized evaluations, as in the objective function includes not distribution area ratios with different levels of anthropogenic disturbance to the area or areas of the field with the presence of oil and gas complex and the numeric expression amounts for each level. General view of the objective function, which takes into account not only the intensity of the

impact of each environmental factor, but also its role (importance) in the formation of favorable or adverse conditions for the existence of biological systems (1), as proposed by R. Pentla looks like a linear multiple regression equation [12]:

$$\text{OFIEA} = a_1 \cdot f_1 + a_2 \cdot f_2 + \dots + a_n \cdot f_n, \quad (1)$$

where OFIEA – calculated value of the objective function for integrated environmental assessment;

f_i – value of a given environmental factor ($i = 1, 2, \dots, n$) at the observation point;

a_i – weighting coefficient reflecting direction (plus or minus with respect to the target) and the importance (weight) of this factor in the formation of the total exposure level.

In this formulation, the objective function is not understood in the classical mathematical sense (where it is understood as a criterion for comparing alternatives using different optimization methods), as well as a function that implements the purpose of the evaluation. Formal similarities with mathematical sense observed here – the procedure is reduced to optimize the sorting of the coefficients a_i significance (estimates are almost always expert) in compliance with the conditions of their study. Objectification of the objective function includes the rationale for the selection of the most significant factors on the basis of taking into account specific geographical, environmental and economic conditions of the evaluated area and completeness of rating scales range. (2) is proposed to solve the latter problem of environmental engineering methods:

$$\Delta = \frac{1}{l^n}, \quad (2)$$

where l – the level of quantization of grading scales used in the assessment of environmental factors (the number of divisions grading scale) [13].

From the formula (2) that even with the rough grading scale with the level of quantization of 2 (ie for peer review on a «yes» or «no») with reasonable accuracy (the error does not exceed 4%) can be achieved with 5 accounted parameters ($\square = 1/25 = 0.03125$, or 3.1%). Thus, a greater impact on the accuracy (ie actually objectivity) has a number of expert assessments of the analyzed parameters of the n (the exponent in the denominator of the formula), and not the level of quantization of grading scales l (the number of divisions on our measuring «line»).

The most crucial moment in determining the degree of objectivity of integrated environmental

assessment, previously thought to build private rating scales. If every parameter is available from their set is estimated on a scale constructed on the basis of independent research in all of its possible range of changes allowed to speak about the objectivity of integrated assessments, as determined by the scale of the last view of the objective function [14, 15].

However, the analysis above formula (2.2) from the standpoint of the general theory of systems and quantitative information theory has shown that the degree of differentiation of the scale and completeness of the range of all possible states accounted parameter plays a subordinate role in the use of multi-dimensional evaluation function [16, 17]. Thus, doubts about the objectivity of rating scales because of the complexity of accounting of non-linear effects of the interaction with other factors can remove the increasing number selected as important to describe factors.

To obtain baseline data in previous studies used published [18] a map of human impact on the relief, degradation map of soil cover, a map of anthropogenic transformation of vegetation, is a private environmental assessment (integrated environmental assessment for one of the components of the natural environment) of anthropogenic impact on the relief, soil cover and vegetation of all the possible sources of degradation relief, soils and vegetation of Mangistau region. Each of these maps is made on the basis of expert generalizations large amount of diverse information and is divided into five levels of human impact zone, with higher levels of exposure corresponds to a more complex set of environmental protection measures for their rehabilitation and correspondingly higher levels of financial costs. Published in the same Atlas [18] search by map anthropogenic disturbance of groundwater knocked out of this number, since it is only three levels of impact A legend to the map shows that the level (degree) of anthropogenic disturbance of groundwater reflect the state of underground water to the extent of security area probable reserves and proven reserves, as well as man-made impact on the underground hydrosphere. The map shows the impact of individual factors or combination of factors to change hydrogeodynamic and hydrogeochemical groundwater status and isolated areas with low (green), moderate (yellow) and strong (red) the degree of anthropogenic disturbance of groundwater. The horizontal shading on the map are reflected in the zone of influence hydrogeodynamic and hydrogeochemical groundwater regime of the Caspian Sea level change and man-made factors,

inclined – man-made factors, pollution and water intake.

The most important anthropogenic factor taken into account when assessing the level of anthropogenic disturbance of groundwater, pollution of groundwater is potable purpose. The level and extent of contamination of groundwater allocated on the basis of the analysis of the results of observations on the regime of the State network of groundwater monitoring and occasional observations. In the region as a result of regime observations revealed 7 centers of pollution of groundwater and 12 according to anecdotal observations. The main pollutants: oil products – up to 10-15 MPC (maximum permissible concentration of pollutants), fluoro – 3-5 MAC, ammonia – 2-4 MAC. The extent of groundwater contamination in the zones of influence of the revealed centers characterized as moderately dangerous. [18]

So, the analysis of maps of anthropogenic disturbance of groundwater and its legends shows that the allocation of levels of disturbance of groundwater status was taken into account the impact of oil and gas, mining, power and chemical industries and animal husbandry to changes in the level and chemical conditions on 7 normalized indicators (sulfates, chlorides, synthetic surfactants, fluorine oils, phenols, radionuclides and uranium), i.e. it is a set of factors taken into account satisfies the requirements of objectivity and accuracy [13]. The basis for the detailed assessment may serve as a map of the natural protection of groundwater (Fig. 2).

The legend for this map provides a brief description of the term and the parameters on which protection was assessed [18]: «Under Protected aquifer from pollution is understood as its deposits overlap, preventing the penetration of contaminants from the surface of the land or of the overlying aquifer.

Analysis maps of natural protection of groundwater in the same way as in the case with the analysis of maps of anthropogenic disturbance of groundwater shows that take into account the impact of more than five factors, ie the allocation of the degrees of protection and this map is fully meets the requirements of objectivity and accuracy [13].

The contours of the four levels of natural protection of groundwater (the outline of each level of natural protection are marked with a separate color) and three levels of anthropogenic disturbance of groundwater (the outline of each level disturbance allocated a separate species hatch). In order to calculate the possibility of the integrated

objective function, taking into account the impact of all environmental components must be of the two scales to build a five-level.

Legend to the map evaluate the degree of natural protection of underground noted that this estimate was based, taking into account not only the natural factors (hydro-geological conditions of the territory, the degree of overlap of groundwater loamy and clayey layers), but man-made (particularly moisture in the vadose zone and the nature of the interaction of pollution with rocks and groundwater). It is therefore logical to choose the basis for building a level of protection taking into account the specifics of allocation of anthropogenic disturbance of groundwater, as described in the legend (Table. 1).

Thus, the Table. 1 is actually a description (algorithm) detail a three-level scale of the degree of disturbance of groundwater («finished» integrated environmental assessment of human impact on groundwater) to the standard five-level scale anthropogenic disturbance components of the environment with the help of an additional map zoning of groundwater in terms of their security. The essence of this method lies in the fact that the contours of each of the five levels for traditional integrated environmental assessment will be determined as the appropriate combination of color and contour circuit with hatching (combination algorithm is presented the third column of Table. 1). The procedure for such a crossing (polygon) is implemented in the Arc GIS to produce a vector shape files, automatically storing certain areas of polygons with an indication of their belonging to the color and shading. As a result, a map with a three-level assessment of anthropogenic disturbance of groundwater is converted to the classical form with a five-level evaluation (Fig. 2)

Now the scheme of the circuit area can be made by analogy with the schemes estimates of anthropogenic disturbance relief, soil and vegetation. The procedure is implemented in the Arc GIS to produce a vector shapefiles.

Thus, the construction of the first part of the method of inverse problem solution integrated environmental assessment with the help of GIS technologies and models of the objective function on the basis of the available in the Atlas of Mangystau region maps with ready-integrated environmental assessment is completed. At the same time it developed a specific method of obtaining evidence in the traditional manner, using a five-level scale. This method is applicable for the areas of polygons like on the territory of the region as a whole as well as for areas with oil and gas complex.

Table 1 – Compliance with degree of protection rating scales and disturbance of groundwater with the conventional five-level scale of anthropogenic disturbance environmental components of Mangystau region

The three-level scale anthropogenic disturbance of groundwater (designated by two types of shading)	Four-scale level of protection of groundwater (Indicated by 4-color)	Five-level scale levels of anthropogenic disturbance of environmental components	The combination of colors of the vulnerability (4 colors) and Species hatch – 3 types (In the box, horizontal lines, diagonal lines)
Little or no (Shading in the box)	Protected	Undisturbed (Means no / no)	Hatching in the box
	provisionally protected		Hatching in the box
	poorly protected	Poor violated (Weak)	Hatching in the box
	Unprotected		Hatching in the box
moderate (Shading horizontal lines)	Protected	Average violated (Moderate)	On the map there is no such zone
	provisionally protected		Hatching horizontal lines
	poorly protected		Hatching horizontal lines
	Unprotected		Hatching horizontal lines
strong (Shading horizontal lines)	Protected	greatly disturbed (Significant)	On the map there is no such zone
	provisionally protected		Hatching oblique lines
	poorly protected	Very much disturbed (Strong)	Hatching oblique lines
	Unprotected		Hatching oblique lines

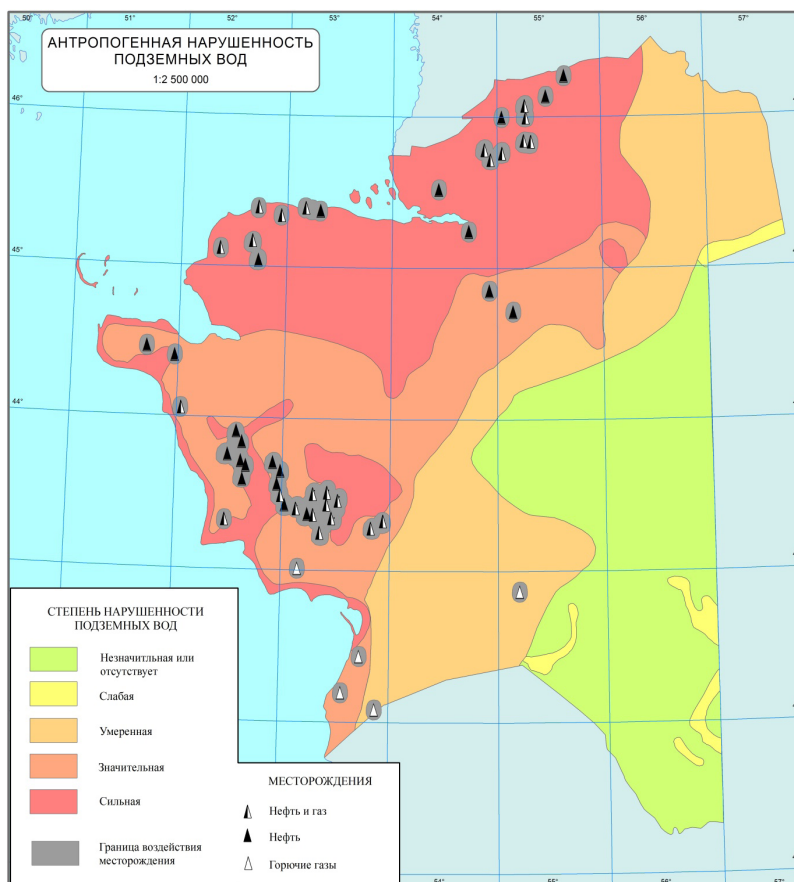


Figure 2 – Map of anthropogenic disturbance of groundwater, reduced to a five-level evaluation

The second method – a comparison of the objective functions for the areas of different levels of human exposure to a specific component of the natural environment (in this case, groundwater) in the whole of Mangystau region of the Republic of Kazakhstan and the same levels for areas with oil and gas complex, ie, the essence of the second method reduces to the construction and justification of the form of target functions.

Weighted load each parameter define the objective function subject to compliance with the five levels of vegetation transformation of the traditional to expert estimates ten-point scale. In the case of linear scale for each of the 5 levels will fall by 2 points, and increase the level of transformation will meet the increase in scoring. This statement, as in previous works, is justified from the standpoint of the complexity and the cost of environmental protection measures, in particular measures to prevent pollution of groundwater, which is often much more expensive measures for the rehabilitation of the vegetation cover.

As for any component of the environment the cost of activities is growing in proportion to the degree of anthropogenic disturbance, will conduct private environmental assessment of the contribution of each zone in accordance with a weighting factor proportional to the level of transformation in point grading scale. In this case, the lower and upper limits are 5 levels (the parameters of the objective function) are the scores:

- for low level or lack of transformation – undisturbed areas – (green + cell of hatching) – $0 \div 2$;
- For low-level transformation – slightly disturbed areas – (yellow + cell of hatching) – $2 \div 4$;
- For moderate levels of transformation – medium disturbed areas – (yellow on the map + horizontal shading) – $4 \div 6$;
- for level significant transformation – much disturbed areas – (pink on the map + inclined hatching) – $6 \div 8$,
- for the level of transformation of strong – very disturbed areas – purple color on the map + inclined hatching) – $8 \div 10$ points.

Whereas for the calculation of the weighted average value of oil and gas complex in the contribution of anthropogenic transformation of vegetation between the boundaries of the Middle class values, we obtain (3) the form of private objective function to the overall transformation of the vegetation on the field (POF_{GWarea}):

$$POF_{GWarea} = f_{GWArea1} + 3f_{GWArea2} + 5f_{GWArea3} + 7f_{GWArea4} + 9f_{GWArea5} \quad (3)$$

where POF_{GWarea} – function of a certain level of the anthropogenic disturbance of groundwater status for the entire region, which is calculated by dividing the total area of the polygons a certain level of anthropogenic transformation of the status of groundwater in the whole area in the whole field area.

In this case, f_{GWarea} is the sum of the areas share a certain level of the anthropogenic disturbance of the status of groundwater in the area of the entire region, ie, The actual contribution of the zone in the overall assessment of the anthropogenic disturbance of groundwater status – feature a certain level of the anthropogenic disturbance of groundwater status and POF_{GWArea} reflects the average (weighted average) assessment of human impact on groundwater in the whole of Mangystau region of Kazakhstan.

To solve the inverse problem of integrated environmental assessment by comparing the objective functions in the areas of various levels of anthropogenic impacts on the status of groundwater in the whole of Mangystau region of the Republic of Kazakhstan and the areas with the oil and gas complex remains to construct a similar way the evaluation function for areas with oil and gas complex (4). Since these areas are defined by the same scoring map, unlike private objective function for the generalized evaluation of the transformation of the vegetation on the region of the objective function for the location of the zones of deposits (POF_{GWOGC}) will be only in the values of petroleum gas producing complex. Now this is the area of color combinations and types of shading zones only within the contours of the oil and gas complex. In this case, divide the sum of the areas the contours of the same level of anthropogenic disturbance of groundwater in areas with oil and gas complex will not be on the area of the entire region, and the total area of the zones of influence of oil and gas complex. Weighted load will remain the same as in equation (3):

$$POF_{GWOGC} = f_{GWOGC1} + 3f_{GWOGC2} + 5f_{GWOGC3} + 7f_{GWOGC4} + 9f_{GWOGC5} \quad (4)$$

where f_{GWOGCi} – function of a certain level of the anthropogenic disturbance of the status of groundwater in the areas of field location, which is calculated by dividing the total area of the polygons of the level in the zones with the oil and gas complex on the total area of all zones with oil and gas complex.

And in this case f_{GWOGCi} is the sum of the areas share a certain level of the anthropogenic disturbance of the status of groundwater in areas of oil and gas

complex to the sum of the areas of all of these areas, ie, in fact the function of a certain level of the anthropogenic disturbance of the status groundwater in areas of oil gas producing complex and POF_{GWOGC} reflects the average (weighted average) assessment of human impact on groundwater in the whole areas to oil and gas facilities in the Mangystau region.

Attention is drawn to the fact that in the equations (3) and (4) will not participate variables and has specific values - the sum of all the circuits of the same color (5 samples from the table shapefile attributes for circuits with oil and gas complex (in the amount) . and the area of the region, and the total area of all zones with oil and gas complex (in the denominators) The solution of equation (3) or (4) is received only 1 result – the number that describes the average anthropogenic transformation of the status of groundwater throughout the area, or only in one of its part where the oil and gas complex is present.

Results and discussion

As the purpose of this work is incorporated to obtain the result of methodical (Admission detail assessment of anthropogenic transformation of groundwater status scale) and quantitative results – determine the contribution of the oil and gas complex in the anthropogenic transformation of the status of groundwater Mangystau region through the use of ready-made expert private environmental assessment.

Methodical result follows from the previous articles in this section, we give it more concentrated formulation.

The results of the inverse problem solution integrated environmental assessment on the basis of the detail of the finished map expert private environmental assessment of anthropogenic transformation of the status of groundwater Mangystau region

The computational process consists of two parts – obtain specific evidence in a form adapted for use in the objective function, realizing easy way to solve the inverse problem and comparing areas of different levels of anthropogenic impacts on the status of groundwater in the whole of Mangystau region of the Republic of Kazakhstan and the same level for areas with oil and gas complex in the objective functions presented in equations (3) and (4).

In accordance with the procedure simplified inverse problem solution on the basis of a comprehensive evaluation of vector shapefiles are determined by the total area of areas with the same color on the map of anthropogenic disturbance of

groundwater, reduced to a five-level scale. As detailed map of anthropogenic disturbance of groundwater status Mangystau region received the sum of squares of each of the circuits five colors that reflect the levels of anthropogenic transformation of groundwater status throughout the region and in the zones with the oil and gas complex (first and fourth rows of Table 2). Then calculated f_{GWArea_i} and POF_{GWOGC_i} (second and fifth rows of Table 2). The third stage of calculations – and getting POF_{GWArea} and POF_{GWOGC} (third and sixth row of Table 2). For a more visual representation of the extent of the impact of oil and gas complex of the state of groundwater in the seventh row of Table 2 shows the proportion of a circuit area of oil and gas complex of individual exposure levels and generally as part of the area of the region. Lines 8-11 are partial description of the calculation results of the objective functions, and 12 and 13 – the final result of the inverse problem solution (Table 2).

So, the main purpose of this work – quantification of the contribution of oil and gas complex in the anthropogenic transformation of the status of groundwater Mangystau region – has been achieved as a result of specific decisions of the new theoretical problems in the field of integrated environmental assessments. As a result of the inverse problem solution integrated environmental assessment to obtain new types of evaluations it is possible Allows you to solve practical questions of economic support for environmental activities on a particular component of the natural environment (in this case – of groundwater) the implementation of the principle of «polluter pays» by quantifying the additional contribution of oil and gas complex in anthropogenic the transformation of the status of groundwater in the Mangistau region, which is 5.78% higher than the weighted average value for all the impact factors.

The weighted average rating of anthropogenic disturbance of groundwater territory of Mangistau region with oil and gas complex was 5.51 points on a scale, which is 2.46 points more than average estimation of anthropogenic disturbance of groundwater in Mangystau region as a whole, il and gas complex creates an additional burden on the state of groundwater in excess of the average for all anthropogenic sources at 24.55%.

The resulting value shows that the impact of oil and gas complex in the state of underground water has gone beyond its specific areas, as well as all other components of the natural environment. This situation highlights the need for control methods of the organization of industrial environmental monitoring, the results of which are not usually show no exceedances of standards issues.

Table 2 – Calculation of the average contribution in the oil and gas complex anthropogenic disturbance groundwater status in Mangystau region

The degree of anthropogenic transformation	Little or no	poor	moderate	significant	Strong	Total
The total area of the zones of different levels of anthropogenic disturbance, km ²	41367	2604	39267	34800	46170	164208
Calculated value $f_{GWAreal}$, nondimensional quantity	0,252	0,016	0,239	0,212	0,281	
Estimated value $POF_{GWAreal}$, score						5,509
The total area of oil and gas complex contours within each level, km ²	0	0	280,11	3142,41	3728,73	7151,25
Estimated value of f_{GWOCCi} , dimensionless	0,000	0,000	0,039	0,439	0,521	
Estimated value POF_{GWOCC} , score						7,964
Share contour area with oil and gas complex%	0,0	0,0	0,7	9,0	8,1	17,82
The weighted average rating of anthropogenic disturbance of groundwater in Mangystau region (value $POF_{GWAreal}$), points						5,51
The weighted average rating of anthropogenic disturbance of groundwater in Mangystau region ($POF_{GWAreal}$ value),%						55,09
The weighted average rating of anthropogenic disturbance of groundwater in the Mangystau region with oil and gas complex (value POF_{GWOCC}), points						7,96
The weighted average rating of anthropogenic disturbance of groundwater in the Mangystau region with oil and gas complex (POF_{GWOCC} value),%						79,64
An additional contribution to oil and gas complex in the anthropogenic disturbance of groundwater in the Mangystau region (the result of the inverse problem solution), score						2,46
An additional contribution to oil and gas complex in the anthropogenic disturbance of groundwater in the Mangystau region (the result of the inverse problem solution)%						24,55

Conclusion

The main purpose of this work – quantification of the contribution of oil and gas complex in the anthropogenic transformation of the status of groundwater Mangystau region – has been achieved as a result of specific decisions of the new theoretical problems in the field of integrated environmental assessments. Quantification of the additional contribution of oil and gas complex in the anthropogenic transformation of the status of groundwater in the Mangystau region, which is 24.55% higher than the weighted average evaluation of the impact on all factors, requires the solution of practical problems of economic support for environmental measures implementing the principle of “the polluter pays”.

A welcome detail scale assessment of anthropogenic transformation of the status of groundwater. The basis for assessment is the detailed map of the natural protection of groundwater. The algorithm that implements a three-tier scale reception detail the degree of disturbance of groundwater (ie, the “ready” integrated environmental assessment of human impact on groundwater) to the standard five-level scale it is that the contours of each of the five levels for traditional integrated environmental assessment

will be determined by how appropriate combination of color and contour (Table. 1). The procedure for such a crossing (polygon) is implemented in the Arc GIS to produce a vector shape files, automatically storing certain areas of polygons with an indication of their belonging to the level of exposure Used for individual and environmental assessments of the generalized objective function is not understood by us in the classical mathematical sense – a criterion for comparing alternatives using different optimization methods, as well as a function that implements the purpose of the evaluation – assessment of oil and gas contribution to the anthropogenic disturbance of the natural environment.

Here optimization procedure is reduced to the average point evaluation of each of the five classes shown in the legend colors, assessed by conventional in the expert procedure a 10-point scale, where in accordance with the purpose of (the level of disturbance of the natural environment components), maximum points are assigned to the fifth class, which characterizes the maximum level of anthropogenic disturbance of the terrain.

Methods of Environmental Engineering from the standpoint of the general theory of systems and quantitative information theory made it possible

to link the completeness of the range of rating scales (quantization levels in terms of information theory) with a number of parameters (the effect of intra-bonds) by calculating the minimum number of parameters at the desired level of accuracy of the description by a simple formula of (2.2). Thus, the problem of objectification of a purely peer approaches were only in justifying the choice of the most important factors.

The large number of cartographic material, summarizing a huge variety of information, in the

form of a series of inventory and evaluation maps collected in one source – Atlas Mangystau region, determines the use of these maps for a variety of environmental challenges.

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