Factors of the Spring Waters Formation and the Evolution of Spring Areas of West Kazakhstan

Kazhmurat Maksutovich Akhmedenov, Dinmuhamed Zhumabaevich Iskaliev, Sayagul Gusmanovna Akhmedenova

West Kazakhstan Agrarian Technical University named of Zhangir Khan, Zhangir Khan Street 51, 090009, Uralsk, Republic of Kazakhstan

Abstract. An estimate of the ecological state of the springs' outlets in West Kazakhstan is given in the article. The research results and the GPS-positioning of groundwater outlets are given in the article. The analyses of foreign research of the springs have been carried out. The results of hydro-chemical and toxicological examination of 30 springs in West Kazakhstan are given in the article. A comparison of the springs parameters have been made. An estimate of the spring water chemistry formation is given in the article. The paper describes the content of cations and anions, heavy metals, oil products in hydro-geochemical samples of spring water in comparison with the sanitary standards and requirements to water quality. In some springs the MPC exceedance of cadmium and chromium has been revealed. The estimation of spring waters contamination by nitrates and the influence of various factors on its level has been accomplished. It was established that the low nitrates concentrations in water, which do not exceed the MPC are peculiar for majority of the studied springs. The "Risk factors" for the occurrence of nitrates in water are the close allocation of agricultural landscapes and the location of springs on the slopes of draws. The influence of anthropogenic factor on the condition of spring areas of the West Kazakhstan has been assessed. Three groups of springs have been distinguished according to the fracturing level of their natural state and to the character of anthropogenic impact.

[Akhmedenov K.M., Iskaliev D.Zh., Akhmedenova S.G. **Factors of the Spring Waters Formation and the Evolution of Spring Areas of West Kazakhstan.** *Life Sci J* 2014;11(2s):155-165]. (ISSN:1097-8135). http://www.lifesciencesite.com. 26

Keywords: Hydrology, hydrogeology, environmental-geochemical monitoring, natural groundwater outlets, spring, spring areas, debit, heavy metals, oil products, certification, ion composition, captureness, mineralization, anthropogenic stress.

1. Introduction

At present, the consumption of fresh water increases from year to year. This is due to many factors, such as high growth of population, industry, economy and others. Therefore, important roles in the provision of fresh water play not only the surface water. A special role plays the groundwater usage. Springs – are one of the types of groundwater egress, which hold a special place not only in nature but also in human life.

The works of Russian scientists from Moscow city, Volgograd, Saratov and Samara regions are devoted to the problem of springs [1, 2]. They state that at present time springs do not solve the water supply problems of big settlements, but they are the source of water supply in small ones[2]. Significant work was done for the assessment and certification of springs in Orenburg region by Z.T. Sivokhip and V.P. Petpischev [3, 4]. Abroad the springs and spring areas are also being actively studied. Thus, the British scientist, Mc Kay [5], has defined the regularity of spring formation in Northern Ireland. The results of springs' geochemistry research of the Utah springs and the Colorado river basin are given in the paper of the American scientist B.Kimbalt [6]. For example, European scientists, Chelmicki. W, Jokiel. P and other s[7] characterize the springs, beginning from their location to geological structure, their usage as wells, considering risk factors of contamination by nitrates. Tomaselli, M., Spitale, D., Petraglia, A. [8] studied the springs considering the environmental conditions and the flora state of springs in Trentino (Italy). Besides these works there are also the works of Lencioni, V., Marziali, L., Rossaro, B. [9] where they mention the study of 124 sources in Alps within the Italy, which were heavily or moderately polluted. There are also the works of Israeli scientists: Bruins, H. J., Z. Sherzer [10] on the degradation of springs in Arava valley due to some anthropogenic and climatic factors. The above mentioned factors indicate that the world interest to the studying of springs is rather high.

The issues on the geo-ecologic features and natural diversity of groundwater natural outlets relate to those poorly studied problems of geo-ecology and landscape geography. For example, the majority of works devoted to the natural water seepage of Caspian region have been done in practical or geological aspect, without reviewing of environmental and geographic peculiarities of springs and spring areas. Due to the combination of factors (geo-structural, climatic conditions, degree of relief dissection and other) the various conditions for the formation of natural outlets of groundwater (springs, exposal, water hollows) have been formed on the West Kazakhstan territory. Considering the complexity of development conditions, they differ in genesis, hydraulic type, conditions of water outcrop, hydro-geochemical structure and other indicators. The study of groundwater outlets has a scientific and practical interest. Investigation of natural water seepage is an integral part of hydro-geologic research program (hydro-geologic survey, water inlets check for the drinking water quality under the hydro-geochemical mapping). Unfortunately, the scientific potential, consisting in the research of hydromorphic landscapes of region, connected with the groundwater outlets is poorly used, and has mostly a minor significance in the research of various geo-systems.

The springs of West Kazakhstan are not normally distributed. The highest number of springs that are close to erosion landscapes with the big deepness of relief dissection of northern and eastern parts of West Kazakhstan within Common Syrt, Predsyrt cliff and Poduralsk plateau [11, 12]. In the flat and lowland landscapes of Precaspian lowland there are comparatively not many springs. They are located mostly along river valleys and ravine-braced net, and also within the territories with the salt-dome tectonics.

Springs – are the concentrated single outlets of groundwater, however, such unloading can be done in the form of seepage (low-yield dispersed outlets), linear or interbedding outlets, which have a certain extension, and of the group outlets (several closely adjacent sources). Formation of a spring as a form of unloading of groundwater is stipulated mainly by three reasons: erosive relief dissection, geologic-structural peculiarities of a locality, and by filtration inhomogenuity of hydrophilic rocks. Groundwater outlets are always located lower the catchment area.

In our research, we set a high value on the identification of the spring water quality, as many of them are being used by local population for drinking needs. During the field research we convinced that many springs are located in communities or near to agricultural areas, i.e. their feeding areas might be contaminated [12]. One of the research tasks was the detection of influence of various factors, including landscape conditions for springs' allocation on the contamination of their water with macro-components, heavy metals and nitrates.

2. Materials and methods. During the field period of 2012- 2013 we have detected and examined 30 springs, where 15 of them on the Common Syrt, 12 – on Poduralsk plateau, 3 – in Precaspian lowland of the West Kazakhstan.

Reconnaissance examination was conducted for the springs feeding area assessment, specifying the spring's location. Fixing of the spring on a topographic map was accomplished. Area, liable the examination on each source is 0.25 km^2. Total examination area is 300 km^2. Scope of work for the examination was fully accomplished together with the examination of flood bed, spring bolson, description of degree of peat formation, photographing (Figure 1).

A B

Figure 1. Hydraulic types of springs
A – Group of ascending springs (Egindybulak spring of Karatobe region in West Kazakhstan); B – Descending spring (spring of Inder in the Inder region of the Atyrau region)

Scope of work for springs examination is close to those for the repeated survey of water intakes of the drilled holes and includes the following: familiarization with the materials of a before accomplished examination, studying the sources arrangement, studying the compliance with the SanRaN 2.1.4.1175-02 [13], sampling, debit measurement, photo registration of an object, detection of spring coordinates by means of GPS-navigator, drafting of sketch, geologic and geomorphologic linking, making a draft copy of spring's passport. 30 springs have been examined.

A map, given in the present article has been drawn up in a system of coordinates of 1942 year, based on the reference ellipsoid of Krassovsky (Pulkovo-1942, SK-42). Geographic coordinates of springs were obtained with the help of Garmin eTrex Venture HC GPS-reciever in the international geocentric coordinate system WGS 84, based on the WGS-84 ellipsoid. Primary before taking the data from receiver the positioning format was transferred from hddd.ddddd^0 to hddd^{0}mm′ ss.s″. As the data from GPS-receiver was obtained in the international geocentric coordinate system WGS 84, for presenting them on map they were re-calculated into the map coordinate system, based on the reference ellipsoid of Krassovsky (Pulkovo-1942, SK-42). Re-calculation of coordinates was done in DNR Garmin program. The used conversion – is a 3 parametric conversion by Molodensky. GIS ArcGis 9.2 package was used as a means of maps drawing, which allows the processing and presenting the spatial information.

Table 1. Geographic coordinates of springs (as per the GPS-positioning data, WGS 84 datum)

#	Spring name	GPS	
		Latitude (N□)	Longitude (E□)
1	Wellspring # 1 in Taskala v.	51□6′19,44″	50□16′ 38,28″
2	Wellspring # 2 in Taskala v.	51□5′44,88″	50□17′24,72″
3	Wellspring # 3 in Taskala v.	51□6′3,6″	50□19′22,44″
4	Wellspring in Aktau v.	51□0′43,56″	50□10′48,72″
5	Wellspring # 1 in Krutoi v.	51□7′16,32″	50□0′23,76″
6	Wellspring # 2 in Krutoi v.	51□7′22,08″	50□2′7,8″
7	Wellspring at Bolshaya Ichka m.	51□12′21,24″	50□15′37,08″
8	Wellspring at Krasnenkoye v.	51□11′53,16″	50□19′19,2″
9	Wellspring # 1 in Tsyganovo v.	51□16′5,52″	50□27′49,32″
10	Wellspring # 2 in Tsyganovo v.	51□16′9,12″	50□27′54,72″
11	Wellspring # 3 in Tsyganovo v.	51□18′28,08″	50□28′9,48″
12	Wellspring in "Arystanova" farm	51□19′14,52″	50□32′35,16″
13	Wellspring in Sokolovka v.	51□21′10,8″	50□30′28,08″
14	Wellspring in Pavlov v.	51□28′49,44″	51□9′51,12″
15	Wellspring at Yanvartsevo v.	51□26′47,76″	52□16′0,12″
16	Wellspring Aksu (Mirgorodsky)	50□52′55,2″	53□28′49,08″
17	Wellspring «Ardak» near Poltavka v.	50□56′22,2″	53□38′53,52″
18	Wellspring «Sholak Bulak» near Belogorka v.	50□42′54″	53□35′4,92″
19	Wellspring «Tozhir» in Belogorka v.	50□41′4,56″	53□36′34,56″
20	Konyr wellspring	50□30′38,52″	53□18′45″
21	Berezovka wellspring	51□14′24,72″	53□20′48,84″
22	Dadem ata wellspring	50□42′15,12″	51□57′55,8″
23	Karakamys wellspring	51□14′43,08″	53□32′32,64″
24	Solyanka wellspring	51□15′55,8″	52□20′27,6″
25	Dadem Agash wellspring	50□53′20,76″	52□23′4,92″
26	Wellspring in Yegindykol v.	50□2′30,48″	54□3′2,16″
27	Sarkyrama wellspring	50□20′56,076″	53□37′37,416″
28	Aibas wellspring	49□8′2,4″	47□40′15,96″
29	Niyaz Aibas wellspring	49□3′21,96″	47□49′21,36″
30	Wellspring at Inder lake	48□30′49,032″	51□52′31,656″

The work on the studying of environmental state of spring waters includes the collection of analytic material and a cameral (GIS-cartographic) data processing, and also the conduction of field research, if necessary. Total capacity of database includes all springs, studied during the groundwater surveys and a data, available in the organizations and authorities. Total amount of spring in database – is 30. The basis for the analytic data was the reports as per the groundwater survey results of 1:200000 scales in territorial geologic funds. As a result of the archive materials processing, the databases that include the specified information on the springs' location, aquifers of the underground water, and chemical composition of spring water, environmental state and captureness of spring's outlets have been formed [14].

The database on the spring outlets of the underground water includes:

- Egress character (ascending, descending), debit, locality (landscape) description, age of aquifer horizon of groundwater;
- Data on cation-anion spring water analysis, data on the heavy metals content, selectively – for oil products and rare elements;
- Environmental state assessment of springs (captureness, usage degree, attendance, contamination with household waste).

Databases are formed in *.*xls* format, and then imported into *.*dbf* format.

Cartographic positioning of database is carried out in the ArcGis 9.2 medium. A topographic base M 1:25000 (work scale) was used for the generation of geo-information system. Scanning and registration of topographic base of 1:25000 work scale and geometric correction of dot-matrix images have been implemented on the first stage. Then a layer-by-layer vectorization of cross line screens, positioning of spring outlets, import of the prepared attributive database to each layer on the initial topographic base, linking of the indicative tables and maps between each other shall be carried out [15]. After the formation of database the following thematic maps for West Kazakhstan have been formed:

- "Springs" - general location of spring outlets;
- "Content of cations and anions" – a general scheme of cation-anionic content of spring water (in mg/ equivalent %), the series of thematic maps on the content of each cation and anion in spring water, in mg /l;
- "Heavy metals content" - a general scheme of Heavy metals concentration in spring water (in mcg/ equivalent %), series of thematic maps for each cation and anion content in spring water, in mg /l;
- "Oil products content" – are the thematic maps on the content of oil products in spring water (in mg/ equivalent %).

Water sampling was accomplished from all 30 springs in order to study their chemical composition and to assess their suitability for drinking purposes. The sampling for the hydro-chemical and toxicological water analysis have been done in accordance with GOST 2874-73 [16] with the use of PE-1105sampler. All springs, together with the salt composition, have been tested for the content of heavy metals - Cu, Zn, Pb, Cr, and Ni. In general, 400 l. are selected during the testing.

The biochemical indicators studies were carried out by chemical (titrimetric, gravimetric) and physical-chemical methods (photo-electric-colorimetric, electrochemical, atomic-absorptive, fluorescent) in accordance with the GOST requirements [13]. Particularly, pH have been identified as per the GOST 26449.1–85, total hardness – GOST 4151-72, mineralization and dry residue – GOST 18164–72, carbonate and hydro-carbonate-ions – GOST 23268–78, iron ions – GOST – 23268.11–78, ammonium ions – GOST – 23268.10–78, nitrate ions – GOST 23268.9–78, nitrite ions – GOST – 23268.8–78, chloride ions – GOST 23268.17–78, sulfate ions – GOST 23268.4–78, oil products – FER (Federal environmental regulations) 14.1:2:4.128–98, boron – FER 14.1:2:4.36–95, heavy metals (copper, cadmium, zinc, lead) – MP (measurement procedure) # 001–87–99.

Results were collate with the norms of GOST 17.1.2.04-77 "Indicators of state and the taxation rules of fishery water bodies" и SanRaN 3.01.070-98

"Protection of surface water from contamination" [17,18].

Chemical–analytical identification of water samples, selected in the springs, was carried out at the accredited test centre of the Scientific-Research Institute of Biotechnology and environmental management, at the West Kazakhstan Agrarian Technical University named of Zhangir Khan. It contained the following types of analyses: full chemical water analysis with the additional identification of permanganate oxidation, micro-elements identification, identification of heavy metals – Ni, Cu, Zn, Pb, Cr, Cd, identification of nitrogenous components – NH_4, NO_3, NO_2, oil products identification.

Chemical reagents corresponded to the "chemically pure" and "analytically pure" marks. Determination of chloride-ions pH was implemented by the universal ionomer using the ЭВ-74 appliance, as per the GOST 26449.1-85; a dry residue content was identified as per GOST 18164-72 "Method for identification of dry residue content". The present standard determines a weight method for determination of dry residue. Concentrations of ammonium ions, nitrate- and nitrite-ions were identified by the photocolorimetric method with the help of spectrophotometer Cary-50. The content of heavy metals was identified as per the relevant methods (MVI 001-87-99), and by the atomic-absorption spectroscopy method by means of the "Varian" appliance. Identification of oil products was implemented by the fluorimetric fluid analyzer "Fluorat-02-3M" as per the FER 14.1:2:4.128-98. For the determination of springs contamination level by heavy metals the regulatory documents of the Republic of Kazakhstan, Russia, and reference materials have been used [13, 16-19].

3. Results and discussions. The springs of Common Syrt. As a result of the research conducted in spring - summer 2012, 15 springs have been studied within the Common Syrt of West Kazakhstan region. Hydrogenous indicator (pH of water) – one of the most important water quality indicators determining the character of chemical and biological processes in water. Depending on the pH value, the rate of chemical reactions, the degree of water corrosivity, pollutants toxicity etc. can vary. A pH of Common Syrt spring water, on the average, is 7.6, and within the maximum allowable concentrations. The next indicator – general hardness. Water hardness — is a complex of chemical and physical water properties, connected with the content of dissolved salts, alkaline earth metals, mainly, calcium and magnesium. The water hardness indicators in springs varies from 0,5 to 5,5. Based on this, it is possible to state that water in all the springs except Taskalinsky 1 and 2 has the medium water hardness.

The ionic composition (salt) is individual for each spring but generally an accuracy, with the sufficient degree, is determined by Na^+, K^+, Ca^{2+}, $Mg2^+$ cations and HCO_3, SO_4^{2-}, Cl^- anions. The other ions are present in water in minor amounts; however their influence on water properties and quality is, sometimes, very high. In unleavened water bodies the calcium content significantly affects the total mineralization of water sources. The average calcium content in spring water is about 0.87 mg/l, but it is necessary to take into account the fact that there is a large difference in value. For example, the lowest calcium content was recorded in Taskalinsky 1spring water – 0.1; and the highest was in spring water near Pavlovo village – 3,146. The calcium content in drinking water does not have a standard value, but it is necessary to take into account the fact that together with the magnesium it defines the water hardness, which in its turn can influence the water taste and quality.

Magnesium, like calcium, is one of the key components defining the mineralization of freshwater and, besides, influences the water taste. Average magnesium concentration in spring water is 2, 1 mg/l. The content of magnesium in some cases exceeds the calcium content.

Chloride ions refer mainly to the basic ions of the chemical composition of natural water. chloride content of natural origin has a large fluctuation range, from milligram to tens of hundreds, and thousands of milligrams sometimes in 1 dm^3. MPC of chloride is 350 mg/dm^3. High content of chloride deteriorates the water taste. Chloride content in water of the studied places is extremely low, and does not exceed the MPC.

Sulfates – are the common components of natural water. In the studied water of the springs the sulfate content ranges from 78 to 304 mg/l. These figures indicate that all the spring waters comply with the MPC norms.

Hydrocarbonate ions appear in natural water in consequence of the dissolution of carbonic acid of limestone, containing in it. These anions are in all waters, except soft water with pH lower than 4. They dominate in freshwater sources. The pH values of the majority of natural waters are due to existence of these exactly ions in it. The indicators of these chemical elements in the studied waters of springs are range from 48 mg/l (the spring near Bolshaya Ichka mountain) to 579 mg/l (the spring near Pavlovo village). In general, a salt background of the studied sources meets all the requirements of sanitary norms and rules. The data analysis indicates a wide interval of spread in values of content elements. Such a large variation can be justified by the diverse chemical composition of aquifers, where from the water supply is performed, and by the factors, that influence the formation of chemical composition of water. The problem of the formation of chemical composition of the underground water is one of the most hard in hydrogeology, as its content is controlled by many factors and processes. Among the first, usually are the climate, relief, existence of organic matter and their derivatives (precipitation, evaporation, temperature, permeability, water exchange etc.); among secondary – are the dissolution, leaching, exchange reactions, evaporative concentration, sorption, mixing, hydrolysis etc.

In assessing the content of cations in the spring waters two parameters were considered: the sum of cations and a ratio of anions affecting the hydro-chemical class of spring waters. According to the sum of cations the spring waters can be divided into two groups: the amount of 100-400 mg / l and the amount of 500-900 mg / l. With that, the springs with a relatively low level of anions are located in the south, with a higher - mainly in the north. A weak correlation (-0.28) is observed: the higher hypsometric position of the spring, the lower the content of cations. Springs with a predominance of HCO_3-ion are concentrated mainly in the north (syrt) part of research area, and the springs with SO_4^2 - ions predominance tend to south (flat) part. With respect to the altitude-tier coordination to eluvial (automorphic) elemental geochemical landscapes tend springs dominated by HCO3-ion, and a low-lying - with a high concentration of SO42-.

Springs with the domination of HCO_{3-} ion gravitate towards the eluvial (automorphic) elemental geochemical landscapes, and springs with a high concentration of SO_4^{2-} towards the low landscapes. A weak negative correlation (-0.13) of altitude localization of spring and the amount of cations is observed. In the northern part of research area there are springs with a predominance of Na+, in the south - Ca2 +. A height-tier differentiation is not observed for cations.

Of the 15 studied springs 12 have the prevalence of chromium in comparison with the concentration of other analyzed heavy metals (Ni, Cu, Pb, Cd, Zn). In the water of one of the springs (near Krutoi village, spring #2), there is a high content of nickel and lead, and besides, there is an excess of MPC for nickel (62 times). Another anomaly spring is the spring in the "Arystanova" peasant farm (high content of zinc and copper) but within the MPC. Excess of nickel concentration (3.2 MPC) have been recorded in a spring #1 near the Tsyganovo village. Huge excesses of lead (Pb) 30 MPC, and cadmium (Cd) 100 MPC content have been recorded in the spring at Yanvartsevo village. four anomalies connected with cadmium have also been recorded: spring at Krasnenkoe village - 167 MPC, spring # 3 in Taskala - 56 MPC, spring # 1 in Tsyganovo village – 54 MPC, spring # 3 in Tsiganovo village - 52 MPC (Table 2). The highest content of oil products (0.037 mg/l) have been recorded in spring near Aktau village, the lowest (0.001-0.004 mg/l) – in springs of Krutoi village. In general, a high content of oil products was observed in big roads and communitis (Table 2).

Springs of Podural plateau. As a result of research conducted in spring - summer period of 2012-2013, there have been studied 12 springs within the Podural plateau of West Kazakhstan region. They differ both by hydro geochemical values, and due to the various landscape- typological ordination and formation of spring. Hydrogenous value (pH) plays an important role in determining the quality of water. Drinking water should have a pH within 6.5-8.5.

In the studied springs this indicator is 7.5 on an average. Spring waters are characterized mainly by weakly alkaline and alkaline conditions of geochemical medium (pH 7.28 … 8.14). Mineralization of water varies from 150 to 1202 mg / l and is 460 mg/l on an average. Oxidability characterizes the total content of reducing agents in water - organic and inorganic, contacting with oxidants.

Table 2.Toxicological values of spring water of the southern slope of Common Syrt within the West Kazakhstan

#	Name of spring	Ni	Cr	Cu	Pb	Cd	Zn	Oil products mg/l
1	Spring # 1 in Taskala v.	Not detected	0,684	0,054	Not detected	Not detected	0,0531	0,011
2	Spring # 2 in Taskala v.	Not detected	0,338	0,014	Not detected	Not detected	0,0112	0,014
3	Spring # 3 in Taskala v.	Not detected	1,102	0,0186	Not detected	0,056	0,0383	0,016
4	Spring in Aktau v.	Not detected	0,542	0,0116	Not detected	Not detected	0,0638	0,037
5	Spring # 1 in Krutoi v.	6,285	0,192	0,0226	1,82	Not detected	0,0331	0,004
6	Spring # 2 in Krutoi v.	Not detected	0,659	0,05	Not detected	Not detected	0,0164	0,001
7	Spring near Bolshaya Ichka	Not detected	0,952	0,0336	Not detected	Not detected	0,0149	0,018
8	Spring near Krasnenkoye v.	Not detected	0,296	0,007	Not detected	0,167	0,0302	0,0215
9	Spring # 1 in Tsyganovo v.	0,320	1,249	0,004	Not detected	0,054	0,028	0,011
10	Spring # 2 in Tsyganovo v.	Not detected	0,731	0,037	Not detected	Not detected	0,0624	0,011
11	Spring # 3 in Tsyganovo v.	Not detected	0,401	Не обн.	Not detected	0,052	0,0414	0,020
12	Spring in "Arystanova" farm	Not detected	Не обн.	0,2683	Not detected	Not detected	0,660	0,013
13	Spring in Sokolovka v.	Not detected	0,149	0,011	Not detected	Not detected	0,0408	0,020
14	Spring in Pavlovo v.	Not detected	0,492	0,008	Not detected	Not detected	0,207	0,020
15	Spring near Yanvartsevo v.	Not detected	Not detected	Not detected	0,855	0,11	0,074	0,013

The content of these substances in the examined samples varies within 1.2 - 4.64 mg/dm^3. Considering that the value of oxidation should not exceed 5 mg/dm^3, the studied waters contain a satisfactory amount of organic matter. As per the indicators of overall stiffness, the studied water should be referred to the stiff, as its values are within 2.42 - 11.5 dm^3. In the samples of spring water the nitrates are detected in the range of 5.17 to 6.47 mg/dm^3, the value of which do not exceed the permissible limits of MPC. The content of nitrite-ions is in the range of 0.010 to 0.246 mg/dm^3, the values of which also do not exceed the permissible MPC limits [12]. When comparing our data with the data of American scientists [20], a low level of nitrates and nitrites in spring waters of Podural plateau has been revealed.

The conducted by American scientists [20] analysis of long-term data (2001-2009) of the four springs that originate from Upper Floridan aquifer and flow into the Flint River (south-west of Georgia, USA) shows the susceptibility of the aquifer horizon and surface water to the biogenic load. Concentrations of nitrate-N ranged from 1.74 to 3.30 mg /l, and exceeded the historical levels for the Upper Floridan aquifer (0.26-1.52 mg/l). Statistical analyses show an increase of the nitrate-N concentration at the ground water outlet in the springs (n = 146 during eight years), also they speak that the concentration of nitrate-N is under the influence of dynamic interaction between the depth of underground water (an indicator of regional hydrologic conditions) and land use.

The average calcium content in spring waters is 2.3 mg/l, but it should be considered that there is a big difference in the meaning. For example, the lowest calcium content was detected in the Ardak spring's water - 0.11, and the highest – 6.08, in Solyanka spring. The calcium content in drinking water has no normative value. Magnesium, as calcium, - is one of the main components determining the mineralization of fresh water and, moreover, influences the water taste. The average concentration of magnesium in the springs water is 3.16 mg/l, the magnitude of fluctuations is from 0.97 in Tozhir spring, and up to 4.97 mg/l in Solyanka spring. The content of magnesium in some cases exceeds the calcium content. Chloride ions belong to the main ions of natural water chemical compound. MPC of chlorides is 350 mg / dm^3. High concentration of chlorides deteriorates the taste quality of water. Chloride content in water of the studied objects does not surpass the MPC.

As per the results of toxicological indicators analysis we have obtained the following values (Table 3): the content of chrome was within 0.008-1.158 mg / dm^3. It is a little higher the MPC value. Such non-regular allocation is explained by the chemical properties of this metal. Chromium ions were actively adsorbed by natural adsorbents in the sediments. Due to the migration mobility the chromium ions are actively deposited on the bottom of reservoir.

Concentrations of lead in water of the studied site were not found. In the studied samples of spring water the content of zinc ionswais on ambient level and did not exceed the MPC. The zinc content in the springs water varied within 0.002-0.0728 mg / l (Table 3).

The content of cadmium is in the range of 0.0325 to 0.0485 mg/dm^3. The results of the research have showed that the cadmium content in these waters was somewhat higher the MPC value. This can be explained by water leaching from agricultural land. According to Stiefel R., Jockel R. [21], in reservoirs cadmium is contained, preferably, in substances adsorbed on the suspended particles, and only 20-30% of it is dissolved in water. Cadmium, from the liquid phase, is binded by clay minerals and insoluble phosphates. As per the chemical properties, this metal is kin to zinc. In aqueous systems, cadmium binds with the dissolved organic substances, especially if they contain the sulfhydryl group SH. Cadmium also forms the complexes with amino acids, polysaccharides, humic acids.

Table 3. Toxicological values of spring waters of Podural plateau and the Caspian lowland within the West Kazakhstan

#	Name of spring	Ni	Cr	Cu	Pb	Cd	Zn	Oil products mg/l
1	Aksu	Not detected	0,143	0,0135	Not detected	Not detected	0,0411	0,014
2	Ardak	Not detected	0,133	0,0022	Not detected	Not detected	0,002	0,019
3	Sholak Bulak	Not detected	0,212	0,0032	Not detected	Not detected	0,0687	0,021
4	Tozhir	Not detected	0,927	0,0031	Not detected	Not detected	0,0728	0,019
5	Konyr	Not detected	0,1125	0,065	Not detected	0,0485	0,0106	Not detected
6	Berezovka	Not detected	0,008	0,002	Not detected	0,325	0,0224	Not detected
7	Dademata	Not detected	0,878	0,0025	Not detected	0,0485	0,0113	Not detected
8	Karakamys	Not detected	0,5835	0,001	Not detected	0,0405	0,0246	Not detected
9	Solyanka	Not detected	1,158	0,0195	Not detected	0,0435	0,0356	Not detected
10	Dadem-agash	Not detected	Not detected	0,062	Not detected	Not detected	0,008	Not detected
11	Egindybulak	Not detected	0,015	0,240	Not detected	Not detected	Not detected	0,008
12	Inder	Not detected	Not detected	0,190	Not detected	Not detected	Not detected	Not detected
13	Sarkyrama	Not detected	0,001	0,005	Not detected	Not detected	Not detected	Not detected
14	Niaz	Not detected	0,44	Not detected	Not detected	Not detected	0,0094	0,008
15	Aibas	Not detected	0,48	Not detected	Not detected	Not detected	0,0040	0,039

Organic decomposition products that come with the runoffs from dumps form water-soluble complexes with cadmium, which also contributes to the leaching of cadmium from sediments. Another source of contamination of agricultural land and runoffs might be the phosphate fertilizers.

The very notion of "oil products" is limited only hydrocarbon fraction, which is 70-90% of total substances that are part of oil and refined products. The ingress of oil products in natural waters is connected with sewage water and its filtration on the groundwater level. Also it is the result of antemortem and post-mortem secretions of plant and animal organisms. Oil content is uncontaminated springs is hundredths or tenths of milligrams in 1 dm^3. MPC of oil products in drinking water is 0.1 mg/l. The presence of cancerogenic hydrocarbons in water is unacceptable.

Oil products content in the studied samples of spring water ranges from 0.014 to 0.021 mg / dm^3, the results values of which do not exceed MPC values. According to these values the studied spring waters can be referred to the water bodies uncontaminated by oil products.

The carried out research has showed that the springs of Poduralsk plateau within the West Kazakhstan are characterized by the absence of nitrate pollution. Factors contributing to the nitrates concentration increase in the spring waters – are the close location of agricultural landscapes and their location on the slopes of hills. Due to the significant impact of agriculture on the underground water quality it is necessary to improve the existing methodology of assessing the performance of sanitary condition of springs [2].

Springs of the Caspian lowland.

During the field period of 2013 we have found and examined three springs in the Caspian lowland of West Kazakhstan. These are the Aibas, Niyaz springs and a spring near the Inder Lake. As per the ingress of underground water to the daylight surface the studied springs belong to rheokrens. The rheokren pours its waters on the slopes or at the base of the hills, on the slopes of river valleys or other erosive hollows. Then, it forms a relatively narrow and a quick spring-water creek, flows along the slope, and usually falls into another larger water basin. The chemical composition of spring waters is formed by deep underground and near-surface underground waters. Ground waters of the Caspian lowlands that are contained in sediments of the Quaternary System are mainly of the chloride-sodium type.

As per the literature data, the Niyaz and Aibas springs location area belongs to the Aralsor depression of Caspian lowland [22]. Groundwater levels in the watersheds are at the depth of 10-12 m, on the slopes – 8-10 m, and on the bottoms of gullies and ravines are even higher. They are in most cases are brackish or salty (mineralization of groundwaters within this area is higher than 10 g/l). As per the chemical composition – they are mainly sodium-chloride and chloride-magnesium -sodium waters.

Hydro-chemical classes of spring water form of the dominant anions and cations. According to the predominance of anions, the Niyaz and Aibas springs refer to hydrocarbonate (HCO3-). As per the dominance of cations both springs belong to natrium (Na+ K+). Thus, the Niyaz and Aibas springs of Caspian lowlands belong to hydrocarbonate natrium class. Niyaz and Aibas springs have, likely, anthropogenic origin. They are located in the analogous balks at the lower part of artificially created dams. Their formation is obviously due to the filtration of dammed water. The chemical composition of these spring waters differs in the chemistry of this sector's groundwater, which is possibly due to the leaching of the carbonate dam material from soil. This leads to the hydrocarbonate-natrium chemistry, not to the sodium chloride one.

S.A. Nikitin (1941) specified that the sodium-chloride salinization dominates in waters that are connected with the salt domes [23]. A big role in the salinization of soil and groundwater of Caspian plains play the salt domes, as per S. A. Nikitin. Salinization of the upper horizons by chloride salts, typical for solonchak solonetz, S.A. Nikitin explains by the result of raising the most mobile chloride salts in hot periods of the year.

The springs are also spread in the Inder salt dome area like the five largest salt dome landscapes of Caspian depression, near the. According to V.P. Petrishev, [24] at the northern bank of Lake Inder there are springs with mineral water, one of which – is Aschebulak – (on the north-east bank of the lake) that is used for balneotherapy. An average annual debit of sources is 78.2 l/sec., ranging within 33-144 l/sec [25]. According I.V. Golovachev [25], there are 32 springs of different debit on the north shore of Lake Inder. The total debit of all springs is 35.25 l/sec. (or 1.1 million m^3/year) on an average. The most powerful is the Aschebulak spring (22.5 l/sec.).

The spring near Inder lake, studied by us, refers to chloride (Cl-) by the prelevance of anions, and by the prelevance of cations – to natrium (Na+ K+). Thus, the spring at Lake Inder refers to sodium and chloride hydro-chemical class of springs. In the spring at Lake Inder a high content of iron (0.4 mg/l at MPC of 0.3 mg/l) is observed. The ferruginized mats have been formed under the influence of oxidation-reduction processes and microorganisms' activities at the underground water egress to the daylight surface. Although the determination of hydrogen sulfide content in the spring at the lake Inder was not carried out by us, this spring can be attributed to hydro-sulfuric by the external signs. Specific external signs of hydro-sulfuric source are: the presence of hydro-sulfuric smell and a light gray or whitish taint that appear on the land cover and the damming that contacts with the spring waters. The presence of sulfates is also an indirect evidence of hydrogen-sulphide content in spring near the Inder Lake. The sulphates concentrations in the Inder spring water is 4135 mg/dm^3, which is 8 times higher than the maximum permissible concentration. The concentration of sulphates is usually correlated with the change in the total mineralization of water. Sulfates present almost in all surface waters and are one of the major anions. The sulphate concentration in natural water is in wide ranges. In river waters and in the waters of fresh lakes the sulphate content often varies from 5-10 to 60 mg/dm^3, in rainwater - from 1 to 10 mg/dm^3. In the underground water the sulfate content is often reaches the high values. A high sulphate content impair the organoleptic properties of water and have a physiological effect on the human organism. Sulfates actively participate in a complex sulphur cycle. In the absence of oxygen, under the action of sulphate-reducing bacteria they recover to hydrogen sulphide, which are again oxidized to sulfates with the appearance of oxygen in natural water.

Summing the abovementioned, as per the spring near the Inder lake, this spring's water can be attributed to chloride-sodium hydrogen-sulfide and ferruginous type of mineral waters.

In the two of three studied springs the prevalence of chromium, compared to the concentration of other analyzed heavy metals is observed. In the Niyaz and Aibas springs an increased content of chromium is observed, but these concentrations do not exceed the permissible limits (Niyaz - 0.44 mg/dm^3, Aibas - 0.48 mg/dm^3). Also, marginal zinc content is observed in these springs, which is also within the acceptable norms. Copper has been found only in the Inder spring. Its concentration is 0.190 mg/dm^3. The highest content of oil products (0.039 mg/dm^3) has been fixed in the Aibas spring, the lowest (0.008 mg/dm^3) – in the Niyaz spring (Table 3). In general, the oil products content is on the satisfactory level.

Groups of spring areas in order of anthropogenic impact.

Human impact on the state of springs outlets in West Kazakhstan region can be assessed by selecting the groups of spring areas in order of anthropogenic impact. According to the degree of disturbance of the natural state of spring ecosystem and the nature of human impact 3 groups of natural outlets of underground water have been distinguished.

1. Spring areas, which experience an intensive anthropogenic impact. This group can be divided into two subgroups. The first subgroup includes the "roadside" springs located in close proximity to highways. Generally, such springs are captured by iron or concrete pipe, which improves the water yield, but not its quality or sanitary condition. The Akbulak and Taskalinsky 2 and 3 springs in Taskalinsky region may serve as an example of such springs area.

In most cases, there is no proper control over spring areas. The primary activities are the chemical analysis of spring water, installation of signs with a name of the spring, results of analyses and the name of organization that is responsible for maintaining the spring in optimal condition.

Anthropogenic impact on the second sub-group of springs is carried out during the construction of ponds, often in the upper or middle course of spring creeks. Predominantly small dams are constructed for livestock watering. As a result, the grass stand is trampled. Basic protecting measures – are the regular cleaning of spring, protection the area from animals.

2. The spring areas, experiencing a human-induced impact to a large extend. This group should include springs, located in the village or within a radius of 1-2 km. There is a tendency of the deterioration of sanitary conditions of such springs. The spring cleaning and repair of damming was not done. The springs, in due course, have turned into the watering place for stock. The natural vegetation of these spring areas is exposed to a significant mutation. The interesting architectural structures, the signs with a brief history of the spring, and the additional planting of the adjacent territory should be here.

3. Spring areas, experiencing a weak anthropogenic impact. Here, first of all, forest and prairie Spring areas, spring ravines and balks, and the interbedding of the underground water outlets should be mentioned. Normally, such springs do not have a damming. They usually have a nymber of additional recreational capabilities. These may include landscape picturesqueness and the non-disturbance, rich species diversity. The spring area #3 (near Krutoi v.) can be attributed to this. Absence of the anthropogenic impact, on the one hand, allows saving such areas untouched, but, on the other hand, many of them (marginal descending and ascending sources) need the regular clearings.

4. Conclusion.

Analysis of hydro-chemical classes of spring water has showed the following regional differences:

- on the Common Syrt the predominance of springs with bicarbonate content is observed within the eluvial geochemical phases, sulfate- trans accumulative and the accumulative phases. As per the cations of spring groups no landscape-geochemical phases are observed. A low mineralization level (below 1 g/l) is observed in the springs, except twj of them. It means that the water hardness is not high, which is determined by the predominance of natrium in the chemical composition of water.

- for the springs of Poduralsky plateau the conjunction with landscape- geochemical altitude steps, i.e., the influence of hydro-geological conditions on the chemical compound of spring water is more significant.

- The demonstration of the underground water outlets for the Precaspian lowland is a rare phenomenon. Two of the studied springs are connected with the shallow ground waters. The spring on the Inder Lake's bank presents a hydro-geochemical anomaly, which is due to the migration of brackish waters of quaternary aquifer through the halogenous-sulphate sediments, embedded at the northern edge of the Inder cavity.

Analysis of the spring areas formation has revealed the following regularities on the research sites:

1. Analysis of spring areas structure of Common Syrt allows the distinguishing the following types:

- Areas, resulted from the underground water rise during the formation of dams (spring # 1 in Taskala village; spring # 3 in Tsyganovo village; spring at Pavlovo village);

- Areas, formed by the springs near the lateral ravine tributaries of large ravines (springs # 2 and 3 near the Taskala village; spring # 1 near the Krutoi village, spring in Sokolovsky village);

- Big spring areas, connected with the big interbedding outlets aquifers (spring near Aktau village);

- Spring areas, resulted from the activization of gully erosion in gullies sources (spring # 2 near Krutoi village);

- Areas of the ascending springs, connected with the local tectonic rise, including salt domes (spring on Bolshaya Ichka mountain);

- Spring areas in floodplains of rivers and streams (springs # 1 and 2 near Tsyganovo v.);

- Spring areas, resulting from the drilling of aquifers (spring in the "Arystanova" farm).

2. Morphostructural features of spring areas of Podural plateau are somewhat different:

- Spring areas, resulted from dams and water reservoirs (Tozhir, Karakamys, Berezovka);

- Spring areas, related to the outlets of horizons of the underground waters , within the big ravines and balks (Sholak-Bulak, Solyanka, Aksu);

- Areas of ascending springs related to the drainage of big sand massifs (Egindykol);

- Spring areas in floodplains of rivers and streams (Dadem-Ata, Dadem-agash);

- Spring areas, resulted from the drilling of aquifers (Konyr, Ardak);

3. The spring of Precaspian lowlands is formed only by two types:

- Areas, resulted from the underground water raise at the formation of dams (Aibas, Niyaz);

- Big areas, connected with the group egresses of suprasalt aquifers, modified under the influence of the salt tectonics (spring on the Inder lake).

Analysis of the landscape -typological position has showed the following:

- only one of 15 springs of Common Syrt is situated within the eluvial elementary geochemical landscape – a spring on the eastern slope of the Bolshaya Ichka mountain, 7 springs occupy transit, 7 - accumulative (lowland) basic geochemical landscapes.

- Only one of 12 springs of Podural plateau is located within the eluvial landscape, 6 - within the trans-eluvial and trans- accumulative, 5 - in the accumulative elementary geochemical landscapes.

- Among 3 springs of Precaspian lowlands: 1 spring (on the coast of the Inder lake) is located on the accumulative, 2 springs – on the transit elementary geochemical landscapes.

In general, analyzing the structure of spring areas and the chemical composition of spring waters, the following conclusions can be made:

- The main reason of expanding of chemically non-uniform spring waters is a complex geological and geomorphologic structure of West Kazakhstan.

- within the research area, when moving from north to south, there is an increase of SO_4, Cl and Na content, which is reflected in the increase in the proportion of brackish and saline underground water outlets.

- in general, the dominance of fresh hydrocarbon classes of springs at the Common Syrt illustrates a hydrochemical zonality of groundwater in the European part of Kazakhstan.

- Within the zones of neotectonic activity the springs presenting the hydro-geochemical anomalies are distinguished (spring on the Inder lake, and the Aksu spring in Belogorsk chalk mountains);

- According to the latitudinal zonality of landscape-forming factors from north to south, the hydro-geochemical characteristics of springs water change: hydro-carbonate composition changes to the of sulfate and chloride, salinity increases, in general the number of springs reduces;

- There are differences between the hydro-geological regions: the predominance of sulphate-hydro-carbonate and natrium at the Common Syrt, and the hydro-carbonate and natrium-calcic on the Podural plateau;

- The following differentiation is observed in order of microelements content: some anomalies of

Ni, Pb at the Common Syrt in the uniform distribution of Zn, Cu, Cd, Cr.

- Identification of significant differentiation of the chemical composition of springs in West Kazakhstan allows assessing their practical and recreational value, and developing the protection measures considering the peculiarities of a particular spring.

Acknowledgements.

The article was written as part of the grant funding of the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan under the project "Development of technology and methodology of the assessment and the certification of spring waters of West Kazakhstan for their protection and sustainable use» (state registration # 0112RK00502).

Authors expresses a deep gratitude to V.P. Petrischev, Doctor of Geography, Associate professor of the Orenburg State University of the Russian Federation, and M.D.Nugmanova, the employee of the Biotechnology and Environmental Management Research Institute of the West Kazakhstan Agrarian Technical University named of Zhangir Khan for their participation in the research and for providing a large number of materials.

Corresponding Author:
Dr. Akhmedenov,
West Kazakhstan Agrarian Technical University named of Zhangir Khan, Zhangir Khan Street 51, 090009, Uralsk, Republic of Kazakhstan.

References

1. Brylev, V.A., Samus N.A. and E.N.Slavgorodskaya, 2007. Springs and rivers of Volgograd region: monography. BOKM, Volgograd, pp:198.
2. Shvets V.M., Lissenko A.B. and E.V. Popov, 2002. The springs of Moscow. Moscow, “Scientific world” publishing house, pp: 160.
3. Petrischev, V.P., 2009. Cluster differentiation of spring outlets of underground waters of South Preuralie. multidisciplinary university as the Regional Center for Education and Research. Materials of the All-Russian scientific-practical conference. Orenburg, Publishing house of Orenburg State University, pp: 1919-1924.
4. Sivohip Zh.T., 2005. The spring landscapes. Geo-ecological problems of steppe region. Edited by Chibilev A.A., corresponding member of the Russian Academy of Sciences. Ekaterinburg, Ural Department of RAS, pp: 97-116.
5. Mc Kay, 1978. Analysis of well waters of Northern Ireland. London, pp: 153.
6. Kimbalt, B., and Briant, 1981. Geochemistry of spring water of south-eastern Uinta Basin, Utah and Colorado. Washington, pp: 169.
7. Chelmicki, W., Jokiel, P., Michalczyk, Z., Moniewski, P., 2011. Distribution, discharge and regional characteristics of springs in Poland. pp: 244-256.
8. Tomaselli, M. Spitale, D., Petraglia, A. 2012. Phytosociological and ecological study of springs in Trentino (south-eastern Alps, Italy). Journal of limnology, pp: 23-53.
9. Lencioni, V., Marziali, L., Rossaro, B. 2012. Chironomids as bio-indicators of environmental quality in mountain springs. FRESHWATER, pp: 525-541.
10. Bruins, H. J., Sherzer, Z., Ginat, H., Batarseh, S., 2012. Degradation of springs in the Arava valley: anthropogenic and climatic factors. Land degradation & development, pp: 365-383.
11. Akhmedenov, K.M., Zhantassova G.M., 2011. The spring areas of West Kazakhstan region as the hydro-geological natural monuments. Geological Science of the independent Kazakhstan: achievements and prospects. Collection of articles, devoted to the 20th anniversary of the Republic of Kazakhstan Independence. Almaty, K. I. Satpaev Institute of Geological Sciences, pp: 387-391.
12. Akhmedenov, K.M., Zhantassova G.M., 2012. Comprehensive assessment of the state of spring areas "Aksu" and "Akbulak" of West Kazakhstan region. Steppes of Northern Eurasia. Proceedings of the VI International Symposium and the VIII International School-Seminar "Geo-ecological problems of the steppe regions." Orenburg, ИПК “Gasprompechat” JSC “Orenburggaspromservis”, pp: 261-264.
13. Santary Epidemiological Rules and Regulations, 2003. SanRaN #2.1.4.1175-02. “Hygienic requirements for water quality of the centralized water supply. Sanitary Protection of Sources”. Ministry of Health of the Russian Federation. Moscow, pp: 20.
14. Klimentov, P.P., 1961. Methods of hydro-geological research. State scientific and technical publishing house for Geology and subsoil protection. Moscow, pp: 390.
15. State standard. GOST 2874-73. 1982. “Drinking water. Hygienic requirements and quality control”, Moscow, pp: 20.
16. State standard. GOST 17.1.2.04-77. 1978. “Nature protection. Hydrosphere. Indices of state and regulation for valuation survey of tisnery waters”, Moscow, pp: 20.

17. Santary rules and standards for the protection of surface waters against pollution, RK SanRaN 3.01.070.98.
18. The maximum permissible concentration (MPC) of chemicals in the water of water bodies of the household and cultural and general water use. SN 2.1.5.689-98. – Moscow, Ministry of Health of the Russian Federation, 1998, pp: 129.
19. Allums, Stephanie E., Opsahl, Stephen P., Golladay, Stephen W., Hicks, David W.Conner, L. Mike Nitrate Concentrations in Springs Flowing into the Lower Flint River Basin, Georgia USA. Journal of the American water resources association, 48(3) : 423-438.
20. Stiefel R., Jockel R., 1986. Kontaminiert eStandorte. Luft und Betrieb. Wasser. - #5, Pp: 70-73.
21. Kamensky G.N., et.al, 1960. Groundwater of Caspian lowlands and their regime within the Volga and Ural rivers. Writings of the Laboratory for the hydrogeological problems named of F.P.Savarensky, Volume XXVII, Publishing house of the Academy of Sciences of the USSR, Moscow, pp: 30-31.
22. Nikitin, S.A., 1941. Types of soil salination of south-eastern part of the Caspian plains. Pochvovedenie Journal #9, pp: 15.
23. Petrischev, V.P., Chibilev A.A., Akhmedenov, K.M., Ramazanov S.K., 2011. Features of landscapes formation of Inder salt dome area. Geography and Natural Resources Journal, # 2, pp: 78-84.
24. Tychino Ya.I., 1953. Some features of thermal regime of chip bittern of the Inder Writings of the Laboratory for limnology, pp:139-147.
25. Golovachev, I.V., 2012. Karst area of Lake Inder. Geology, geography and global energy Journal, 2 (45): 7-15.

2/19/2014