A thesis submitted to the Department of Environmental Sciences and Policy of Central European University in part fulfillment of the

Degree of Master of Science

Assessment of current situation regarding uranium tailings and the role of state management in the field of Kyrgyzstan.

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Author’s declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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ABSTRACT OF THESIS submitted by:

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for the degree of Master of Science and entitled: Assessment of current situation regarding uranium tailings and the role of state management in the field of Kyrgyzstan.

Month and Year of submission: July, 2016.

Nowadays, one of the main environmental problems in Kyrgyzstan is uranium tailings. This issue started to threaten in connection with the production of uranium for military purposes for Soviet Union, when Kyrgyzstan was part of the union (from 1924 to 1991).

The biggest threats to the uranium tailings are avalanches, landslides, floods and earthquake that can trigger contamination of uranium waste, increasing the risk of radioactive radiation, as well as pollution of transboundary water resources. Most tailings contain radionuclides, heavy metals and trace elements that have negative impact to the environment and human health.

State management in the field of uranium tailings plays an important role for the sustainable development of the country. One of the possible solutions for uranium tailings is reclamation and rehabilitation. Solving this problem is one of the most difficult issues for the Government of Kyrgyzstan due to insufficient state funds.

In this regard, this thesis will assess the risk level of radioactivity which can occur cause the risk of cancer and influence the radiation level to human health through the food chain process. In addition, this paper will introduce the governmental regulation in the field of radiological safety and uranium tailings, regulatory bodies and legal framework at the national level, international regimes, and as well as current international and local projects funded by international organizations which can help for sustainable development of the country.

Keywords: uranium tailings, radioactive radiation, radionuclides, heavy metals, trace elements, state management, and sustainable development.

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1. Introduction

1.1 Background

In Kyrgyzstan the mining of uranium started in 1944 and continued until 1968 when the country was part of Soviet Union (1924 to 1991). Thereafter, the mining works were closed but the tailings of uranium production were not managed properly (Baigaziev 2011). In the Soviet period these issues did not get attention and the health of millions of people who lived in nearby the tailings were in danger. After the collapse of Soviet Union, Central Asia started to raise the issues on the adverse effects of uranium tailings and advocate the seriousness of uranium tailing as a big threat to human being and ecosystem. Until the Kyrgyz government took over the responsibility to manage the tailings, most of the tailings were left without proper repair and management. Thus, it became difficult and required huge amount of investment to neutralize uranium tailings because of limited resources and money (Baigaziev 2011).

The biggest threats to the uranium tailings in Kyrgyzstan are avalanches, landslides, floods and earthquake. These may result in contamination of uranium waste, increasing the risk of radioactive radiation, as well as pollution of transboundary water resources. In this regard, uranium waste threatens not only Kyrgyzstan but also Central Asia more broadly, because many uranium wastes tailings are in the Mailu-Suu river basin, a watershed of the Syr Darya River, which flows into Uzbekistan, Tajikistan and Kazakhstan (Moldogazieva 2010).

Nowadays most uranium tailings are in critical situations because in the Soviet period long-term measures to protect tailings were not considered at the planning state such as from the effects of natural processes (avalanches, landslides and flood) (Aidaraliev *et al.* 2016).

During mining activity amount of uranium and mining dumps were accumulated in the settlements that contain radionuclides, heavy metals and trace elements that negative impact to the environment and human health (Djenbaev *et al.* 2012).

To solve the adverse effects of uranium tailings, Kyrgyzstan needs to carry out reclamation and rehabilitation of uranium tailings. However, Kyrgyzstan does not have sufficient financial resources and does not have sufficient technical capacity to ensure the proper maintenance and rehabilitation of radioactive waste and contaminated areas. Aware of this problem, the Kyrgyzstan government regularly raises the issue of the need for priority to solve this problem at various international levels, meetings and events (Aidaraliev *et al.* 2016).

1.2 About Kyrgyzstan.

Kyrgyzstan is located in the middle of Central Asia (figure 1). The area is about 198000 km² with a population about 5,957 million people (World Bank 2015). Kyrgyzstan borders with Kazakhstan, Uzbekistan, Tajikistan and China. There are seven administrative districts (called "oblast"). The capital city of the country is Bishkek.

Kyrgyzstan is a country with mountainous region approximately 95% of the whole territory. The most part of mountains belong to the Tien Shan system. The highest peaks of Thien Shann ranges are Pik Pobeda (7, 439 m), Khan Tengri (7, 010 m) and Lenin peak (7, 134 m). Most part of mountain peaks usually cover with snow and ice. Ice is the form of glaciers. The largest glacier with 62 km long is Inylcheck glacier which is in the Central Tien Shan region. In Kyrgyzstan there are about 6.500 distinct glaciers with together hold about 650 km^3 of water (Mitchell, 2015). Among the main rivers: Naryn (535 Km), Talas, Chui and Chatkal of Kyrgyzstan, the Naryn River is the main water body and the main source of energy of the country. It contributes 73% of water resources of the Syr Darya River basin and 25% of the Central Asia (Mitchell 2015).

Political Map of Kyrgyz Republic

Figure 1 Source: www.nationsonline.org

There are about 2000 lakes beside rivers, which are contributing to watershed of Naryn River. Among them the largest one is Issyk-Kul Lake in Central Asia lies 1606 m above mean sea level.

The climate in Kyrgyzstan is continental because it is influenced my mountains and location from the ocean (Mitchell 2015). In the lowlands, in January the temperature varies between -4^0C and -6^0C and in July about 16^0C and 24^0C (Figure 2). The coldest temperature is in the mountains.

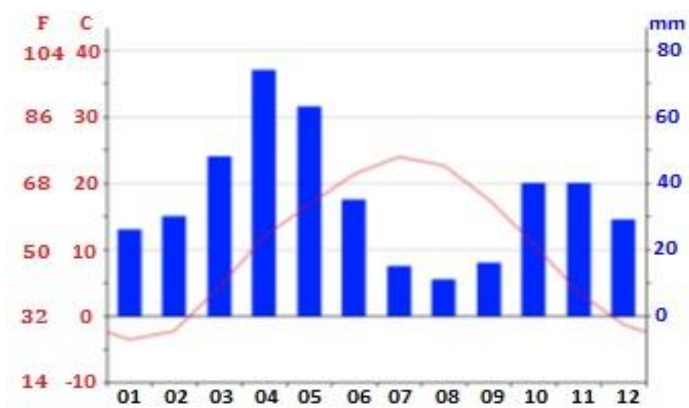


Figure 2 Source: Climate-data, 2011

"Sometimes it ranges from -30 ^{0}C to -53.6^{0}C which was record has been measured. However, generally in the mountain valleys -14^{0}C to -20^{0}C is more usual. Rainfall is generally low about 380 mm. The wettest months are March to May and October and November" (Mitchell 2015).

1.2 Aim and objectives of thesis

The main aim of this thesis is *to assess the current situation of uranium tailings and to find out the main challenges (e.g. lack of funds, lack of planning and management, gaps in national laws) of remediation.*

The objectives of the thesis are:

-To find out the risk level of radioactivity that can cause the risk of cancer and the influence of radionuclides, trace elements and heavy metals to human health through the food chain process;

-To find out weaknesses of the state management in the field of uranium tailings;
-To evaluate the type of works that have already been done since 1991 until now by the government;
-To identify the key measures and recommendations that government need to consider for solving this problem.

1.3 Structure of the thesis:

The first chapter presents background of the issues of the thesis. Background describes the situation of uranium legacy in Kyrgyzstan which begun during the period of Soviet Union and still remains unsolved. The aim and objectives of the thesis are also described in this chapter.

The second chapter describes the methodology of the thesis. The data collection and data analyses are highlighted in the methodology. The research method is based on interviews and literature review. Interviews were conducted to gather data. Moreover, the limitations of the researches are also showed in the chapter.

The third chapter presents a briefly description about mining industry in Kyrgyzstan. It also discusses the consequences of mining industry, which created amount of wastes and tailings and negative impact to the environment. Besides, this chapter presents two graphs of the process of enriched uranium and the process of construction a new tailing dump for uranium waste from 1944 to 1968, which were done by Stella program. The same chapter shows current situation of the uranium tailings and tailings that have critical situation as a threat of a dam failure due to mudflow, landslide, and earthquake.

In the fourth chapter, the author assesses the risk level of radioactivity of tailings that can cause the risk of cancer by employing the method of Djenchuraev (1999). Thereafter, the author compares the result with the findings of Arabian Gasette (2015). After assessing the risk level of radioactivity that cause the risk of cancer, the author analyses influence of radio nuclides and trace elements and heavy metals to human health through the food chain process (air, water, soil, aquatic and terrestrial organisms) by doing literature review.

The fifth chapter is based on the analyses of interviews of the governmental officials in the field of the management of uranium tailings in Kyrgyzstan and literature review of reports, national laws and international programs, which relates to the problem of uranium tailings. This chapter describes the scheme of management in the field of uranium tailings by including functional responsibilities of the state structures. Overview of legislation framework that is related to uranium tailings and works that has already been done since 1991 until now by the government are also presented in this chapter. At the end of this chapter, the author presents the analyses and findings of the main challenges of remediation, which was done according to interviews, and literature reviews.

In chapter six, the author gives the conclusion and recommendations, which can improve the current situation of uranium tailings and the state management in the field of uranium tailings in Kyrgyzstan.

2. Methods

For achieving the aims and objectives of the thesis, the research methods are based on literature review and interviews that were conducted to gather data.

2.1 Data collection:

Data was collected by the author from the primary and secondary resources. The primary resources were taken from governmental authorities and specialists by conducting interviews. The secondary resources were gathered from academic reports, books, journals, articles of scientific organization as well as legislative acts of governmental organizations. In order to come up with the conclusion, the author reviewed and analyzed the primary and secondary data.

2.2 Literature review

The review of related literature covers books, articles, reports, journals, international and national programs and different research studies that are related to uranium wastes and mining waste dumps in Kyrgyzstan. In addition, the literature reviewed includes legislative acts in the field of radiation safety, uranium tailings in Kyrgyzstan, as well as the structure and position of the state bodies directly related to the management of uranium tailings. The majority of literature was in Russian language and only a few were in English language.

2.3 Interviews

An important method of collecting information is the interview. Interview is the best technique in this kind of research in order to collect material for study and analysis because of the interchange of information that happens during an in-depth interview wherein participants can ask and answer questions simultaneously. Interviewing method is useful when the interviewee is the expert in the field and can answer the research questions objectively and confidently.

The most common interviewing method is semi-structure interview. Because it is useful for exploring planned aims and objectives. "Semi-structured interviews are conducted with a fairly open framework, which allow for focused, conversational, two-way communication. They can be used both to give and receive information" (FAO 1990).

In this thesis, the author used semi-structure interview for collecting the answers of questions of the thesis. Individual and face-to-face semi-structure interviews were conducted with the Head, deputy director and chief specialists of the Agency for the management of tailings under the Ministry of emergency situations of the Kyrgyz Republic, and with chief and leading specialists of the State Inspectorate for ecological and technical safety under the Government of the Kyrgyz Republic. A total of five interviews were conducted during the research period from 5 May to 20 May. All interviews were in Bishkek, which is the capital city of the Kyrgyz Republic.

2.4 Data analyses

Interviewees answered the questions formulated by the author. In addition to answers, interviewees also provided documentary support in the form of reports, articles, books, presentations, legislative laws and statistical data related to uranium tailings. All materials were provided in the form hard copy and electronic versions.

Data analyses includes the principles of achieving the aims and objectives of the thesis such as:

-analyses the current situation of uranium tailings by assessing the risk level of radioactivity that can cause the risk of cancer and the influence of radionuclides, trace elements and heavy metals to human health through the food chain process;

-identification the main challenges of the state management in the field of uranium tailings.

2.5 Limitations

For assessment, the risk level of radioactivity to human health that can cause the risk of cancer the main limitation was the lack of data for other tailings. This is the reason why the assessment was done only for 4 tailings as Mailu-Suu, Min-Kush, Shekaftar and Kadji-Sai.

Another limitation was the lack of interviewees for the findings and analyses on the main challenges of the state management in the field of uranium tailings. Therefore, the interviews were conducted only in the Agency for Tailings Management under the Ministry of Emergency Situations of the Kyrgyz Republic and the Department of radiological safety of the State Inspectorate for ecological and technical safety under the Government of the Kyrgyz Republic. The personal interview that the author initially intended to do in the Department of prevention of diseases and the State Sanitary and Epidemiological Surveillance of the Ministry of health was unproductive because at the time when the author was doing her research in Kyrgyzstan, the Head of Department and key specialists were in away on a business trip. Thus, the author decided to conduct a phone interview. However, the phone interview was likewise unproductive because when the author began to ask some questions related to public health in the area of uranium tailings, the Department just offered to get all the information in the Agency for tailings management at the Government of the Kyrgyz Republic. It is the author's opinion that vital information related to the assessment the risk level of radioactivity to human health could have been provided by the Department of radiological safety of the State Inspectorate for ecological and technical safety under the Government of the Kyrgyz Republic which would have been very helpful for this thesis considering the discussion on the risk level of radioactivity to human health.

3. Current situation of tailings and waste dumps

3.1Mining in Kyrgyzstan.

The main economy of Kyrgyzstan is considered as agriculture but the mining industry contributed significantly in the increment of GDP from 5% to 12% in 2005 (Ibraev 2012). At present mining industry is playing main role in the industrial production of country (CDS 2009). Mining sector has been providing employment for about 15000 workers (World Bank 2009). In the Soviet Union period, mining industry was engaged in production of mineral products like lead, mercury, antimony, rare metals and uranium (Hodkonen 2012). However, when union collapsed the deposits of minerals were abandoned. The deposits were at Kumtor (with gold deposit about 12 million ounces), Jerooy and Taldy-Bulak Levoberezhnyi (gold deposits about 3 million ounces for each). Apart from above minerals, Kyrgyzstan is rich in with other minerals. The other minerals include tin, iron, aluminum, molybdenum and rare earth metals (Hodkonen 2012). But, gold is the main mineral because it represents about 90% of volume of the country mining production (Coffey 2010) as represented in Figure 3.

Production of minerals in Kyrgyzstan from 2005 to 2011

Production	Unite of measurement	2005	2006	2007	2008	2009	2010	2011
Antimony	tonn	39.6	203.3	1702	241	918.8	842.4	892.1
Mercury	tonn	303.3	168.9	331.5	270.1	140.5	98.7	113.7
Gold	kg	16758.1	10721.1	10469.1	18132.3	16996.5	18071.6	18920.5
Coal	thousand tons	335	321	396	492	607	575	839

Figure 3 Source: Ministry of Economy of Kyrgyz Republic

For example, in 2011, the deposits as Karakazyk, Djamgyr and Ishtamberdy with gold reserves of 22 tons put into operations (Hodkonen 2012). In 2012, the deposits of Kumbel, Bozymchak and Nasonovskoye with the reserves of gold about 30.9 tons and copper about 1.517000 tons completed contractions of mines (Hodkonen 2012). Actually, amount of deposits with gold reserves are planned to put in operation in the future.

According to forecast of gold mining industry, development of mining is divided into three stages. The first three years the important ore production can lead to following mines: Kumtor, Solton-Sary, Terek-Sai, Zhamgyr, Makmal, Ishtamberdy) (Ministry of Economy of Kyrgyz Republic2013). Next stage from 2016 to 2022 about 40 tons excluding production at Kumtor and 60 tons with taking account Kumtor, the strong growth of production is projected (Ministry of Economy of Kyrgyz Republic 2013). The final stage from 2024 to 2052 was taken because of the end of extraction of Kumtor deposits (Ministry of Economy of Kyrgyz Republic 2013). (Figure 4), (Figure 5).

Key indicators of gold mining industry for periods of development (inertial scenario)

Indicator	Unit of measurement	Period of development		
		2013-2015	2016-2023	2024-52
Ore mining	Thousand tonn	22300	132009	93731
Gold in ore	tonn	60.6	418.2	205.4
Investments, total	mln.$	1179.6	2215.3	0.0

Figure 4 Source: Ministry of Economy of Kyrgyz Republic, 2013

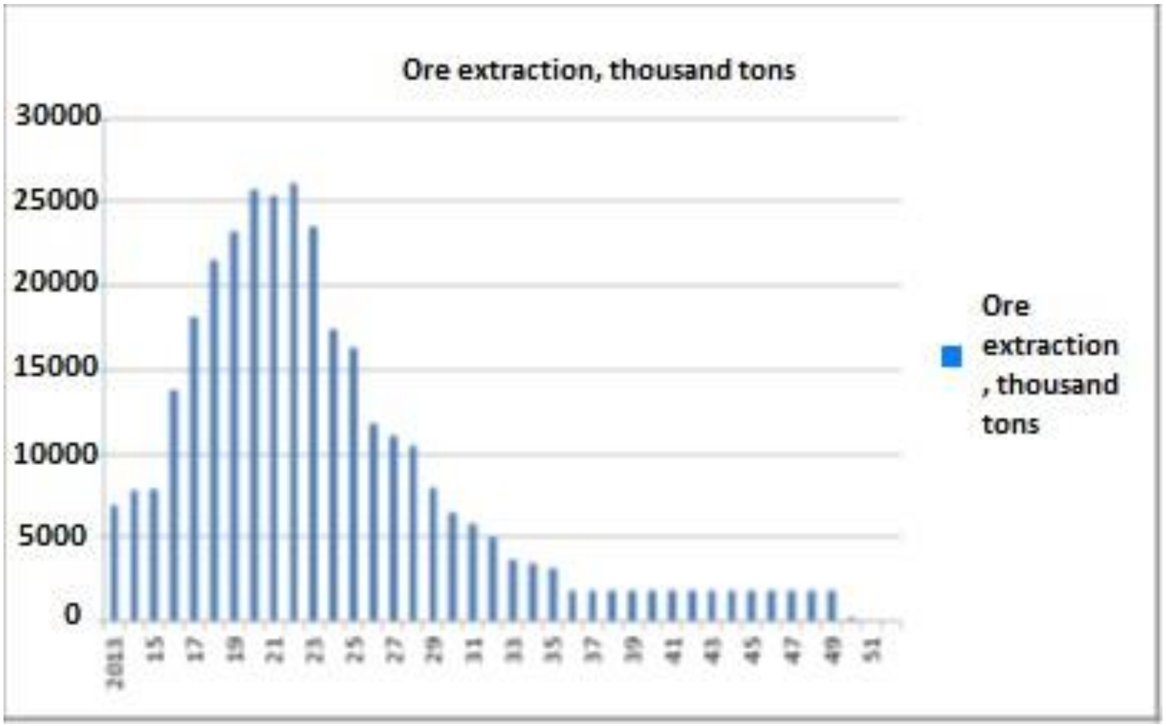


Figure 5 Source: Ministry of Economy of Kyrgyz Republic 2013

3.2 Environmental consequence of mining industry

One of the main environmental problems in Kyrgyzstan is uranium exploration, legacy of Soviet Era (Mitchell, 2015). According to information the State Cadaster of the Kyrgyz Republic there are 92 tailings and waste dumps with toxic and radioactive mining waste. In Soviet period time mining uranium activity were doing by Ministry of Medium Machine Building (Minsredmash) and Ministry of non-ferrous metallurgy (Mintsvetmet) of the USSR from 1944 to 1968 (rada.gov 2006). The main aim of mining uranium ore was for military purpose of the Soviet Union. For production of enriched uranium, the quantity of uranium wastes were increasing (Figure 6). Due to the accumulation of waste, it was required to build a new tailing dump (Figure 7).

Process of mining uranium ore and production of enriched uranium from 1944 to 1968

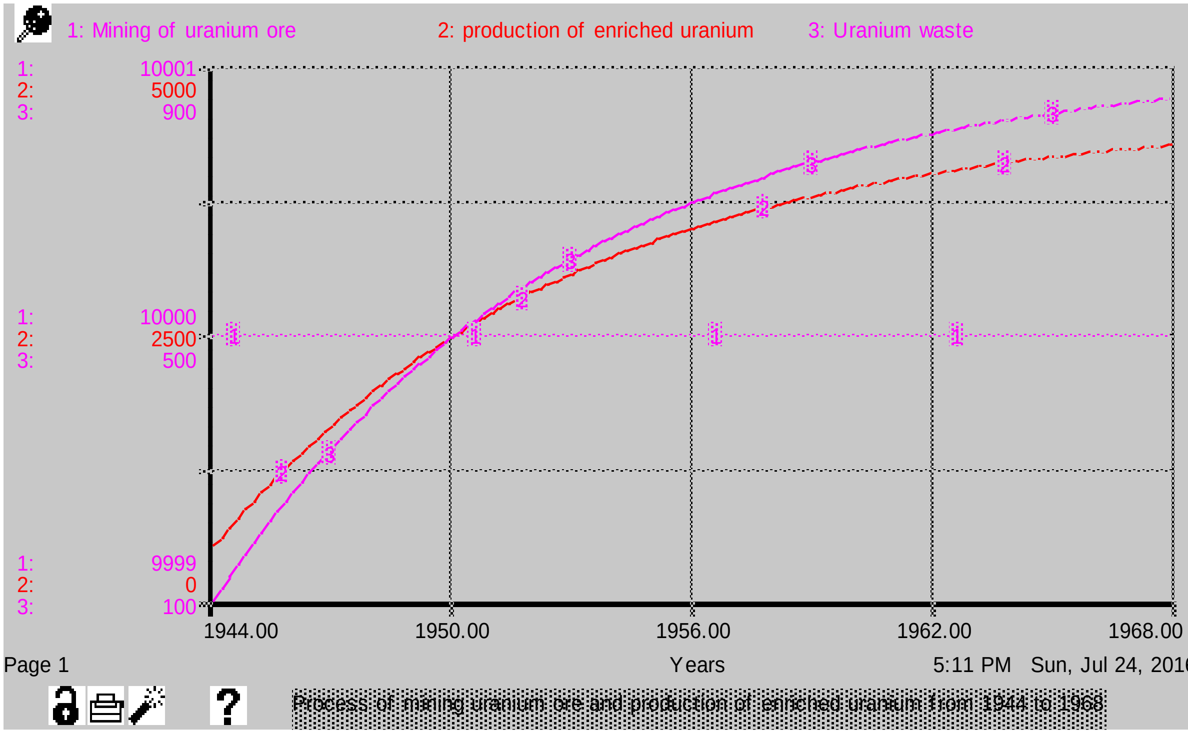


Figure 6 Source: Stella

Graphs 6, 7 were done by the Stella program. “Stella is a dynamic modeling program in which relational models are built by creating a pictorial diagram of a system and then assigning the appropriate values and functions to it” (Hirst *et al.* 2002).

The first model shows (Figure 6) the process of uranium ore and production of enriched uranium from 1944 to 1968 in Kyrgyzstan during Soviet period. For instance, it describes that the mass of mining uranium ore was about 10000 tons. Then mass were enriched in the factory for production of enriched uranium. According to the graph we can see that by the production of enriched uranium the mass of uranium waste were increasing. According to the results, the mass of the uranium waste was about 900 tons, which usually was transferred to uranium tailing.

Process of accumulation uranium waste and construction a new tailing dump from 1944 to 1968 in one uranium deposit.

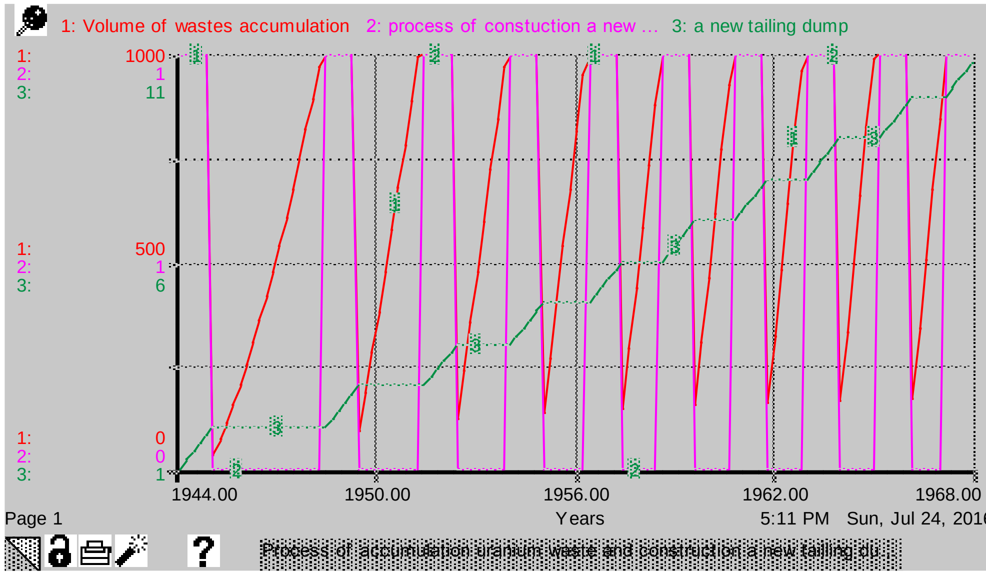


Figure 7 Source: Stella

The second model (Figure 7) shows the process of construction a new tailing dump for uranium waste. The volume of accumulation waste for each tailing was about 1000 m^3. Therefore, the volume should not exceeded 1000 m^3. Every time when the volume of uranium waste was, exceed 1000 m^3 it was required to build a new tailing dump. So, according to the table the number of uranium tailings was about 11. This model was done only for one uranium deposit, which was continued from 1944 to 1968.

Actually during soviet period about 33 uranium tailings and 25 mining dumps were accumulated on the territory of Kyrgyzstan. In the Soviet period long-term measures to protect and secure the tailings were not considered properly at the planning state (Aidaraliev *et al.* 2016). Therefore, nowadays, uranium tailings still cause the most dangerous threats to the environment.

Nowadays, there are other mining activities in Kyrgyzstan that cause big environmental concern. For example, in 1999 in the Barskoon Valley of Issyk-kul province, the Kumtor gold mining spilled toxic chemicals as cyanide in the Barskoon River (Mitchell, 2015). “After the accident, most part of cyanide were dissolved in the river and another part was transporting downstream to Issyk-Kul Lake" (Health & Consumer Protection Directorate Genera, 2007). "Smaller streams were transporting to the irrigation and small part was emitted to the air as HCN" (Health & Consumer Protection Directorate Genera, 2007). In fact, there are 230 mining facilities in Kyrgyzstan that annually produce about 600 million m^3 toxic waste (Mitchell, 2015).

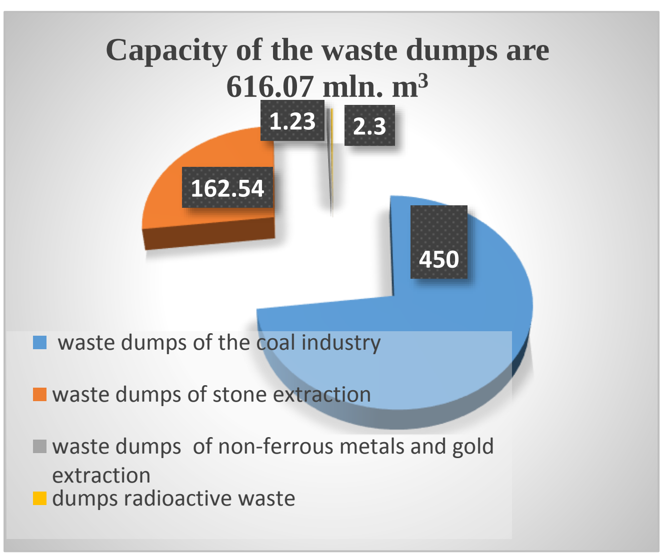
In Kyrgyzstan, there are some mining industry areas with critical environmental conditions. There are Mailuu-Suu-Koktashskyi, Sumsar-Shekaftarskyi, Aktuz-Keminskyi, Kadamjai, Khaidarkan, Kadjisai-Segutynskyi, Min-Kush and Sovet settlemet. (Torgoev and Aleshin, 2009). The environmental critical situation caused by human-made impact as underground mining and processing of uranium-containing ores, coal, open development of non-metallic materials (lead, zinc, copper) and downhole oil production (Torgoev and Aleshin 2009). Consequences of mining industry from these areas led to disruption of the natural landscape, contamination uranium dumps, pollution air by Radon (Ra), pollution soil, pollution surface and ground water by radionuclides, heavy metals and trace metals and as well excess of natural background radiation in 10-100 times in some local areas (Torgoev and Aleshin 2009). Besides there is a high risk of physical destruction of uranium tailings and waste dumps with possible earthquakes, landslides, mudflows, and abnormal weather condition with a direct hit of radioactive wastes in Transboundary River (Torgoev and Aleshin 2009).

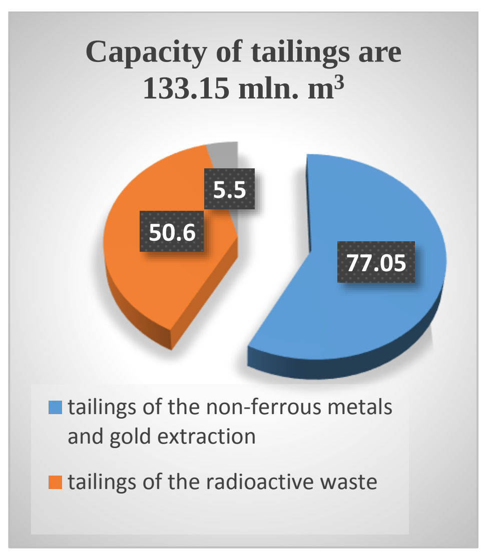
In Kyrgyzstan about 60 thousand people live in critical environmental situation (Torgoev and Aleshin 2009). According to studies done by World Economic Forum (Switzerland), Kyrgyzstan is in the list of environmentally unsustainable countries and ranks 98th place out of 122 countries (Akipress). Neighboring countries such as Kazakhstan ranks 91st place, Uzbekistan ranks 90th, and Russia ranks 93rd place (Akipress). Environmental Sustainability Index includes 5 main groups: 1) environmental system (air, soil, water): 2) degree of anthropogenic pollution: 3) institutional factor (society's ability to respond to changes): 4) human's susceptibility to environmental changes: 5) global cooperation (Torgoev and Aleshin, 2009). According to opinion of experts, the lowest place of Environmental Sustainability Index is due to poor condition of 2 components. First is environmental system (pollution of the environment) and the second one is institutional factor (imperfect environmental legislation, unconcern of population, corruption etc. (Torgoev and Aleshin, 2009).

3.4 Current situation of waste dumps and tailings.

The intensive development of the mining activities during the last 80 years in Kyrgytan with the aim of extracting mineral resources on the surface result in waste dumps, tailings and slag collector. Most of waste are toxic and has negative impact to the environmental condition (Torgoev and Aleshin 2009).

As of January of 2008, the capacity of waste dumps are about 700 mln. m^3 (figure7) with an occupied area of about 1500 ha. Additionally, there are 55 tailings with an occupied area of about 770 ha (figure8), and has the capacity of about 132 mln. m^3 tailings (Torgoev and Aleshin 2009).





Figures 7, 8. Source: Torgoev and Aleshin 2009

Nowadays, the situation of most tailings is critical. The dam stability of tailings is destructive condition. During the construction, long-term protection measures from natural process (landslides and floods) were not taken into account (Aidaraliev et. al 2016). Thus, there is a high risk to face with environmental catastrophes. From a radiological point of view, the most problematic is tailings of radioactive waste, such as Mailuusuu, Min-Kush, Shekaftar, Kadjy-Sai, Kara-Balta and the rare earth dumps as Orlovka, Kashka and Aktuz.

Ideal geomembrane for tailings

Figure 9 Source: gamma-flex.ru

Radionuclides naturally reach the environment through landslides, floods and earthquakes. However, when the dam was built without covering the bottom of tailing by geomembrane (Figure 9) (Aidaraliev et al, 2016), the radionuclides likewise reached the environment (Aidaraliev et al, 2016). The government claimed that it was inefficient to cover the dam and the bottom of tailings by geomembrane.

Information about of tailings and waste dumps in Kyrgyz Republic

№	Name, type and location of waste storage	Total amount	the amount of closed objects	The capacity of waste (mln. m^3)	Occupied an area (thousand m^3)	Special characteristics and the possible impact on the environment
1.	Uranium tailings (Mailuu-Suu-23., Kadjy-Sai-1, Min-Kush-3, Kara-Balta -1).	28	Tailing in Kara-Balta	50,6 and in Kara-Balta with 47 mln. m^3	3300	Consist of uranium elements, which can impact to air, surface and ground water. The specific activity of Ra waste is 28220-172000

						Bk/kg, Th is 372-660 Bk/kg.
2.	Tailings of nonferrous metals and gold extraction (Sumsar-3, Kan-3, Khaidarkan-1, Ak-Tuz -4, Kadamjai -2, Orlovka – 2, Terek-Sai-3, Kazarman – 1, Kumtor -1, Solton-Sary-1, At-Djailoo -1).	22	Sumsar-3 Kant-3, Terek-Sai-2, At-Djailoo-1, Solton-Sary -1, Khaidarkan-1, Kadamjai -1	77,05	3400	Consist of toxic metals, and mercury, lead, cadmium, arsenic, cyanide. Tailing in the village of Ak-Tuz contain radionuclides of thorium.
3.	Sludge and slag collectors (Khaidarkan, Orlovka, Kadamjai, Chauwai)	5	3	5,5	about 1000	Consist of mercury, arsenic and thorium
The total amount of tailings and slag collectors		55	16	133,15	7700	
4.	Waste dumps of uranium mines (Mailuu-Suu, Min-Kush,Kyzyl-Djar)	27	27	1,23	190	Consist of mining stones with radioactivity above 1000 mkr/hour. Dumps didn’t suspended and most of them are in living zone.
5.	Waste dumps of nonferrous metals and gold industry (Khaidarkan, Kadamjai, Chawai, Terek-Sai, Ak-Tuz, Makmal, Kumtor).	22	22	162,4	3627	Doesn’t t represent any risk. Except waste from Khaidarkan mercury industry. Because there were damaged by water and wind erosion.

6.	Waste dumps of coal industry (Tegene, Abshir, Sulukta,Tash-Kumyr, Kyzyl-Kya, Kara-Suu, Kok-Jangak, Kara-Keche).	28	10 are still in active	450	10 000	Occupied big square , destroy nature landscape, and accelerate of appearing landslide
7.	Waste dumps from constriction and stone mining (Kainda, Chychkan, Ak-Olon, Kyrta-Vulga).	10	Still in active	2.3	>640	Doesn't t represent any risk.
The total amount of waste dumps		87	59	616,07	14 457	
The whole amount objects		142	75	749, 22	22 157	

Figure 9 Source: Torgoev and Aleshin 2009.

Location of tailings and waste dumps in Kyrgyz Republic

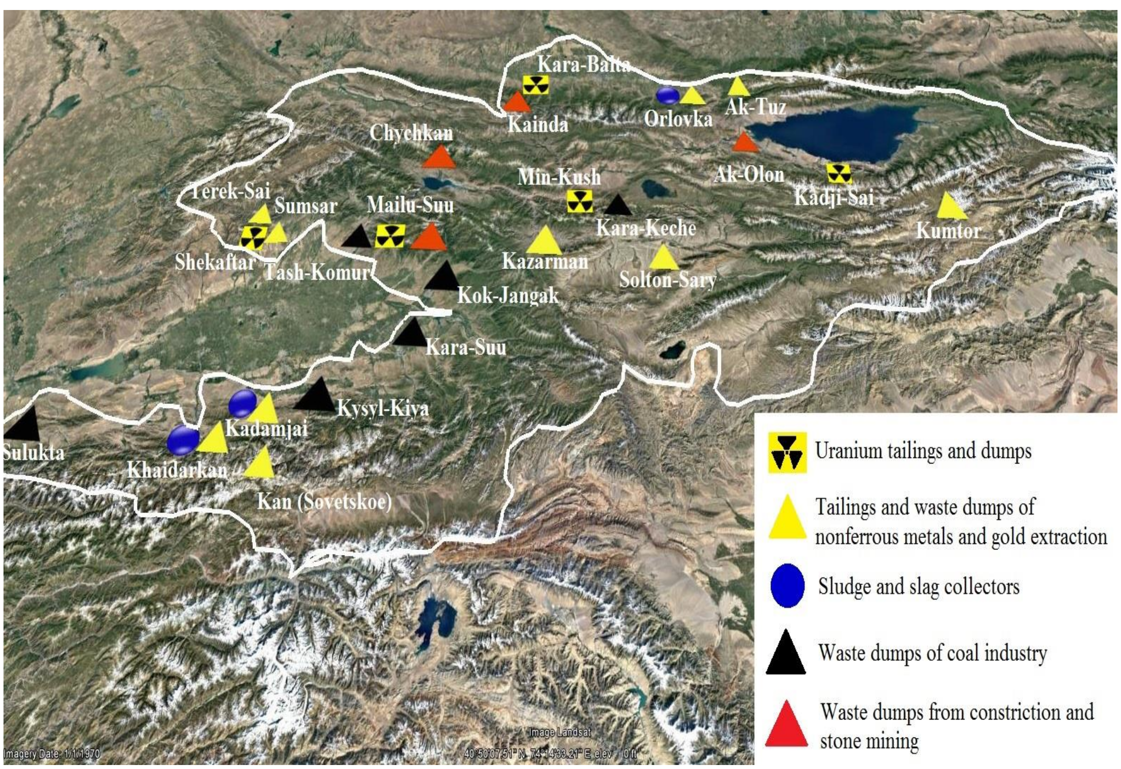


Figure 10 Source: Google Eart

As previously discussed, nowadays the most dangerous and critical situation of tailings in Kyrgyzstan are Mailu-Suu, Min-Kush, Shekaftar,Sumsar, Kadjy-Sai and Kan (Sovetskoe) areas. Most tailings are next to river basins as Naryn, Mailu-Suu, Chu, Sumsar which are connected to Transboundary Rivers. Nowadays, there is a high risk of dangerous environmental disasters, which can affect the territory of the potential contamination zone in Kyrgyzstan, Kazakhstan, Uzbekistan, Tajikistan, with 5 million inhabitants (Aidaraliev *et al.* 2016) (Figure 11, 12).

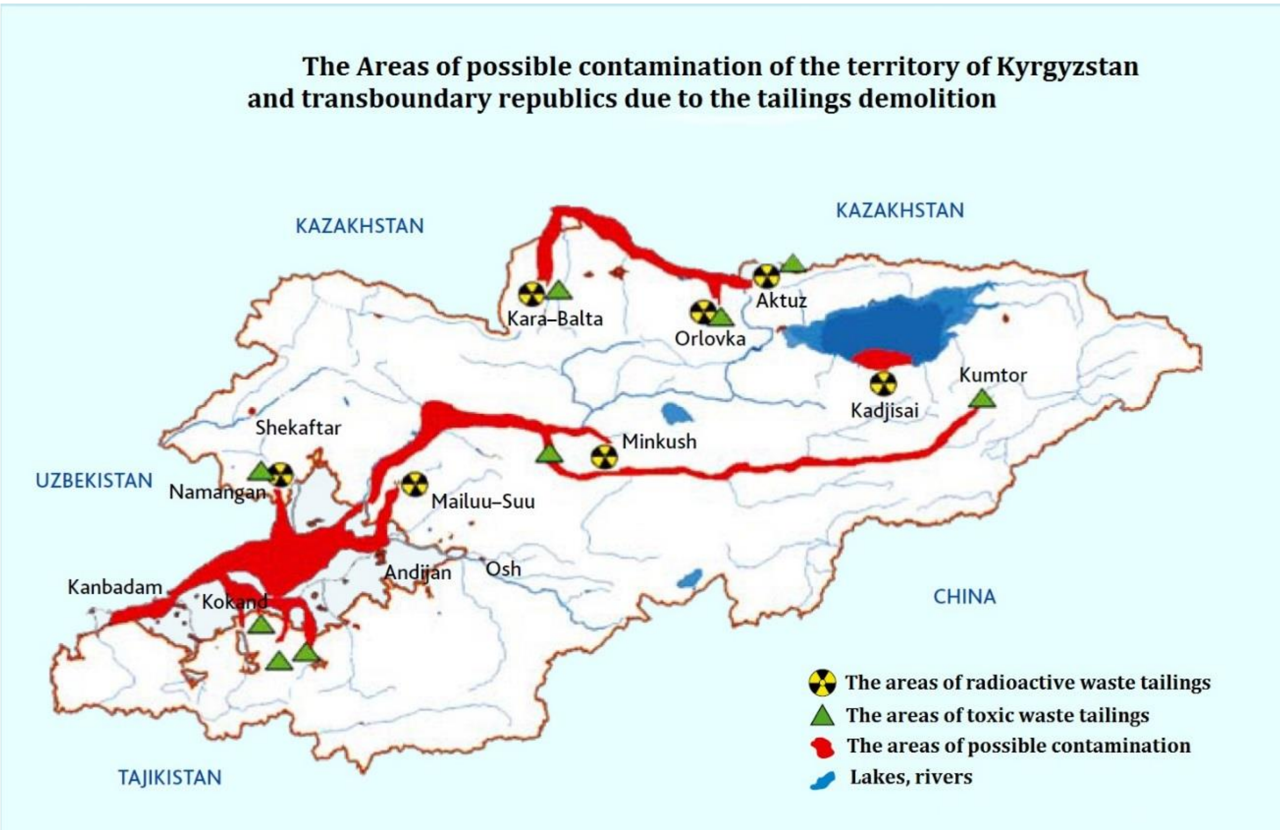


Figure 11 Source: MES2015

Possible contamination by uranium waste in Fergana valley

Figure 12 Source: Economist. com 2015

3.4.1 Mailuu-Suu uranium tailings.

Uranium tailings in Mailu-suu

Figure 13. Source: Agency for the management of tailings

Uranium deposits in Mailu-Suu settlements were worked from 1946 to 1967. During that period about 10000 ton U_3O_8 were extracted. From those results nowadays there are 23 tailings and 13 dumps in Mailu-Suu area (Aidaraliev *et al.* 2016). The total amount of waste 3 million m^3.The average rate of gamma-radiation on the surface of the tailings is 30-60 mR / hour, on anomalous areas up to 1000 mR /hour (Agency for the management of tailings in KR). The main feature of the objects in Mailu-Suu is potential dangerous of appearing landslide which can destroy of uranium tailings (Aidaraliev *et al.*2016).

3.4.2 Min-Kush uranium tailings.

Uranium deposits in Min-Kush area were worked from 1958 to 1969. Ore extraction was carried out underground mines. Nowadays there are 4 tailings ("Tuyuk Suu", "Taldy-Bulak", "Kak" and "Dalnee") in Minkush settlement. The average rate of gamma-radiation on the surface of the tailings is 20-60 mR / hour, on anomalous areas up to 1500 mR /hour (Figure 14) (Agency for the management of tailings in KR).

Three-dimensional model of radiometry measurement of tailing «Dalnee» in Min-Kush

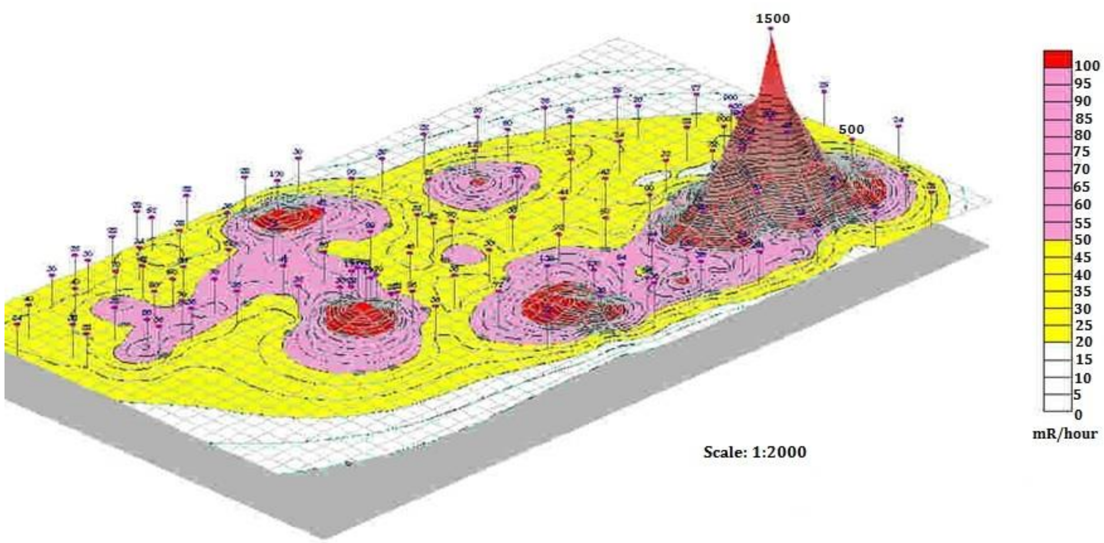


Figure 14. Source: Agency for the management of tailings in KR

Nowadays, there is a destruction of protective structures and of some parts of the surface. The most dangerous tailings are "Tuyuk Suu" and "Taldy-Bulak". Most concern makes in Tuyuk Suu tailings, where there is risk a landslide which can destroy the tailing by blockading and discharging waste material to the river (Figures 15, 16) (Agency for the management of tailings in KR).

Tuiuk-Suu uranium tailing

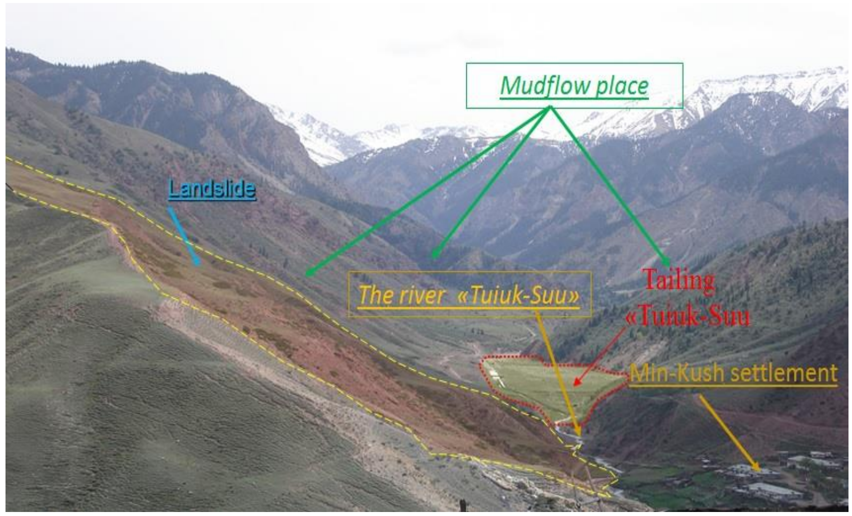


Figure 15 Source: Source: Agency for the management of tailings in KR

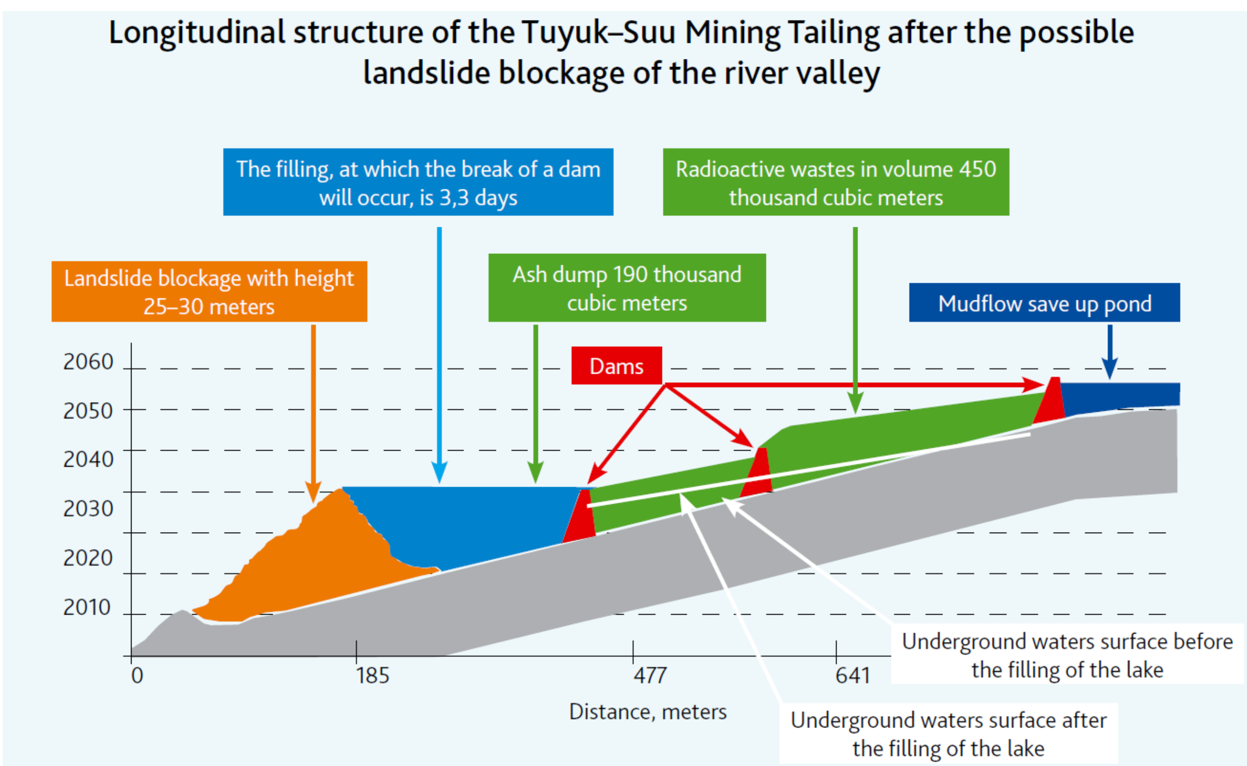


Figure 16. Source: MES, 2015

3.4.3Uranium tailing in KadjiSai

Uranium tailing in KadjiSai

Tailing in the village Kaji-Sai located in 1.5 km south of the unique lake Issyk-Kul (Figure 17). The total capacity of radioactive material tail is 150 m3. The radiation background at the surfacetailings is 30 - 60 mR / h, locally up to 1500 mR / h(Agency for the management of tailings in KR).

Figure 17.Source: Agency for the management of tailings in KR

From 1966 to 1991 the supervision and technical equipment service was doing by workers of industrial complex. In 1992 Ministry of emergency situation built the dam for prevention contamination of Lake Issyk-Kul (Aidaraliev *et al.* 2016). But nowadays the tailings dam is scouringby surface water (Figure 18).

Figure 18. Source: Agency for the management of tailings in KR

3.4.4 Uranium dumps in Shekaftar.

On the territory of the Shekaftar there are 8 uranium dumps with the capacity 700 thousand m^3. Exposure dose rate of gamma radiation is 60-150 mR / h(Agency for the management of tailings in KR). Radionuclide contaminationhappens not only the territory of the village Shekaftar, but also the territory of the Ferghana Valley (Agency for the management of tailings in KR). Dumps which are in the next to the River intensively scours by its water. The lack of vegetation on the surface of dumps promotes the development of wind erosion and scours of surface materials on the dumps.

Uranium dumps in Shekaftar.

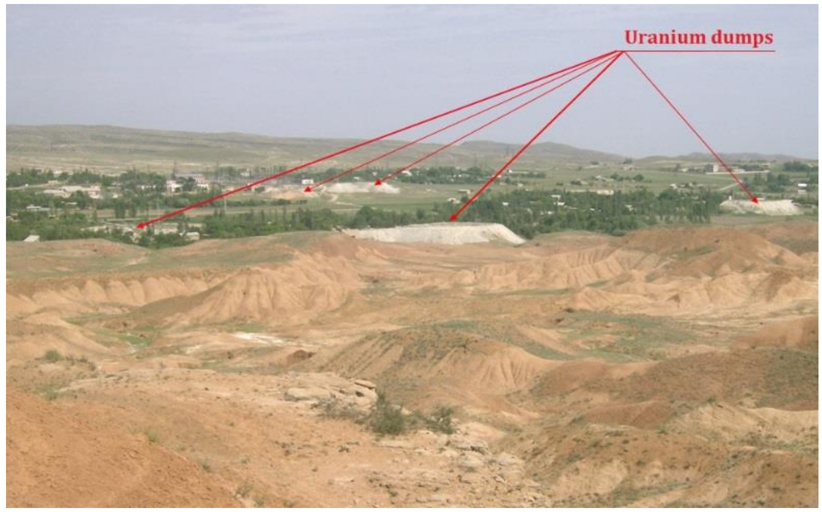


Figure 19. Source: Agency for the management of tailings in KR

In such situation, surface materials can lead of reaching the river which flows to Fergana valley (Agency for the management of tailings in KR).

3.4.5 Tailings with heavy metals in Sumsar.

Due to the mining activity from 1950 to 1978 nowadays there are 3 tailings with heavy metals with the capacity 2.65 mln. M^3 in Sumsar village (Agency for the management of tailings in KR). Hydraulic structures and the dam of tailing №1were destroyed. In the tailings №2 (Figure 20) happens intensive erosion of the dam where tailings materials usually reach the Sumsar River (Agency for the management of tailings in KR).The main pollutants is heavy metals (zinc, lead, cadmium, antimony) (Aidaraliev *et al.*

Tailing 1. In the village Sumsar

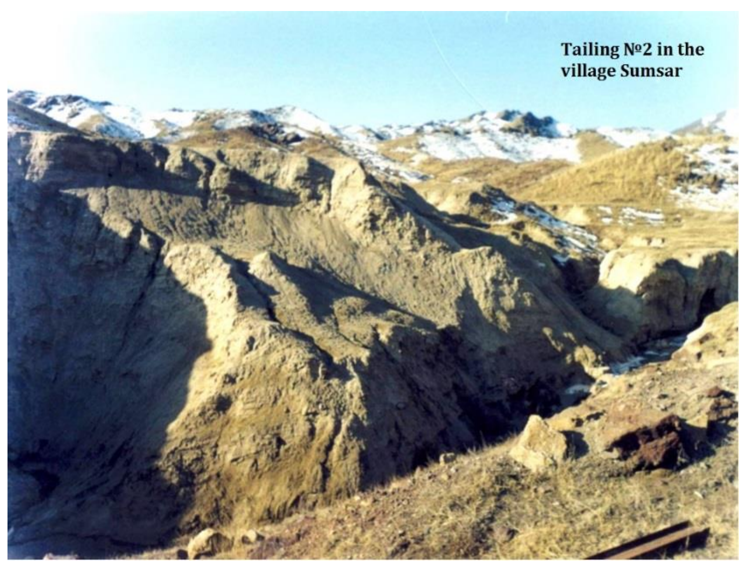


Figure 20.Source: Agency for the management of tailings in KR

2016).According to information Sanitary-epidemiological station the content of manganese in the water of the river Sumsar exceeds Maximum Allowable Concentration in 9 times, and cadmiumin 320 times (Aidaraliev *et al.* 2016).

3.4.6 Tailings with heavy metals in the village Kan.

Tailings in the village Kan

Figure 21. Source: Agency for the management of tailings in KR

During the mining operation from 1930 to 1971, there were created 2 tailings with capacity 2.5 million. m^3, which contained heavy metals (Agency for the management of tailings in KR 2015). Tailings are not closed. There is a wind erosion, erosion of tailings material and surface water contamination with heavy metal not only in the Kyrgyz Republic and the Republic of Uzbekistan. Local people use the tailings material as building materials (Agency for the management of tailings in KR).

4. Assessment the risk level of radioactivity of tailings.

4.1 Assessment of risk level of radioactivity to human health that can cause risk of cancer.

After the accident in the nuclear power plant in Chernobyl and Fukusima, people have started to be concerned about radiation dose in the soil, vegetation, air, water, wild mushrooms, wild animals, and as well as materials for building and foods (Aidaraliev *et al.* 2016). Actually, radioactive radiation is naturally present around us. It is from the sun and some radioactive elements in the water, soil, air. Natural radiation background does not have adverse effects to the human health (Aidaraliev *et al.* 2016). Natural radiation comes from cosmic radiation and natural radio nuclides which is present in the soil, water, air, food and in the organism of human and animals (Aidaraliev *et al.* 2016).

"Technogenic radiation background is a natural radiation background that changes in the result of anthropogenic activity" (Aidaraliev *et al.* 2016). Technogenic radiation connects with mining uranium, incineration of coal, oil, gas and as well as nuclear power and Nuclear Tests (Aidaraliev *et al.* 2016). The radiation from Chernobyl, which was unfortunate accident happened in 1986, affected about 134 lives which were exposed to high radiation and resulted to radiation sickness. Among those people, some died within the first three months and rest died of various causes rather than radiation exposure. From the report of UNSCEAR (2008), it was revealed that over 6000 cases suffered from thyroid cancer who were exposed to radiation during accident (UN 2012).

As of 19.02.2015 the radioactive background of Kyrgyzstan is about 22 mkR/hour (Figure 22).

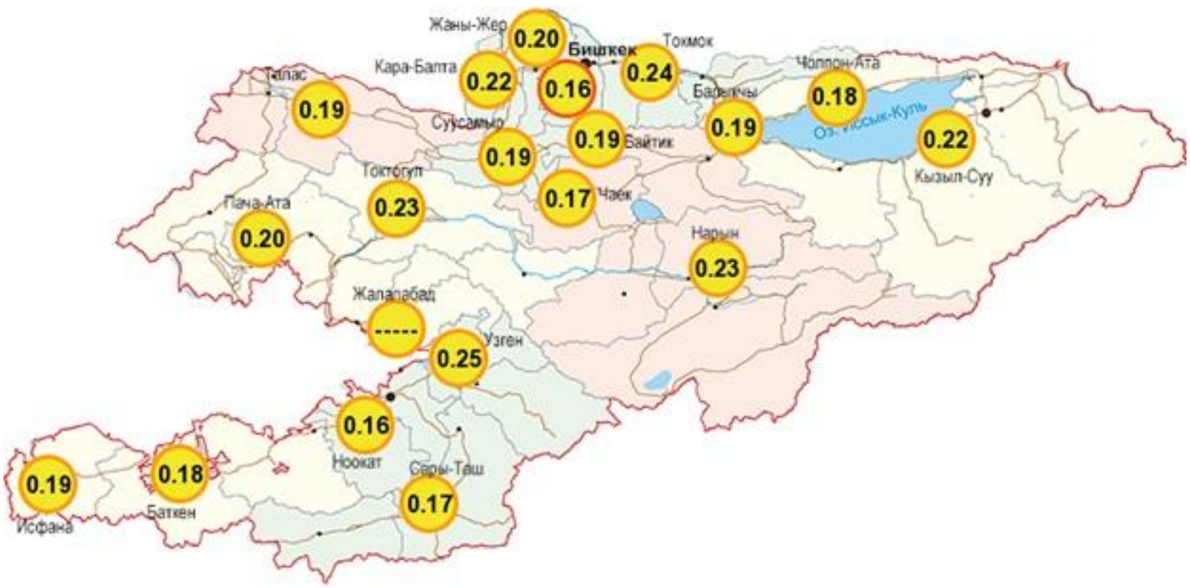


Figure 22. Source: Aidaraliev *et al.* 2016.

But the average radioactive background on the surface of tailings is about 30-60 mkR/hour, and there are anomaly spots where the radiation represents up to 1500 mR/hour. In this regard, the assessment of the risk level of radioactivity that can cause the risk of cancer will be done using the method of Djenchuraev (1999). His method was based on classifying 11 different sites as high risk, intermediate risk and low risk from anthropogenic aspect and natural aspect (mudflow, landslide, and earthquake) respectively (Figure 23). Then Djenchuraev (1999) identified the final result by cumulating the result from different aspects (Djenchuraev1999) (Figure 24).

Risks to mining hot-spots sites incurred by earthquakes

	Name of mining complex	Seismic activity, points	Risk Level
1	Mailuu-Suu	8-9	High
2	Sumsar	8-9	High
3	Shekaftar	8-9	High
4	Ak-Tyuz	9	High
5	Min-Kush	7	Intermediate
6	Kan	8-9	High
7	Kadamzhai	8-9	High
8	Khaidarkan	8-9	High
9	Kumtor	7-8	Low
10	Kadji-Sai	8	Intermediate
11	Kara-Balta	9	Low

Figure 23 Source: Djenchuraev 1999

Cumulative levels of risk arisen from anthropogenic and natural hazards

	Mining site	Level of man-induced risks	Level of landslide risks	Level of mudflows risks	Level of earthquake risks	Cumulative level of risk
1	Mailuu-Suu	High	High	High	High	High
2	Sumsar	High	Low	High	High	High
3	Shekaftar	High	Intermediate	High	High	High
4	Ak-Tyuz	Intermediate	Low	High	High	Intermediate
5	Min-Kush	Intermediate	Low	Intermediate	Intermediate	Intermediate
6	Kan	High	Low	High	High	High
7	Kadamzhai	Low	Low	High	High	Intermediate
8	Khaidarkan	Intermediate	Low	High	High	High
9	Kumtor	Low	Low	Low	Low	Low
10	Kadji-Sai	Intermediate	Low	High	Intermediate	Intermediate
11	Kara-Balta	Low	Low	No	Low	Very low

Figure 24 Source: Djenchuraev 1999

To assess the risk level of radioactivity by this method, 4 different uranium tailings sites will be studied: Mailu-Suu, Min-Kush, Shekaftar and Kadjy-Sai sites. Data of the dose of gamma radiation on the surface was taken from The Agency for the management of tailings in Kyrgyz Republic and the State Inspectorate for ecological and technical safety under the Government of the Kyrgyz Republic. To find out the risk level of radioactivity that can cause the risk of cancer, the average gamma dose and the dose of anomaly spot of tailings will be compared according to the figure 25.

Radiation effects to human health

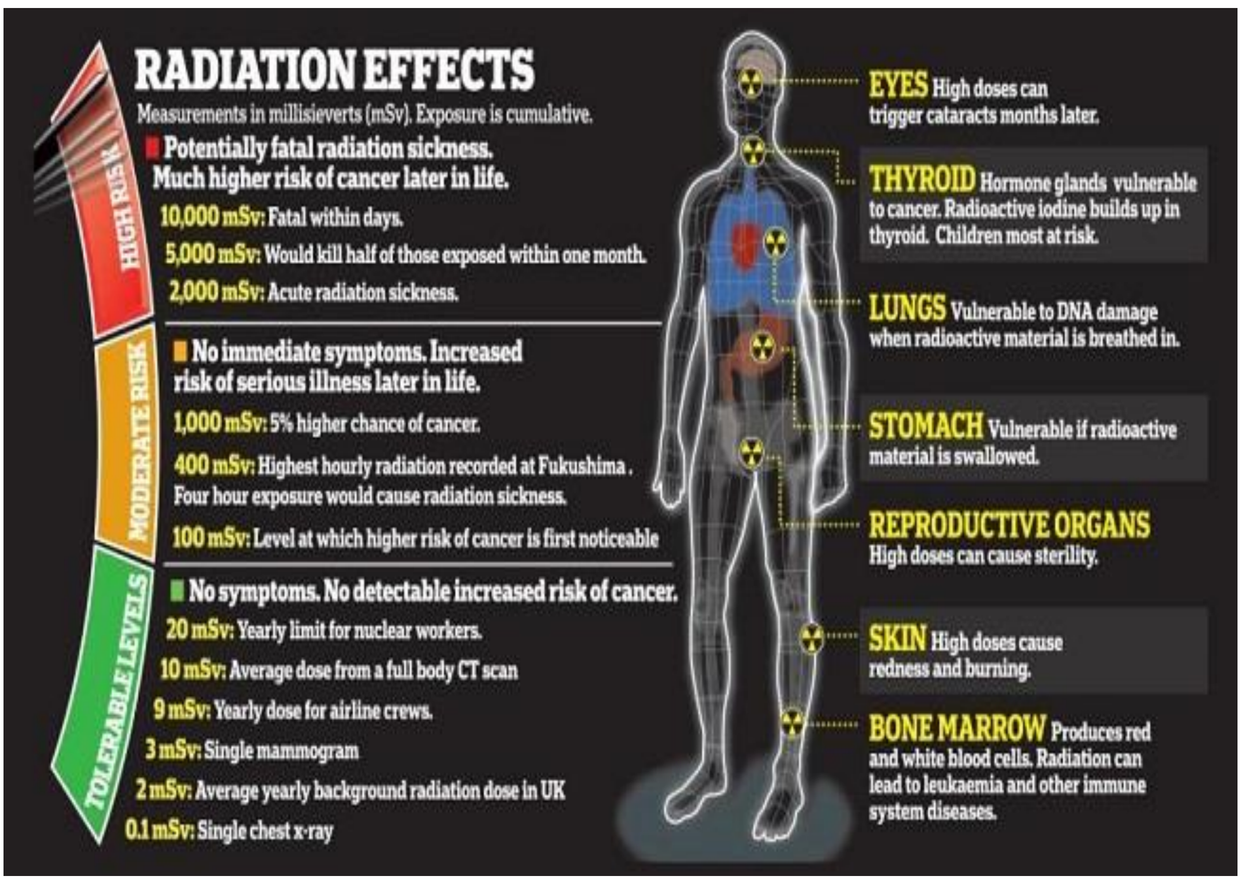


Figure 25 Source: Arabian Gasette 2015

Hence, the result of this assessment can be finalized in the following ways:

Assessment the risk level of radioactivity

Name of uranium tailings	Exposure dose of gamma radiation on the surface				Risk level of radioactivity that can cause risk of cancer (especially for adult person).
	The average dose		The dose of anomaly spot		
	mR/hour	mSv/hour	mR/hour	mSv/hour	
Mailu-Suu	30-60	0.3-0.6	1000	10	Low
Min-Kush	20-60	0.2-0.6	1500	15	Low
Shekaftar	60-100	0.6-1	150	1.5	Very low
Kadji-Sai	30-60	0.3-0.6	1500	15	Low

Figure 26. Source: The Agency for the management of tailings in Kyrgyz Republic and the State Inspectorate for ecological and technical safety under the Government of the Kyrgyz Republic

Tailings with the average and anomaly dose spot.

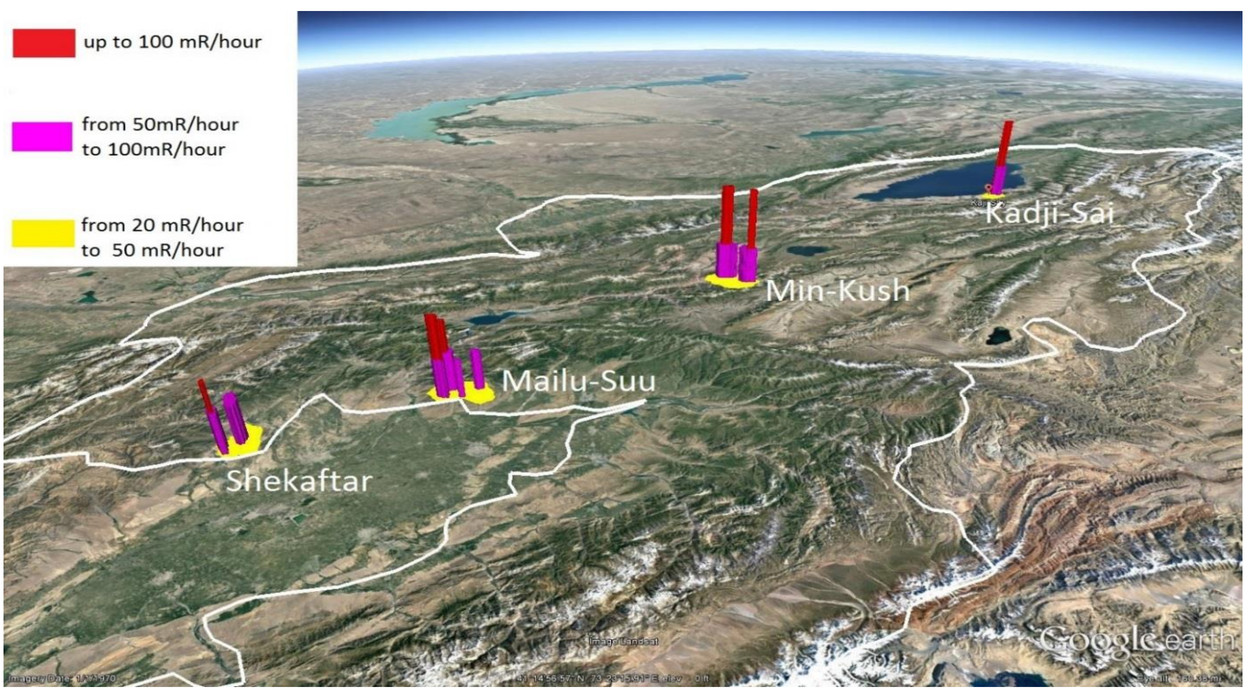


Figure 27. Source: Google earth. The measurement dose was taken from the Figure 14.

The result of this assessment according to Figure 26 shows that the risk level of radioactivity to human health that can cause the risk of cancer is low. Even if the anomaly dose spot 10-15 mSv/hour (Figure 26) were taken, it will still be equal to average dose from all body CT scan (Figure 25). In this regard, the risk of radiation level that can cause the risk of cancer to human health for adult person from 4 tailings is low. Besides, some studies which was done in Mailu- Suu, Kadji-Say and Min-Kush says that "there is a negative correlation (-0,729) between average expected life span with sickness rate of cancerous diseases" (Moldogazieva 2010).

However, "there are positive correlation (+0,938) between radiation level and infant mortality and between (+0,938) maximum permissible discharge and general sickness rate among the people" (Moldogazieva 2010).

According to studies (Saatova *et al*. 2014) of investigating environmental pathology among children, who live in the area of tailing dumps in Mailu-Suu, can be resulted in the following ways:

"The registration of the level of congenital malformations in Mailu-Suu town was not the same range over the years. According to the maternity ward in Mailu-Suu, from 1990 to 2002, the frequency of congenital malformations in children born ranged from 2.5 to 8.17% " (Saatova *et al*. 2014). "Over the past 3 years (2010 to 2012), the frequency of congenital malformations of the number of births ranged from 10.15 to 5.8%" (Saatova *et al.* 2014). "The highest rate of children born with congenital malformations observed in 2010 (10.15%) (Figure 28). Besides, in 1998 and 2010 a high level of neonatal mortality due to congenital heart defects (38.5 and 62.5%, respectively)" (Saatova *et al.* 2014).

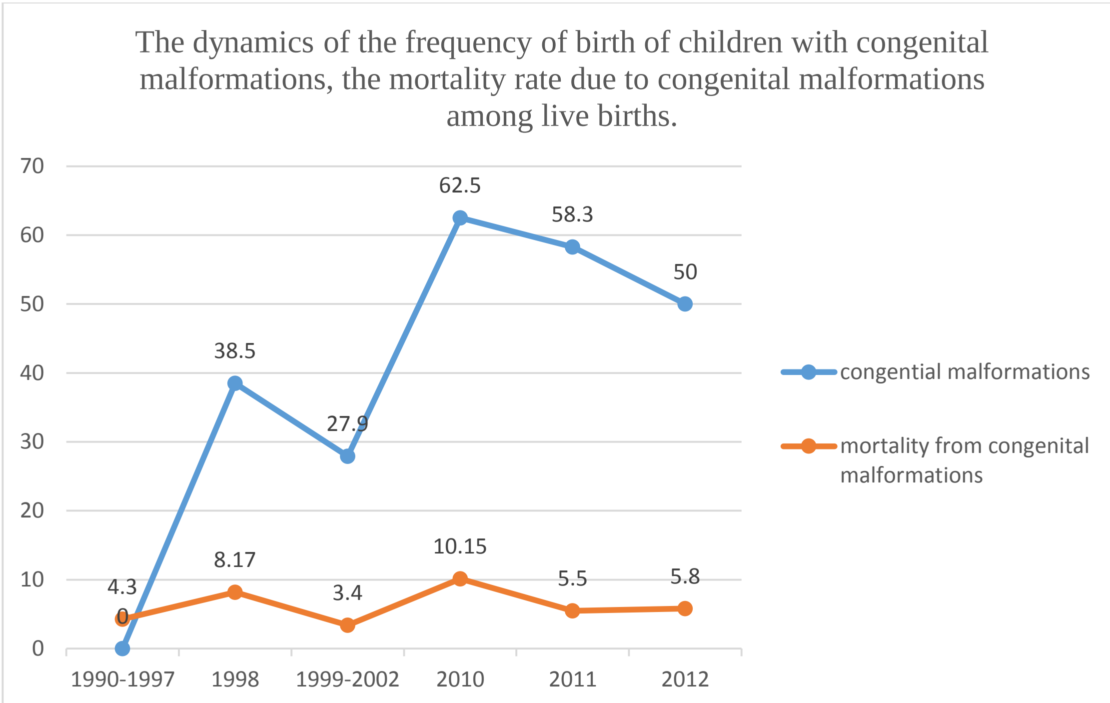


Figure 28. Source: The maternity ward in Mailu-Suu town that sited in Saatova *et al.* 2014.

"Over the past 5 years, there was a trend of reducing child mortality, while maintaining a high level of mortality of children under 1 year" (Saatova *et al*. 2014) (Figure 29).

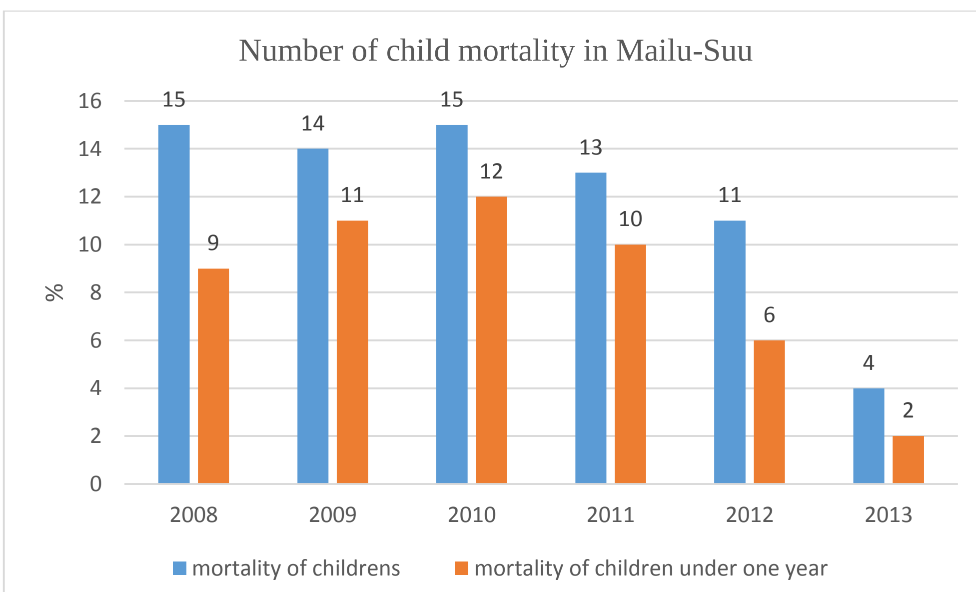


Figure 29. Source: Saatova *et al*. 2014

To find out the main reason of the risk of congenital malformations of children residents, the high level of mortality of children and general sickness rate among the people, the author of this thesis reviewed some studies which investigated radionuclides, trace elements and heavy metals that are in the water, soil, air and in aquatic as well as terrestrial organisms that can impact to human health through the food chain.

4.2 *Assessment of influences of radionuclides, trace elements and heavy metals that are in the water, soil, air and in aquatic as well as terrestrial organisms that can impact to human health through the food chain.*

“Uranium tailings are a source of radiation danger. Ensuring the safety of such facilities requires an understanding of exposure of radiation from tailings” (Aidaraliev *et al.* 2016). A large amount of radioactive waste can cause radioactive pollution that adversely affects not only the environment but also living organisms (Aidaraliev *et al.* 2016).

“Tailings are a set of special buildings and equipment intended for the storage or disposal of radioactive, toxic and other waste dump of the mining processing industry” (Bellona 2003).

Generally, radioactive wastes consist of naturally appearing radionuclides, heavy metals and trace metals.

”**Radionuclides** is the group of atoms with radioactive properties, with a certain mass number, atomic number and energy of the nucleus status” (Okeydoc 2016).

Radiation toxicity radionuclides are divided into 4 categories:

“A - the most highly toxic to humans. They have a relatively long half-lives. Also, these radioactive substances tend to accumulate in different organs of the body; B - highly toxic radionuclides; C - average toxicity radioisotopes; D - radiation isotopes of low toxicity” (Okeydoc 2016).

Scheme of spreading of radioactive substances in the environment

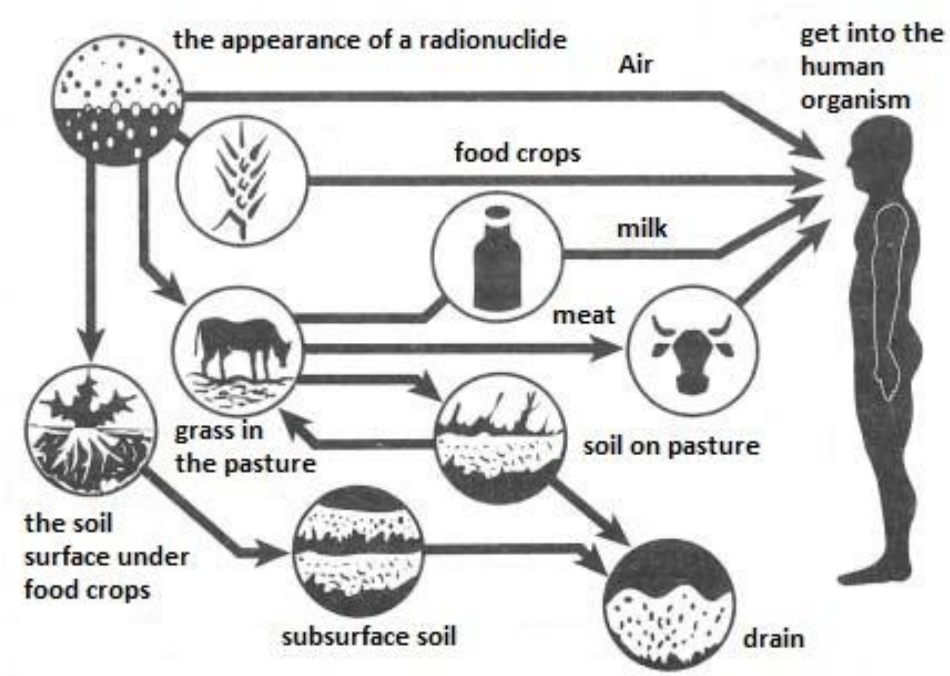


Figure 30. Source: Okeydoc, 2016

"**Heavy metals** as Pb, Zn, Fe, Cd, Cr and others are among the highly toxic pollutants. The sources of heavy metals are rocks, igneous, sedimentary, and rock-forming minerals. Heavy metals come in the biosphere because of human-made emissions. Emissions usually spread at high temperature processes in the steel, non-ferrous metals and combustion of fossil fuel. Also, heavy metals thrown out from mines and metallurgical enterprises through the water and air currents. Some human-made emissions of heavy metals carried over a considerable distance and cause global pollution. Getting on the surface of the soil, heavy metals accumulate in the soil mass. They slowly removed by leaching plants consumption. The half-life of heavy metal (from initial concentration) takes a substantial period of time" (Aidaraliev*et al.* 2016).

Zn – from 70 to 510 years

Cd – from 13 to 110 years

Cu - from 310 to 1500 years

Pb - from 770 to 5900 years

“Trace elements is a group of chemical elements (rubidium, cadmium, scandium, gallium, indium, thallium, germanium, hafnium, vanadium, selenium, tellurium, rhenium), naturally-occurring mainly as an impurity in the various minerals and extracted simultaneously from other ores or minerals” (Mining-enc., 2008).

“Heavy metals and trace metals dangerous because they are able to bioaccumulate. Proceeding with food and fluids, they are held and accumulated in the body as a filter. The body can not break free from heavy metals, because they are strongly bound to proteins. Bioaccumulation is exacerbated in the food chain, and the organisms that are on the top of the food pyramid, have the highest dose of toxic chemicals”(Aidaraliev *et al.* 2016).

According to studies of Djenbaev *et al.* (2012) and the NATO RESCA Project in Kyrgyzstan, four tailings for assessment radiological situation were selected: Mailu- Suu, Shefkartar, Min-Kush and Kadji-Sai (Figure 31). The radiological assessment was done by measurement of gamma dose rates in air at the uranium tailing sites and by determination radionuclides from U and Th decay series in the water and soils. In Kadji-Sai, studies were done more comprehensive by investigating radionuclides and trace elements in aquatic and terrestrial environments (Salbu1*et al.*2011).

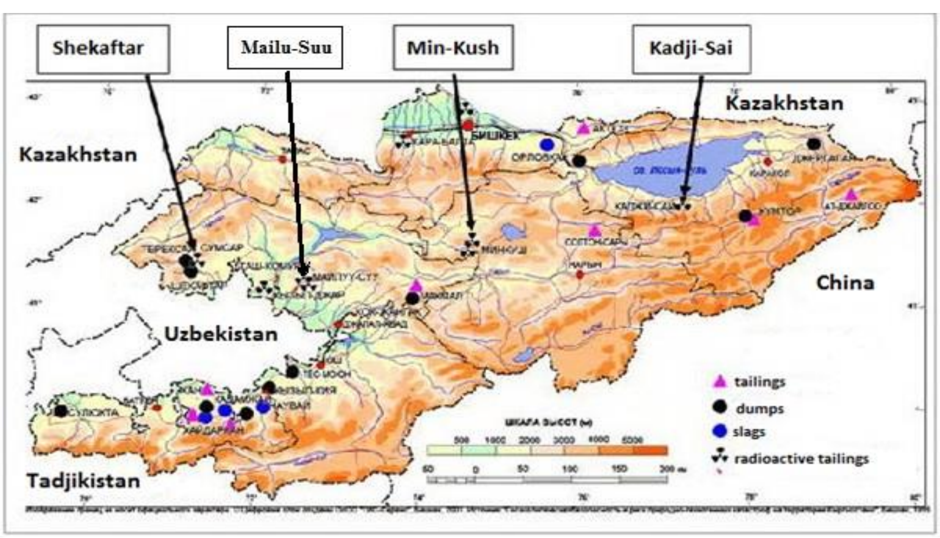


Figure 31 Source: Salbu1*et al.*2011.

4.2.1 Gamma dose rates in Shekaftar, Minkush and Kadji-Sai

Salbu1 and Stegnar stated that "The gamma radiation rate was assessed by different three radiological instruments in Shefkaftar. In the settlement of Shefkaftar radiation rates were measured ranged from 0.16 to 0.40 μGy/h" (Salbu1 *et al.* 2011) (Figure 32).

Gamma dose rates at 8 sites in Shekaftar

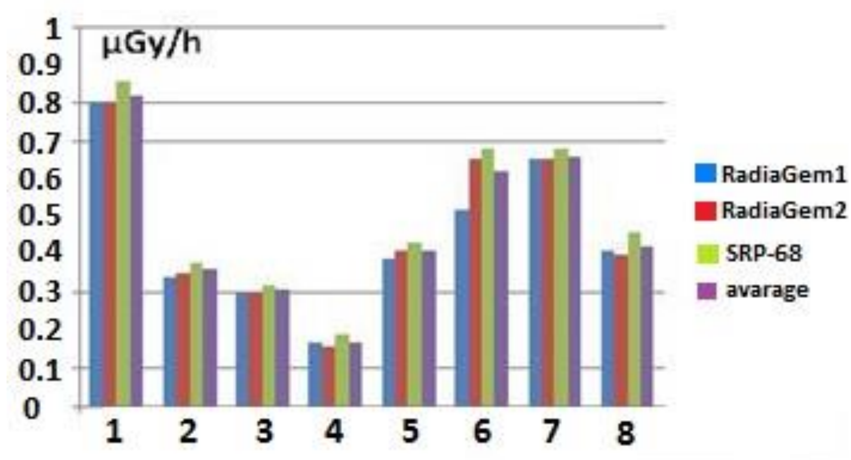


Figure 32 Source: Salbu1 *et al.* 2011.

There are four uranium production sites consist of 2 million m3 tailings. Among those sites Tuyuk-Suu tailing site is most critical and hazardous to human and ecosystem of the Minkush settlement area which lies in seismic active zone with high risk of landslide (Salbu1 et.al, 2011).

But the radiation rate of major dose are low (0.2 to 0.3 μGy/h) as compared to Shekaftar site. Similarly, outdoor Rn concentrations were low (below 10 Bq/m3) (Salbu1 *et al.*2011). It is due to the effective protective cover of the Tuyuk site but in some places eroded spots were seen where dose rates measured up to 1 μGy/h (Salbu1 et.al, 2011).

The average radiation rates at the tailings of Kadji-Sai measured from 0.3 to 0.6 μGy/h. In addition the study conducted by joint NATO and Norwegian field mission, the radiation rate at hot spots measured up to 100μGy/h (Salbu1 et.al, 2011). But in some locations those radiation rates found to be up to 15μGy/h because of consequences of human activities (Torgoev 2008; Torgoev 2009)

4.2.2 Trace metals and radionuclides in the water of Shekaftar, Mailu-Suu, Min-Kush and Kadji-Sai.

At Shekaftar, to find out the concentration levels of radio nuclides and trace metals, investigation was done in the local water supplies and various locations of the Sumsar River. From the investigation it was found that the level of U was higher in downstream of mining area than upstream area (Salbu1 *et al.*2011). This was happened because of leaching process from the deposits of waste and tailings. The concentration of ^{238}U in the Sumsar River varied from 30 mg/l near to mining area to 19 mg/l in the drinking supply areas. The concentration of ^{226}Ra found to be 38 mBq/L (figure 33) which is less than international standard for ^{226}Ra (1 Bq/L). The concentration of Uranium in drinking water is far less than recommended value by USEPA (30 μg/L) therefore water can be used for drinking purpose (Salbu1 *et al.*2011).

Concentrations of radionuclides in surface and drinking waters in the Shekaftar/Sumsar area

Source of water	Activity concentration mBq/L				μg/L
	^{238}U	^{234}U	$^{234/238}$U	^{226}Ra	^{238}U
Sumsar drainage stream	290	360	<23	<23	30
Sumsar river #1	48	85	<20	<20	3.4
Sumsar river #2	150	180	<11	<11	8.0
Drinking water	25	45	38	38	1.9

Figure 33 Source: Salbu1 *et al.* 2011.

In Mailu-Suu area the study suggested that the water of Mailu-Suu River is not suitable for drinking purpose. Because in some sections of river the concentration of trace elements such as Se which exceeds maximum allowable concentration by 23 times and Fe by 6 times. Similarly, concentration of elements such as Cd, Al, Hg, Mn and Pb were more than 2 times than its permissible value. But the concentration of Co, Ba, Zn and Ni was below permissible concentration (Djenbaev *et al.* 2012) (Figure 34).

Trace elements in the Maili-Suu river (average annual mg/kg)

Elements	MPC	Sampling point (the river) and the mean values					
		1	2	3	4	5	Σ
1. Al	0,5	0,55±0,09	1,076±0,15	0,94±0,031	1,026±0,13	1,086±0,13	0,935±0,22
2. Ba	4,0	0,068±0,01	0,009±0,001	0,024±0,003	0,088±0,012	0,102±0,012	0,074±0,068
3. Co	1,0	0,005±0,002	0,0073±0,001	0,005±0,001	0,006±0,001	0,005±0,001	0,005±0,001
4. Cu	1,0	0,004±0,001	0,007±0,002	0,005±0,001	0,008±0,002	0,008±0,001	0,006±0,001
5. Fe	0,5	0,248±0,025	0,46±0,062	0,34±0,025	2,54±0,42	3,209±0,54	2,601±1,01
6. Hg	0,005	0,01±0,003	0,01±0,001	0,01±0,002	0,01±0,002	0,01±0,002	0,01±0,001
7. Mn	0,1	0,07±0,012	0,225±0,013	0,081±0,012	0,181±0,032	0,192±0,016	0,101±0,03
8. Co	0,5	0,005±0,001	0,004±0,001	0,010±0,002	0,003±0,001	0,010±0,002	0,006±0,004
9. Ni	0,1	0,026±0,006	0,032±0,001	0,025±0,003	0,028±0,004	0,025±0,004	0,22±0,14
10. Pb	0,1	0,02±0,001	0,035±0,001	0,02±0,003	0,02±0,003	0,02±0,003	0,023±0,002
11. Se	0,001	0,023±0,005	0,02±0,003	0,023±0,02	0,02±0,004	0,023±0,005	0,021±0,001
12. V	0,1	0,007±0,001	0,011±0,002	0,006±0,001	0,008±0,001	0,006±0,001	0,007±0,001
13. Zn	1,0	0,005±0,001	0,011±0,002	0,003±0,001	0,142±0,023	0,077±0,011	0,047±0,023
14. U	0,037	0,004±0,001	0,04±0,002	0,19±0,021	0,04±0,005	0,04±0,005	0,04±0,01
15. Cd	0,001	0,002±0,001	0,002±0,000	0,002±0,001	0,002±0,000	0,002±0,000	0,002±0,0002

Figure 34 Source: Djenbaev *et al.* 2012

In the Minkush, the water was sampled and investigated from Tuyuk Suu, Minkush Rivers and the old uranium production shaft. The investigation showed the concentration of ^{238}U ranged from 8.7 to 36 µg/L and lowest concentration was found on the drainage stream from old uranium shaft. Furthermore, in drinking water samples and surface water samples the concentration of ^{238}U, ^{210}Po and ^{210}Pb levels were below permissible concentration (Salbu1 *et al.* 2011) (Figure 35).

Concentrations of radionuclides on surface and drinking waters in Minkush

Source of water	Activity concentration (mBq/L)					
	^{238}U	^{234}U	^{238}U µg/L	^{226}Ra	^{210}Po	^{210}Pb
Tuyuk-Suu river #1	440	-	36	120	n.d.	n.d.
Tuyuk-Suu river #2	300	-	25	140	n.d.	n.d.
Drainage stream at area 21	130	135	8.7	540	86	19
Water supply (area 21)	290	380	21	77	72	59
Water supply (area 20)	440	500	33	125	<50	<20
Water supply (area 16)	67	110	5.4	140	<50	<20
Min-Kush river	320	470	30	100	<50	<20

n.d. –below detection limit

Figure 35 Source: Salbu1 *et al.* 2011.

"At Kadji Sai, the ^{238}U levels of drinking water was 36 μg/L, which was lower than from three different samplings of Issyk-Kul Lake (from 43 to 63 μg/L). In this regard, the ^{238}U levels from three samplings in Issyk-Kul Lake exceed 3 times of the WHO guideline for drinking water. Besides the concentration of trace elements and As (about 16.1) were higher from accepted drinking water guideline (Figure 36)" (Salbu1 *et al.* 2011).

Concentrations of trace elements in the water of Issuk-Kul Lake

Site	As μg/L	Cr μg/L	Ni μg/L	Pb μg/L	Cu mg/L	Al mg/L	Ca mg/L	Fe mg/L	K mg/L	Mg mg/L	Mn mg/L	Zn mg/L
Issyk-Kul, beach West of Kadji Sai	14.8	2.4	5.1	0.36	<0.002	1296	150	<0.005	n/a	272	n/a	<0.03
Issyk-Kul, Kadji Sai beach	16.1	1.2	5.8	0.05	<0.002	0.03	108	0.012	65.6	231	0.001	<0.03
Issyk-Kul, beach East of Kadji Sai	15.8	1.0	5.6	0.04	<0.002	0.02	109	<0.005	65.6	235	<0.001	<0.03
Artesian well, Kadji Sai village	0.8	2.7	3.4	0.02	<0.002	<0.01	102	0.006	3.16	20.6	<0.001	<0.03
Borehole, mining site	12.7	51.2	47.7	37.7	0.018	1.44	56.8	71.9	4.33	12.3	0.507	0.09
Stream, down-stream mining site	3.0	9.6	4.6	0.19	<0.002	0.27	125	0.089	4.79	25	0.005	<0.03
Pond within mining site	3.1	2.6	4.7	0.94	<0.002	1.95	78	0.565	5.17	11.8	0.058	<0.03
WHO guideline values	10	50	70		2						0.4	
Russian and Kazakh accepted levels for drinking water	50	50	10	30	1.0	0.5		0.3			0.1	5.0

Figure 36 Source: Salbu1 *et al.* 2011.

4.2.3 Trace metals and radionuclides in the aquatic organisms of Issyk-Kul Lake.

In the lake of Issyk-Kul, examination of radio nuclides and trace metals that are present in fishes was done. The concentrations of those elements were found in different organs of fish such as gills, liver and muscle. The highest concentration of As was found in rainbow trout muscle/filet (1.53 mg/kg). Uranium was found in liver and the concentration level of Hg was below the permissible European limits of 0.5 mg/kg in the muscle of chebachok and pike perch fish (Figure 37) (Salbu1 *et al.* 2011).

Concentrations (mg/kg) of As, Cd, Mo, Pb, U-238, Th-232 in gills, liver and muscle tissue of Issyk-Kul chebachok, pike perch and rainbow trout.

Tissue	Element mg/kg	Issyk-Kul Chebachok	Pike perch	Rainbow trout
Gill	As	0.04 + 0.01 (n = 11)	0.14	0.06+0.02 (n = 4)
	Cd	0.0014+0.0005 (n = 4)		0.001+0.0005 (n = 4)
	Mo	0.01+0.002 (n = 6)	0.009	0.01+0.004 (n = 3)
	Pb	0.01+0.007 (n = 3)		0.01+0.006 (n = 4)
	U-238	0.013+0.004 (n = 11)		0.014+0.006 (n = 4)
	Th-232	0.0009+0.0008 (n = 7)		0.0017+0.0013 (n = 4)
Liver	As	0.009+0.082 (n = 12)	0.090+0.027 (n = 6)	0.147+0.04 (n = 5)
	Cd	0.001+0.007 (n = 10)	0.006+0.002 (n = 4)	0.002+0.0004 (n = 4)
	Mo	0.03+0.02 (n = 9)	0.03+0.02 (n = 6)	0.12+0.03 (n = 5)
	U-238	0.010+0.008 (n = 7)	0.003	0.006+0.002 (n = 5)
Muscle/ filet	Hg	0.062+0.02 (n = 21)	0.066+0.03 (n = 6)	0.026+0.004 (n = 6)
	As	0.33+0.19 (n = 18)	1.28+0.76 (n = 4)	1.53+0.55 (n = 5)
	Cd	0.001+0.0004 (n = 3)	0.002	
	Mo	0.01+0.004 (n = 13)	0.01+0.001 (n = 4)	0.01+0.002 (n = 4)
	Pb	0.02+0.01 (n = 8)		

Figure 37 Source: Salbu1 *et al.* 2011.

4.2.4 Trace metals and radionuclides and in soils and sediments in Shekaftar, Mailu-Suu, Min-Kush, Kadji-Sai.

The soil samples of Shekaftar and Sumsar area from eight spoil deposits were taken to assess the concentration of radio nuclides and trace metals in sediment (Salbu1 *et al.* 2011). From the field investigation it was found that the naturally occurring isotopes in soil deposits were large and can impact downstream due to surface run-off. The concentration of U and Th is presented in Figure 38 (Salbu1 *et al.* 2011).

Concentration of the U and Th series radionuclides in waste rock materials.

Sample	Activity concentration, Bq/kg					
	^{234}Th	^{226}Ra	^{210}Pb	^{230}Th	^{228}Ac	^{228}Th
Spoil heap No.2	3080	4130	1680	3370	25	5.6
Spoil heap No.3	6950	5450	2980	4390	33	7.5
Spoil heap No.4	3360	3750	2100	3410	9.0	6.1
Spoil heap No.5	3440	3530	2050	3330	34	5.2
Spoil heap No.5	8950	6610	4230	7280	56	7.9
Spoil heap No.6	66	71	62	nd	23	14
Spoil heap No.7	7300	11400	5750	11500	<10	12
Spoil heap No.8	5350	3960	1950	4220	64	13

nd: Below detection limit

Figure 38 Source: Salbu1 *et al.* 2011.

The soil samples of Mailu-Suu revealed that the soil was not contaminated much in relation to maximum permissible concentration (MPC) (Djenbaev *et al.* 2012). But the trace elements such as Al, Mn and Se were 2-3 times higher in the spring and autumn seasons. Similarly, Zn was found to be 6 times and in sub region U exceeded 10 times than MPC (Djenbaev *et al.* 2012).

The soil samples at Min Kush area were taken from rocks and coal ash insulation materials to assess the concentration of radio nuclides and trace metals in sediment (Salbu1 *et al.* 2011). The concentration of ^{226}Ra, ^{232}Th and ^{40}K exceeded maximum permitted concentration of 370 Bq/kg. The result of such concentration increases annual radiation and effects population (Figure 39) (Salbu1 *et al.* 2011).

Radionuclides in the waste of rock-coal ash insulation material in Minkush

Sample	Activity concentration, Bq/kg						
	^{234}Th	^{226}Ra	^{210}Pb	^{230}Th	^{228}Ac	^{228}Th	^{40}K
Coal #1	3630	2770	2190	3560	98	79	190
Coal #2	3610	2760	2360	2940	60	73	92
Coal #3	1650	1210	1010	1240	60	67	140
MPC for ^{226}Ra + ^{232}Th + ^{40}K			370				

MPC: Maximum Permissible Concentration

Figure 39 Source: Salbu1 *et al.* 2011.

At Kadji-Sai area the soil samples were collected from sediments of the water sources. The level of ^{238}U showed from 1.1 to 5.9 kBq/kg d.w. ^{238}U and ^{226}Ra concentration in the soil were low in some sites, but stone showed high concentration of ^{238}U and ^{226}Ra (Figure 40) (Salbu1 *et al.* 2011).

Radionuclides of 234U/238U in soil samples that was collected in the Kadji Sai mining area

Map loc		^{234}U/^{238}U AR	^{238}U Bq/kg	^{226}Ra Bq/kg	^{228}Ra (^{228}Ac) Bq/kg
1	Mean	0.99	2405	2320	89
	Min	0.94	1082	1285	54
	Max	1.03	5859	4990	102
	RSD (%)	3	69	57	19
	n	7	7	7	7
2	Stone (UO_2)	0.98	112902	91829	
3	Soil	0.98	336	410	70
7	Soil		80.0	110	94

Figure 40 Source: Salbu1 *et al.* 2011.

4.2.5 Trace metals and Radionuclides in vegetation in Mailu-Suu and Kadji-Sai.

In the Mailu-Suu River basin the presence of trace elements were found and were in slightly higher concentration. Djenbaev, Kaldybaev and Zholboldiev stated that Al, Ba, Be, Fe, Mn, and Zn are 2 times higher; As, Hg, Ni, Pb, Se and U are 5 times higher; Mo, Co, Cd are 10 to 15 times higher (Djenbaev *et al.* 2012). Concentration of trace metals were found different in locations; middle and low current area of river contents high concentration such as Hg's concentration was found 10 times higher. In the samples of vegetables micro nutrients were found significantly less in the upper part. However, Al was found 2.5 times high likewise, Cu, Se, V was found 2 to 2.5 times high, Ni was 10 times high. Those concentration was studied in the plants; Artemisia ferganensis, Astragalus lasiosemius, Astragalus lasiosemius, Artemisia ferganensis (Djenbaev *et al.* 2012).

At Kadji-Sai the samples of vegetation were collected from the tailings are and found that the concentration of radionuclides and trace elements showed different patterns on different species of vegetation. Fox example, (Salbu1 et.al, 2011) stated that the concentrations of U and As showed very high level in Chenopodiaceae, Salsola and the concentration of Cd, Cu, Ni and Pb showed also high level in Asteraceae, Lactuca sp (Figure 41) (Salbu1 et.al, 2011).

Source: Salbu1 *et al.* 2011

A) *Chenopodiaceae*, *Salsola* sp. At location 1., **B)** *Asteraceae*, *Lactuca* sp. At location 1, **C)** *Asteraceae*, *Chondrilla* sp, at location 4 and 7, **D)** *Asteraceae*, *Artemisia dracunculus* L

Concentrations of trace elements and radionuclides in vegetation samples in the Kadji Sai mining area.

	Map loc	U Bq/kg	As mg/kg	Cd mg/kg	Cu mg/kg	Ni mg/kg	Pb mg/kg
Artemisia dracunculus L.	1	1.9	0.28	0.17	7.6	6.3	0.7
Chenopodiaceae, Salsola sp.	1	416	25	0.53	7.3	2.4	5.4
Asteraceae, Lactuca sp.	1	149	2.9	0.80	27	10	9.7
Artemisia dracunculus L.,	4	0.3	0.13	0.24	6.3	1.9	0.5
Asteraceae, Chondrilla sp.	4	12	0.79	0.28	6.6	4.1	2.6
Caryophyllaceae , Asteraceae, Chondrilla sp.	7	30	0.56	0.38	9.4	5.9	1.9

Figure 41 Source: Salbu1 *et al.* 2011.

4.2.6 Trace metals and radionuclides in terrestrial and aquatic organisms in Kadji-Sai and Shekaftar.

From the study conducted by Salbu1 and Stegnar in Kadji-Sai area and the spoil heaps at Shekaftar. In both sites the doses of ^{226}Ra showed the highest level in lichens and bryophytes (at 164 µGy/h at Kadji Sai and 372 µGy/h at Shekaftar) (Figures 42, 43). Such high concentration could influence to living organisms from the high dose in soil and in water resources of those sites (Salbu1 *et al.* 2011).

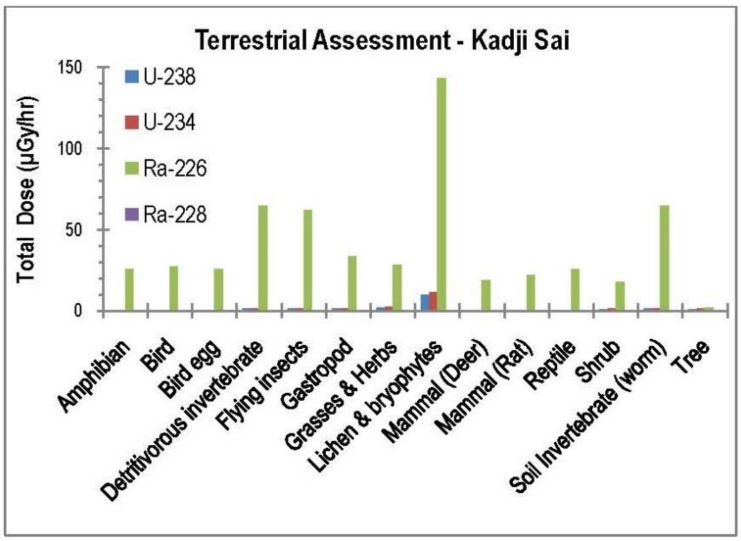


Figure 42. Source: Salbu1 et.al, 2011

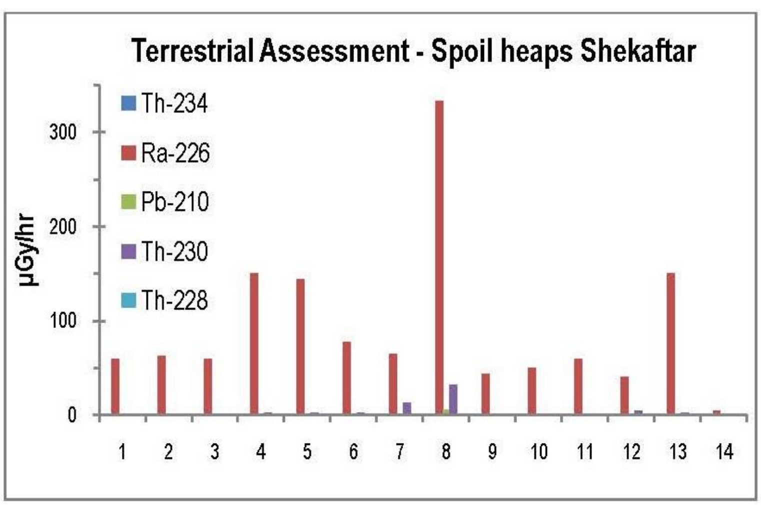


Figure 43. Source: Salbu1*et al.* 2011

4.3 Analysis of the study research

From the scientific studies at the Shekaftar, Mailu-Suu, Minkush and Kadji Sai sites the results can be finalized in the following ways:

-the gamma dose of Rn and Tn generally were low. But there is dangerous threat from abandoned radioactive materials where most Min-Kush residents usually use at home for living needs (Salbu1 *et al.* 2011).

-in most uranium tailings were found elevated level of trace metals like As and heavy metals like Cu, Ni, Cd and Pb (Salbu1 *et al.* 2011). The effect of these elements can cause biological effects like ionizing radiation (Salbu1 *et al.* 2011).

-"at Kadji-Sai, the concentration of trace elements and radionuclides were low, but with high level of As in Issyk-Kul lake. Uptake of U also found in fish of the lake" (Salbu1 *et al.* 2011). "The concentration of uranium was varied from 0.02-0.05 mg/L at the Kadji Sai area, except from the downstream mining area where U reached 10 times higher (0.2 mg/L)" (Salbu1 *et al.* 2011). "Besides most trace elements exceeded the level for drinking water quality" (Salbu1 *et al.* 2011).

-the soil was also enriched with U, As and trace elements. Hot stop of the highest radioactive level was observed at Kadji-Sai area (Salbu1 *et al.* 2011). "Besides in this area were observed radioactive bright yellow particles that contains Na-zippeite that could be interpreted as uraninite" (Salbu1 *et al.* 2011).

-the radiation dose of ^{222}Ra and ^{220}Rn indoor exceeds national and international standards "Maximum Permissible Concentrations of Rn for living: 400 Bq/m3 and for working environment 1000 Bq/m3" (IAEA 2003).

- "in Kadji-Sai and Shekaftar biota as byrophytes and lichens showed very high doses for Kadji –Sai was 164 μGy/h and for Shekaftar was 372 μGy/h because of 226Ra" (Salbu1 *et al.* 2011).

- “trace elements as Se that exceeds Maximum Permitted Concentration in 23 times and Fe in 6 times in the water of Mailu-Suu river, that is not drinking water” (Djenbaev *et al.* 2012).

-“at Shekaftar the level of Uranium in the downstream (8.0 μg/L) of the river were 3 times higher than upstream (3.4 μg/L) of the river because of leaching from the waste rock deposits” (Figure 44) (Salbu1*et al.* 2011).

Total U (238U) concentrations in the Sumsar river.

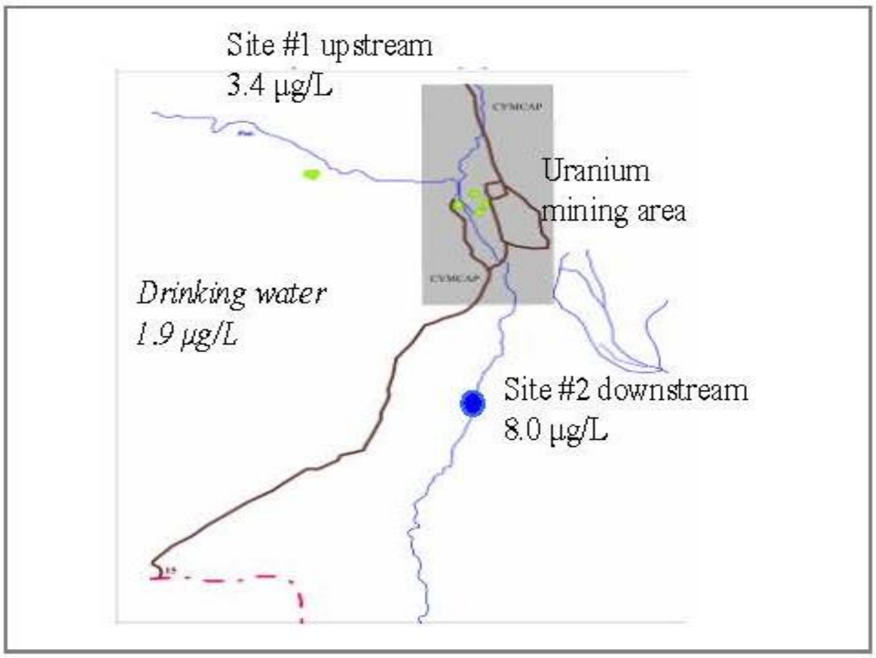


Figure 44. Source: Salbu1*et al.* 2011

To sum up the above the main factor of the „positive correlation (+0,938) was observed between indicators of maximum permissible discharge and general sickness rate among the people and infant mortality” (Moldogazieva, 2010) of investigated areas is can be the water with high contamination level (Figure 45), the soil with that enriched with U, As and trace elements, the radiation dose of ^{222}Ra and ^{220}Rn indoor and abandoned radioactive materials where most Min-Kush residents usually use at home for living needs.

Heavy metals and trace elements in the water

Figure 45 Source: Agency for the management of tailings in KR

Because, “the most significant exposure pathways are external gamma radiation from radionuclides (that is in the soil), internal radiation by inhalation of radionuclides with the dust (that is the air), internal radiation by ingestion of radionuclides with drinking water, internal radiation by ingestion of food which were grown in the garden by watering from the surface water bodies and the rivers and internal radiation by inhalation of radon and its daughter products” (Rosatom, 2012) (Figure 46).

Ways of getting radionuclides into the biosphere and human organs

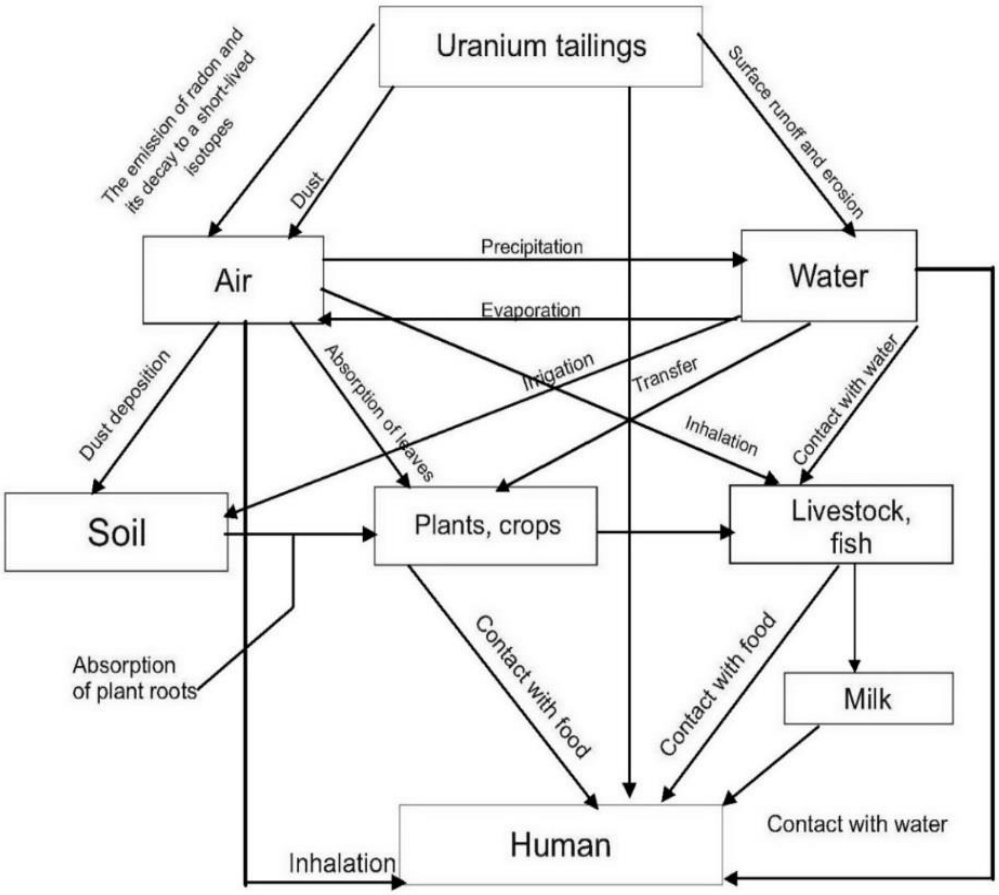


Figure 46 Source: Torgoev and Aleshin, 2009.

However, there some factors can be also the reason of general sickness rate among the people and infant mortality. For instance medical and social factors of settlements that are in the mountainous areas.

5. State management in the field of uranium tailings

This chapter is based on the analyses of interviews of the governmental officials in the field the management of uranium tailings in Kyrgyzstan, and literature reviews of reports, national laws and international programs relevant to the problem of uranium tailings.

5.1 Governmental regulation in the field of radiological safety and uranium tailings

State management in the field of uranium tailings plays an important role for the sustainable development of the country. Currently, there are two ministries and four government agencies, which deal with governmental regulation in the field of radiological safety. The main objectives of these state structures are to control, supervise, monitor, manage and regulate in the field of radiological safety (Figure 47).

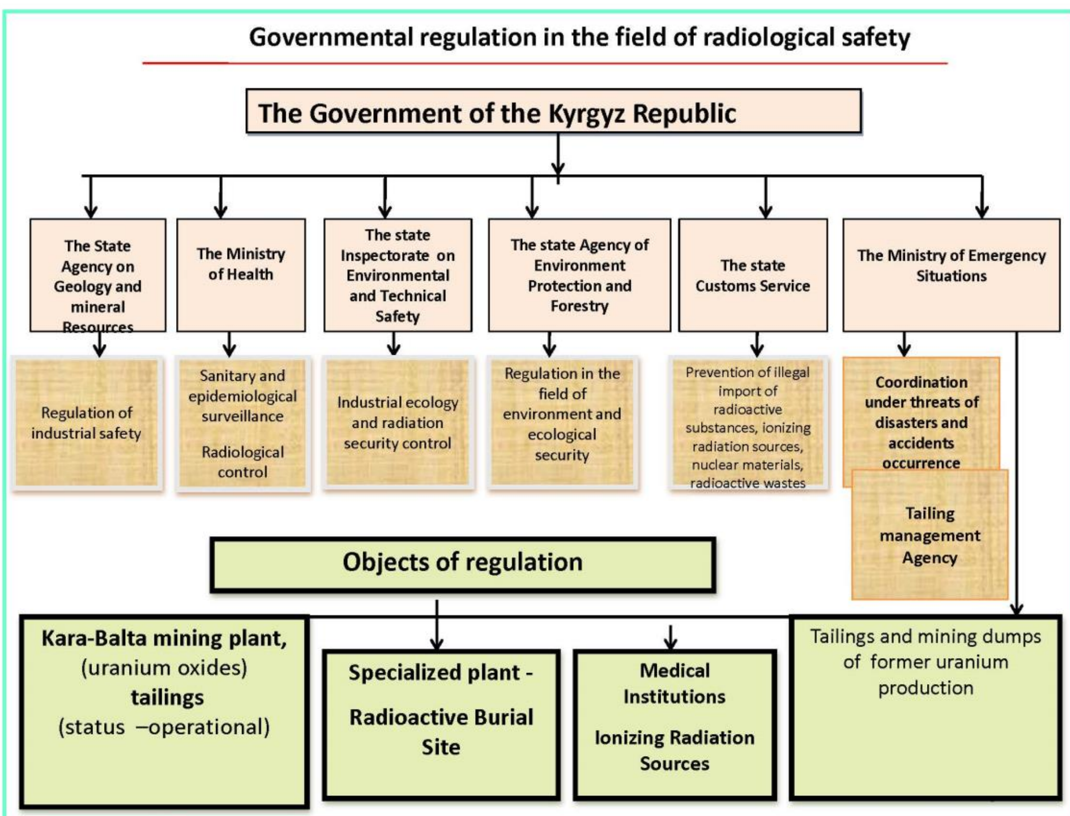


Figure 47 Source: Agency for Tailings Management of KR

Many agencies are involved in the process of regulation in the radiological. All functional responsibilities was distributed by the government in the following ways:

- "The State Agency for Geology and Mineral Resources under the Government of the Kyrgyz Republic implements the regulation of industrial safety as well as maintains records of technogenic deposits of tailings and waste dumps" (VVG 2009);

- "The Ministry of Health implements sanitary and epidemiological surveillance and radiological control" (VVG 2009);

-"The state agency of environment protection and forestry implements the regulation in the field of environment and ecological security" (VVG 2009);

- "The State Customs Service implements the prevention of illegal import of radioactive substance, ionizing radiation sources, nuclear materials and radioactive wastes" (VVG 2009);

-"The Ministry of emergency situations implements coordination under threats of disasters and accidents occurrence" (Agency for Tailings Management of KR);

- "Department of industrial safety of the State Inspectorate for ecological and technical safety under the Government of the Kyrgyz Republic implements control of the safety design, construction, operation and conservation of tailings at existing mining enterprises" (VVG 2009);

- "The State Agency for Hydrometeorology (Kyrgyzhydromet) under the MES carries out radiation monitoring in large settlements of Kyrgyzstan" (VVG 2009).

Along with the government agencies listed above, Kyrgyzstan has a radio-ecological, geochemical laboratories, research institutions, engaged in measurements of radioactivity, the analysis of the content of radionuclides and other toxicants in different fields and materials (VVG 2009).

However, according to the words Mr. Kushbakov D., Head of the Agency for Tailings Management, the main regulatory and national operator of the state management of uranium tailings, is the Agency for Tailings Management under the Ministry of Emergency Situations of the Kyrgyz Republic. The aim of this agency according to its Statute, accepted by government resolution № 406 from 12.06.2012 of the Agency for the management of tailings at the Ministry of Emergency Situations of the Kyrgyz Republic is "implementation of measures to ensure safety and compliance with established security requirements for handling tailings and waste dumps, under the jurisdiction of the Ministry of Emergency Situations of the Kyrgyz Republic". Moreover, the objectives of this agency are "implementation of state programs on the safe maintenance of tailings and waste dumps, implementation of monitoring the of rehabilitation and emergency repair work on the tailings and waste dumps, development of proposals to attract investments for the implementation of programs aimed at ensuring the safety of tailings and dumps" (Agency for Tailings Management of KR).

According to the government resolution about "Organizational measures in connection with the reform of the executive authorities of the Kyrgyz Republic № 12 from 12.12.2012", the Agency for Tailings Management was established in 2012. Before, the main task of this agency was in the function of Department of monitoring, forecasting of emergency situations of the Ministry of Emergency Situations of the Kyrgyz Republic and the Agency on Nuclear and Radiation Safety under the Ministry of Emergency Situations of the Kyrgyz Republic. But later, the Agency on Nuclear and Radiation Safety was reformed and became the Agency for Tailings Management in 2012 (Agency for Tailings Management of KR).

According to the Manning table of the Agency for Tailings Management, about 18 people work there. 14 people are governmental servants and 4 are junior staff (Agency for Tailings Management of KR) (Figure 48).

Scheme of the Agency for Tailings Management under the MES of KR

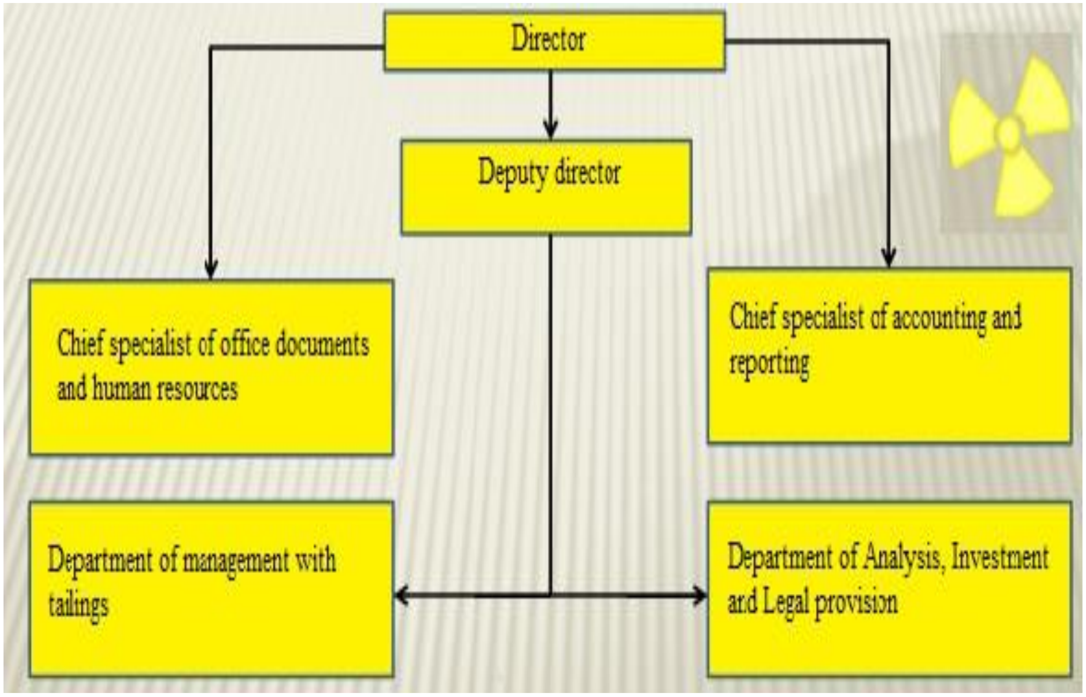


Figure 48. Source: Agency for Tailings Management of KR

According to the information provided by Mr. Aidaraliev B., the chief specialist of the State Inspectorate for ecological and technical safety, the functions of control and supervisor in the field of radiological safety belong to the State Inspectorate for ecological and technical safety under the Government of the Kyrgyz Republic, which was established in 2012. These functions were transferred to them from Agency for Tailings Management of KR in 2012. Before, functions of control, supervision and monitoring belonged to Agency for Tailings Management of KR. Thus, currently, the only function of the Agency for Tailings Management of KR is monitoring and observation.

Ms. Soltobaeva G., the leading specialist of the State Inspectorate for ecological and technical safety stated that only one year ago the Department of radiological safety was established in the State Inspectorate for ecological and technical safety under the Government of the Kyrgyz Republic.

Before the function of control in the field of radiological safety was executed by the Department of Environmental Safety (from 2012 to 2015). According to the Manning table of Department of radiological safety about only 7 people work there (GETI 2015).

In this regard, despite the fact that two main agencies were established recently, and previously some work had already been done by the Ministry of Emergency situation of the Kyrgyz Republic (which will be further elaborated in 5.2 below) there are some challenges for implementing qualitative works for the two newly established agencies.

Looking at the number of workers of each agency or department can give rise to some questions on how they usually manage to do their responsibilities. For solving uranium tailings problem, the government first of all has to increase the number of workers and to create good working condition, instead of reducing the civil servants in Kyrgyzstan. Also, the functions of some agencies and departments are confused and some functions are duplicated. For example, one agency is doing monitoring, observation, regulation and another one doing control and supervision. For a high-quality performance of tasks, it is necessary to combine all the functions of those agencies and departments in one agency or ministry.

5.2 Works has already been done since 1991 until now by the government

Nowadays, about 58 objects are under the Ministry of Emergency Situations, including 33 uranium tailings and 25 mining dumps with a total capacity of 11.7 million. m3. From the 33 tailings contain 28 radioactive waste from uranium production and 5 - waste non-ferrous metal production (Agency for Tailings Management of KR) (Figure 49).

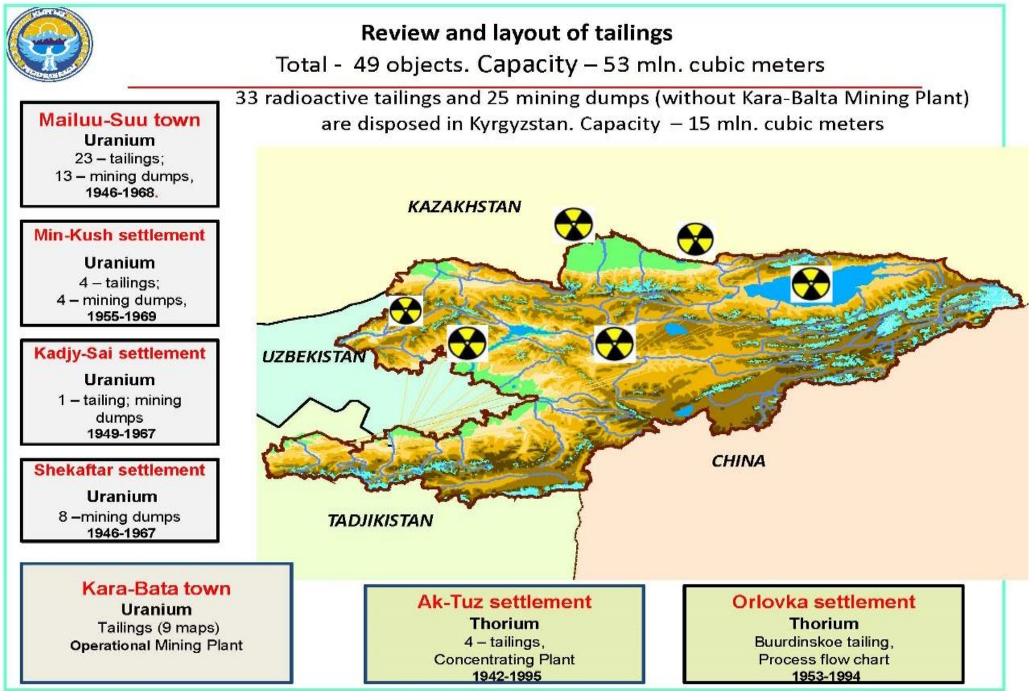


Figure 49 Source: Agency for Tailings Management of KR

According to information Ms. Seitkazieva A., the deputy director of the Agency for Tailings Management of KR, one of the possible decision of this solving of uranium tailings are reclamation and rehabilitation of uranium tailings. But, nowadays, solution to this problem is one of the most difficult issues for the government of Kyrgyzstan because of insufficient state funds. Therefore government of Kyrgyz Republic could not manage and perform these tasks on its own. In this regard, the Government usually gets help from international donors who could assist to address the uranium tailings.

For instance, for reclamation and rehabilitation for all tailings is need to about 47 million US dollars, including:

1. Mailu-Suu tailings - 22 million US dollars.

2. Min-Kush tailings -14 million USDdollars.

3. Kaji-Sai tailings pond - 2.6 million US dollars.

4. Shekaftar mining dumps - 1.5 million US dollars.

5. Sumsar tailings - 5.0 million US dollars.

6. Soviet tailings Kan -2.0 mln. USD. Source: Agency for Tailings Management of KR

However, in recent years, some work have already been done for solving problems of uranium tailings, as a result of international donations. According to the information provided by the deputy director of the Agency for Tailings Management, starting from 2004, the Ministry of Emergency Situation has been implementing project of «Prevention of emergency situations» which is sponsored by World Bank. Moreover, there were other works, which are described as follows:

- From 2004 to 2005 by International technical center in the village Kadji-Sai was implemented project of the initial stage of tailings reclamation (restored diversion of surface water systems, built cascade absorbers, works on the shelter abnormal areas, decontaminated sites with increased activity in the territory of Kadji-Sai (Agency for Tailings Management of KR);
- From 2004 to 2006 in the Ak-Tuz village implemented the project "Geo-ecological surveys and assessment of environmental pressures and risks in the vicinity of mining and processing complex" funded by the Government of the Czech Republic (Agency for Tailings Management of KR);
- From 2006 to 2007 according to regional project of "Management of Radioactive Waste", funded by NATO, carried out work to assess the radiation situation in the area of Minkush and Shekaftar (Agency for Tailings Management of KR);
- In 2009, the Federal Agency of the Russian Federation initiated development works of rehabilitation (reclamation) of the tailings "Tuyuk Suu" in Min-Kush settlement, in the framework

of implementation of the decisions of the EurAsEC member states (Agency for Tailings Management of KR).

The biggest work was done from 2004-2012 in Mailu-Suu by rehabilitation uranium tailings. There were done following works:

-transferred tailings from №3 to №6;

-transferred 4 waste dumps;

-works for stabilization of landslides, basic monitoring system as hydro and landslide monitoring and assessment of water quality in Mailu-Suu.

Rehabilitation works of uranium tailings in Mailu-Suu.

Figure 50 Source: Agency for Tailings Management of KR

Moreover, Ms. Seitkazieva A., the deputy director of the Agency for Tailings Management of KR said that the rehabilitation of the only one tailing in Mailu-Suu was done in ideal according to all international standards (Figure 50).

Nevertheless, according to words Mr. Apiev K., the leading specialist of the Agency for Tailings Management currently the Government of the Kyrgyz Republic with the cooperation of international donors is working on a project "Re-cultivations of territories of EurAsEC member states exposed to uranium production" (The project will last until 2018) (Rosatom, 2012). This project consists of two parts: the first part is clarification of information data bank for engineering solutions and searching advanced technologies (from 2013 to 2016), and the second one is construction and installation works on recultivation uranium tailings (from 2017-2018) (Rosatom 2012).The main customer and coordinator of the project is the State Atomic Energy Corporation «Rosatom». The main participants of this program are Belarus, Kazakhstan, the Russian Federation, Kyrgyzstan and Tajikistan (Rosatom 2012).

The main aim of this project is «reduce the risk of emergencies radioecological consequences in the territories of states members of Evrozes exposed by uranium production, improvement of facilities and implementation of recultivation works, as well as ensuring safe living conditions and social rehabilitation of the population in these regions» (Rosatom, 2012). According to the project first of all the recultivation works will do in Kadji-Sai area and Tuiuk-Suu uranium tailing of Min-Kush area (Kyrgyzstan) and Taboshar uranium tailing (Tajikistan). According to the expert opinions of Evrozes members, these tailings threaten transboundary disasters (Rosatom, 2012).

In addition, in 2015 the Government of Kyrgyzstan presented a new project "Socio-economic development of the settlements located near the radioactive tailings in the Kyrgyz Republic" by supporting international organizations. This project focuses on “increasing awareness of the local population and the establishment of a system of regular monitoring of the environment, rehabilitation socio-economic infrastructure and the development of income-generating activities, supporting local initiatives through funding from the Small Grants Fund/ small investment and increasing capacity of local authorities and communities" (UNDP in Kyrgyzstan, 2015).

To sum up the above, currently the problem of uranium tailings is only starting to be solved with the help of international programmers and international funds. In fact, the government heavily depends on the funds from international programmers. This notwithstanding, the government still needs to consider of providing with enough civil servants for improving and accelerating the condition of uranium tailings.

5.3 Legal Framework in the field of uranium tailings

According to information Ms. Soltobaeva G., the leading specialist of the Department of radiological safety of the State Inspectorate for ecological and technical safety, the main regulatory documents at the national level in the field of uranium tailings are laws "On tailings and mining dumps“, “On Radiation Safety of the population of the Kyrgyz Republic”, " Common technical regulations “On Radiation Safety“, “On Production and Consumption Waste“, "On sanitary and epidemiological welfare of population“ and "On industrial safety of hazardous production facilities“.

Besides, there are some norms and rules of radiological safety as “Radiation safety standards (NPB -99)”, «Basic sanitary rules», «Sanitary rules of radiation safety personnel and the public during transportation of radioactive materials», «Hygienic requirements for design and operation of radioisotope devices», «Sanitary norms and rules for the treatment of radioactive waste (SPORO-2000)» (Aidaraliev *et.al* 2016). But some local standards and norms do not meet the requirements of the international norms and standards, because these local norms and rules were created in the Soviet Union era and some were adapted by the Russian Federation and are thus not suitable in a specific situation concerning radioactive tailings in Kyrgyzstan and other Central Asian countries (VVG 2009). Besides, there are no special provisions for engineering measures and recovery processes in respect of the former uranium facilities in their reclamation and rehabilitation of contaminated sites (VVG 2009). In this regard, according to country report of the IAEA "Brief description infrastructure, radiation safety and waste in Kyrgyzstan (Part A, 2005)" notes that further work is needed to ensure an adequate legal framework, as most of the documents related to remediation that is still insufficiently developed (VVG 2009).

In addition, the Government adheres to international regimes, which have been ratified by the laws of the Kyrgyz Republic. The major international regimes are "The Nuclear Non-Proliferation Treaty"(5 July 1994), "Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction" (29 April 2003), "Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction" (17 August 2004) and "The General Conference of the IAEA" (International Atomic Energy Agency) adopted a resolution on the admission of the Kyrgyz Republic for membership (16 September 2003) (Center on Export Controls in Kyrgyzstan 2011).

In this regard, "Kyrgyzstan does not possess nuclear, chemical, or biological weapons programs, because is a member of relevant nonproliferation treaties and organizations" (Building a Safer World 2015).

Aside from those laws which were mentioned above, there are other laws, which the state controlling bodies use for inspection. For example, the law «On the procedure for businesses». According to Ms. Soltobaeva G., the leading specialist of the Department of radiological safety of the State Inspectorate for ecological and technical safety, this law is a hurdle for control of such dangerous objects and can allow to check (routine) dangerous objects (which are in high level risk) only one time in year. Such decision was accepted by the government of the Kyrgyz Republic for improving the condition of economic development. According to words the previous Minister of Economic development such decision was done "First, it will reduce the number of inspections. Second, it creates the conditions for business development. Third, it helps to identify and eradicate violations in business. And the regulatory authorities will be able to better prepare for the inspection and do not interfere with businesses to do business “(Mambetshaeva 2012).

In this regard, the control and supervision by the State Inspectorate for ecological and technical safety under the Government of the Kyrgyz Republic, such as uranium tailings which are still working condition, belong to private organizations makes a limitation for environmental and radiological safety. According to the words Ms. Soltobaeva G., the leading specialist of the Department of radiological safety of the State Inspectorate for ecological and technical safety, during one year they do not know the situation of tailings. Of course they can secure some information from other government agencies, but the data which they can get by their own would be better for reliable information and doing effectiveness work for radiological safety of the country.

6. Conclusion and recommendations

Nowadays many countries are suffering because of the current environmental degradation problems, but also there are countries suffering because of past environmental problems which still remain unsolved. For finding out the main issue of this problem, the aim of this thesis was to *assess the current situation of uranium tailings and to find out the main challenges (e.g. lack of funds, lack of planning and management, gaps in national laws) of remediation.*

To achieve the aim of the thesis, four main objectives were formulated that can be described in the following ways:

-to find out the risk level of radioactivity that impacts to human health and food chain process (air, water, soil, aquatic and terrestrial organisms).

-To find out weaknesses of the state management in the field of uranium tailings.
-To evaluate the type of works has already been done since 1991 until now by the government.
-To identify the key factors that government need to consider for solving this problem.

It is the author's findings that the risk level of radioactivity (by radiation dose on the surface of the tailings) for four uranium tailings that can cause the risk of cancer for human health especially for adult person is low. In this regard, the direct risk of radioactivity of radiation dose which was taken from the surface of the tailings that can cause the risk of cancer is low.

However, according to the "positive correlation (+0,938) between radiation level and infant mortality and between (+0,938) maximum permissible discharge and general sickness rate among the people" (Moldogazieva 2010), one of the possible factor of radioactivity to human health through the food chain process. Because of the water with high contamination level, the soil that enriched with U, As and trace elements, the radiation dose of ^{222}Ra and ^{220}Rn indoor and abandoned radioactive materials where most residents usually use at home for living needs.

The main challenge of the state management in the field of uranium tailings is lack of funds. For instance, about 47 million US dollars was needed for the whole rehabilitation of the tailings. In this regard, the government tries to solve this issue through the international donors.

In the Manning table of the Agency for Tailings Management under the MES of the KR and the Department of radiological safety of the State Inspectorate for ecological and technical safety under the Government of the Kyrgyz Republic, it was shown that there was a lack of amount people. This manpower requirement is the responsibility of the state to provide. Lack of people can limit good management.

In the field of legal framework, it was found that some local rules and standards do not relate to international standards for the specific situation concerning radioactive tailings in Kyrgyzstan (VVG 2010). In addition, the law about «On the procedure for businesses» where the state controlling bodies use for inspection especially the tailings that are working conditions and belong to private mining companies is the main limitation for radiological safety.

Currently, the main environmental problem has only been started to be solved with the help of international donors. Although rehabilitation and recultivation works on uranium tailings have been ongoing since 2004, it only affects some tailings. The main dangerous tailings remain unrehabilitated. In this regard, the government is working with the international programmer that can help remediate and rehabilitate the main dangerous tailings that can cause transboundary contamination.

Recommendations

For effective solution of the main issue on uranium tailings, the following measures can be pursued:

- to avoid the risk of contamination of uranium wastes in the water, soil, vegetables and living organisms which can occur due-to avalanches, flood and landslides need to:

  -to build protective dams;

  -to transfer tailing dumps from the river and settlements to another place;

  -to rehabilitate tailings;

  -to cover the rehabilitation place by the fat soil;

  -to plant seedlings and plants after rehabilitation.

- Attraction of the public concern through various awareness strategies to involve the public in the decision making process, and to address the problem of uranium waste. This is important so that the public can take ownership and feeling of belongingness of the policy and show effective participation on implementations;

-Parallel cooperation with NGO's and local governing bodies should be made more effective to penetrate up to the root level of consciousness of people under the threat;

- Sufficient allocation of funds by coordinating among stakeholder countries, as well as the involvement of other international organizations, through the provision of donor assistance;

- The union of all the functional tasks (controlling, supervision, monitoring, regulation) in a single state agency for the effective performance of tasks;

- To increase the number of civil servants in the field of managing uranium tailings;

-To amend the law «On the procedure for businesses» to increase the level of inspection and checking (routine check) more than once a year or to make checking as often as needed in the field of radiological safety;

-To harmonize local regulations and standards in the field of radiological safety with international standards;

-To carry on working with international programmers and international donors in order to finish the remediation and rehabilitation works in the tailings as soon as possible to avoid environmental disaster that threatens many Kyrgyz and Central Asian lives because of uranium contamination.

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