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The cyanide accident in Barskoon (Kyrgyzstan)

R. F.M.J. Cleven, M. van Bruggen

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This investigation has been performed by order and for the account of the Directorate of Health policy, within the framework of project 609026.

ABSTRACT

About two tons of sodium cyanide (NaCN) were directly released into the Barskoon River (Kyrgyzstan) as the result of an accident with a truck on May 20, 1998. As the river water was used for irrigation and drinking water purposes, the accident evokes a strong commotion among the population and the Kyrgyz authorities. On request of the World Health Organisation, two missions from RIVM have been sent to the Barskoon to assess the consequences of the cyanide spill for the public health and the environment in the region. The outcome of both missions is reported. The highest total cyanide concentration, as measured by the Laboratory of Inorganic Analytical Chemistry one week after the accident, did not exceed 1 mg/kg (soil). This concentration posed no threat, neither to the environment, nor to the health of humans and animals. Recommendations have been made for a proper risk communication strategy and for the implementation of measures to avoid future accidents. Although the conclusions of our missions convinced the Kyrgyz authorities, the commotion among the population persisted for more than a year.

CONTENTS

SAMENVATTING	4
SUMMARY	5
1 INTRODUCTION	6
2 THE ACCIDENT IN BARSKOON	9
2.1 Reconstruction	9
2.2 Social and economic implications	10
2.3 Geo-political situation	10
3 CYANIDE IN THE ENVIRONMENT	12
3.1 Background exposure	13
3.2 Toxicity of free cyanide	13
3.3 Toxicity of complex cyanide	14
3.4 Speciation in soil	14
3.5 Uptake by plants	15
4 THE LOCAL ENVIRONMENT AFTER THE ACCIDENT	16
4.1 The first days	16
4.2 Worst-case calculations	18
4.3 Chemical analyses after one week	18
4.4 The complaints	21
5 RECOMMENDATIONS AND DISCUSSION	22
ACKNOWLEDGEMENTS	33
REFERENCES	34
APPENDIX: MAILING LIST	35

SAMENVATTING

Op 20 mei 1998 vloog een truck geladen met 20 ton natriumcyanide (NaCN) uit de bocht door een brugleuning en belandde in Barskoon Rivier (Kirgizië). Dit bergriviertje, dat door de lokale bevolking wordt gebruikt als drinkwater, en voor bevoeiing van tuinen en akkers, komt in het grote Issyl-Kul meer uit. Bij het ongeval kwam 1700-1800 kg NaCN in de rivier terecht, ongeveer 8 km stroomopwaarts van het dorpje Barskoon. De cyanidelozing veroorzaakte grote commotie onder de bevolking en de autoriteiten van Kirgizië, vanwege het potentiële gevaar voor gezondheid en milieu, mede door het laat melden van het ongeval door het betrokken bedrijf. Op 25 mei 1998 vroeg de WHO in Kopenhagen het RIVM om bijstand, om de milieugevolgen van het ongeval te beoordelen. Een week later verzocht de WHO opnieuw om bijstand, nu om follow-up analyses en om medisch/toxicologische assistentie. Ervaringen van beide missies zijn in dit rapport beschreven. De hoogste totaal-cyanideconcentraties, een week na het ongeluk gemeten door het Laboratorium voor Anorganisch-analytische Chemie van het RIVM, overschreden niet de waarde van 1 mg/kg (grond). Dit concentratieniveau is niet bedreigend, noch voor het milieu, noch voor de gezondheid van mens en dier. De resultaten en conclusies zijn direct gemeld aan de Kirgizische autoriteiten. Echter, de bezorgheid voor de gezondheid van de mogelijk blootgestelde bevolking had inmiddels geleid tot - deels onnodige - behandeling van tientallen mensen, en tot honderden bezoeken aan ziekenhuizen en klinieken. De evacuatie van enkele duizenden mensen in de dagen na het ongeluk kon evenmin worden gerechtvaardigd door de cyanide concentraties die in het milieu waren aangetroffen. Op grond van onze metingen en conclusies zijn aanbevelingen gegeven voor een passende risico-management strategie, en voor de implementatie van maatregelen om ongelukken in de toekomst te voorkomen. Ofschoon de conclusies van onze missies de Kirgizische autoriteiten overtuigden, bleef de commotie onder de bevolking nog meer dan een jaar aanhouden.

SUMMARY

On May 20, 1998, a truck with 20 tons of sodium cyanide crashed and fell into the Barskoon River (Kyrgyzstan). This small stream, used by the local population for irrigation and drinking water purposes, flows into Lake Issyk-Kul, a major tourist resort. As a result of the accident, some 1700 - 1800 kg of sodium cyanide (NaCN) was released directly into the river, some 8 km upstream the village of Barskoon. The cyanide spill evoked a strong commotion among the population and the Kyrgyz authorities, due to its potential for health and environmental risks, and the omission of the company to report the accident immediately. On May 25, 1998, the World Health Organisation in Copenhagen asked RIVM for assistance to assess the environmental consequences of the accident. One week later, the WHO made a new request for follow-up analyses and toxicological/medical assistance. The outcome of both missions is reported here. The highest total cyanide concentration, as measured by the Laboratory of Inorganic Analytical Chemistry one week after the accident, did not exceed 1 mg/kg (soil). This concentration posed no threat, neither to the environment, nor to the health of humans and animals. These results and conclusions have been communicated to the the Kyrgyz government. However, great concern over the health of the possibly exposed population had led to - partly unnecessary - treatment of dozens of people, and hundreds of visits to hospitals and outpatient clinics. The evacuation of a considerable number of people in the days after the accident could not be justified by the environmental concentrations of cyanide. Recommendations have been made for a proper risk communication strategy and for the implementation of measures to avoid future accidents. Although the conclusions of our missions convinced the Kyrgyz authorities, the commotion among the population persisted for more than a year.

1 INTRODUCTION

On May 20, 1998, a truck loaded with a container with 20 tons of sodium cyanide crashed into the Barskoon River (Kyrgyzstan), which flows into Lake Issyk-Kul. The truck was on its way to the gold mine of Kumtor, high in the mountains. As a result of the accident, some 1700 - 1800 kg of sodium cyanide (NaCN) was said to be released into the river. The place of the accident was located some 8 km upstream the village of Barskoon. The water from the Barskoon River is used by the local population as drinking water and to irrigate home gardens and agricultural fields. Estimates by the authorities of the amount of death victims as a result of cyanide poisoning the first two weeks, were inbetween 1 and 4. The cyanide spill evoked a lot of political and social commotion in Kyrgyzstan. On May 25, 1998, WHO-Europe in Copenhagen asked WHO-ECEH (European Centre of Environment and Health) in Bilthoven to organise analytical-chemical, environmental and (later) medical assistance, which has been given by RIVM in two missions, in May and in June 1998. Experiences of these missions are reported here.

The goal of the first mission, from May 26 to June 2, 1998, was primarily to give 'emergency humanitarian assistance'. As the Kyrgyz authorities wanted a rapid advice about how to handle the situation (for instance with respect to the consumption of local food and water), how the situation would probably develop (with respect to the threat of the environment), and how to normalize social life in the area, the main objective was to trace the pathways, to assess behaviour and to estimate the concentration-profiles of the spilled cyanide.

The strategy of the first mission was:

- To interview authorities and witnesses to be able to estimate what happened at and directly after the accident in terms of possible exposure of the local population, cattle and the environment to the cyanide spill;
- To visit the place of the accident and its immediate surroundings to enable 'worst case' calculations of the impact of the released cyanide to men and environment, and calculations of the dilution by the river water and the concentrations in Lake-Issyk-Kul;
- To control the quality of local chemical-analytical determinations of cyanide in environmental samples;
- To pay special attention to the state of (natural) drinking water and food supply, the mortality of fish in the lake, and the general behaviour of patients.

The increasing number of patients that kept visiting the local and regional hospitals in the days and weeks following the accident and the need for an independent assessment of potential medium or long term consequences of the cyanide release, called for a second WHO mission.

The goal of the second mission, from June, 5 - 10, 1998, was to assess the medical situation in the Barskoon area, in relation to the accidental release of cyanide in the environment, and the potential for current and future health and environmental risks of the accident. The following objectives have been selected:

- To acquire information on the likelihood of exposure, during and after the release;
- To collect information on the motives for identifying a patient as being a cyanide victim;
- To collect information on the motives for starting (and ending) treatment;

- To form an opinion on the complaints that led the patients to seek medical care;
- To confirm the expected decrease in the remaining low soil concentrations of cyanide.

Strategy of the second mission included:

- Consultation of the physicians, dealing with cyanide victims on:
 - individual symptoms;
 - type of exposure and interval between exposure and symptoms;
 - potential clinical picture of 'the intoxicated patient';
 - treatment protocol and results;
- Interview of selected patients on:
 - moment, duration and type of exposure;
 - interval between accident and exposure;
- Estimation of concentrations of cyanide in the environment, particularly in soil and in air during and after the accident, by repeated measurements of the cyanide concentration in soil on suspected places, and in in air, by RIVM portable field equipment;
- Refining the initial 'worst-case' calculation of the extent of the environmental pollution by cyanide, through closer inspection of the area downstream of the place of accident.

In our efforts to reach the objectives, much support has been given by both the Kyrgyz authorities as well as the regional WHO liaison officer, with respect to transport, communication, translations, and introductions at the required locations. However, some restrictions existed, such as request not to communicate with the executives of Kumtor during our investigations, and to provide firm and rapid recommendations on the basis of rather quick and necessarily provisional investigations. Moreover, as a rather stressing entangling of political and financial interests appeared to exist inbetween the 'parties' involved (the local population, the authorities and Kumtor), all information provided had to be weighed against the background of all these interests. In the middle of the interests, we insisted on keeping close to observed facts, and to confront the parties involved with the same facts.

The financial interests that played a role could be distinguished in:

- the fact that their agricultural products of the local population were kept from the markets in the neighbourhood;
- the fact that the state would miss income by cancelled bookings at holiday resorts at Lake Issyk-Kul, and by the fact that the state is an important shareholder in Kumtor;
- the fact that Kumtor had promised that it could be charged for the costs of medical treatment and restauration of the environment.

Both national as well as international press agencies and environment-watching groups, were eager for news on the accident. As the authorities were still puzzled by an increasing number of people claiming to be a ill as a result of the accident, there was a growing breeding ground for rumours. In this report, impressions of public information by press agencies, gathered from sources on the internet, newsletters and newspapers (1a-c), on the accident and its aftermath, is given in frames. Obviously, the authors have no responsibility for the content in the frames. At June 1, 1998, an international news agency reported extensively on the accident. See Frame 1. Three items in this press report, one week after the accident, are striking, and will be discussed later:

- the focus on financial aspects, and the promise for compensation by Kumtor;

- the water supply (by the river to the irrigation systems) had been shut as a precaution measure;
- 16 people are said to be hospitalized.

(Frame 1)

(June, 1, 1998)

AMM Online, the international news service Focus: EnvironmentMarket
Cameco facing cyanide spill lawsuit, By PHILIP BURGERT

LONDON, June 1 -- Cameco Corp., Saskatoon, Saskatchewan, late last week confirmed that granular sodium cyanide had spilled into the Barskoon River in Kyrgyzstan following a traffic accident. The river feeds into the giant Lake Issyk Kul. Reuters reported that Kyrgyzstan's environment ministry said it would seek damages. Environment Minister Kulubek Bokonbayev told a news conference that a lawsuit would seek 160 million Soms (\$8.4 million) compensation for losses to the environment as well as "damage to human health, moral damage and damage from missed benefits." He added, "The prosecutor-general already has instituted criminal proceedings on the facts of the accident." Cameco executives said the spill had been contained and the environmental impact of the spill was being assessed, although initial reports indicated the impact was negligible. According to statements from both Cameco and Kumtor Operating Co. (KOC), the Cameco unit that operates the Kumtor gold mine, the spill occurred May 21 when a truck transporting a container with 20 one-ton packages of cyanide overturned into the river while en route to the nearby gold mine. Executives said it appeared that one of the packages ruptured, spilling some of the contents. Kumtor executives said the water supply to a nearby village had been shut by local authorities as a precautionary measure. However, KOC said that there had been no major contamination of either the river or the lake. "The quantity of sodium cyanide that was spilled did not exceed 1,762 kilograms (3,885 pounds)," it said, adding that water contamination levels were less than the maximum allowed under Kyrgyzstan legislation. KOC president Gerhard Glattes said that the company was prepared to pay compensation. "This is a very sad and unfortunate incident for Kumtor," he said. "Of course, our company will compensate for any damage."

Bokonbayev dismissed fears that Lake Issyk Kul, a popular health resort renowned for its clear water, was contaminated. "The lake has not died. It is alive, and the situation has become normal," he said Friday. "Yesterday, I drank water at the site of the incident--and I am alive, as you see." But he said the spill had already scared off many potential visitors and some Russian companies had notified the Kyrgyzstan government that they had put on hold planned investments in the resort area. The minister said that in the previous few days about 240 cases of minor poisoning had been registered in the nearby village of Barskaun and 16 people had been taken to hospital. Several domestic animals and river trout had died, he added. The Kumtor Mine is two-thirds owned by the government of Kyrgyzstan and one-third by Cameco. It began production in 1997 and produced 500,000 ounces of gold in its first year of operations, Cameco said.

2 THE ACCIDENT IN BARSKOON

2.1 Reconstruction

The accident was said to have occurred at about noon on May, 20, 1998, in Barskoon (also transliterated as: Barskaun) in Kyrgyzstan (also known as: the Kyrgyz Republic).

Barskoon is located about 80 km south-west of Karakol (see map at bottom of this page) some 6 km south from Lake Issyk-Kul, where the Lake is at its largest width. The place of the accident was located some 8 km upstream of the village of Barskoon at a bridge over the river. The southside parapet of the narrow bridge over the river was destroyed. Just before the bridge the small sandy road curves quite sharply. Of the 20 packages with sodium cyanide (NaCN) in the sea container on the truck, two had burst open, resulting in a spill of some 1700 - 1800 kg of NaCN in the pristine river water. Photographs, taken from a video of the salvage of the truck, confirmed this situation. The NaCN freight was being transported, in a convoy (usually four to seven trucks) on a regular basis by the Kumtor Operating Company to their gold mine at about 80 km from Barskoon, high in the mountains of Tien Shan.

The water from the Barskoon River is used by the local population as drinking water and to irrigate home gardens and agricultural fields, both at the Barskoon side (east of the river) and the Tamga area (west of the river). Both the inlets of the two main irrigation channels had been fully open. They had been closed some hours after the accident. These main inlets are situated about 3 kilometers downstream of the bridge. The size of both inlets is about 1 m². With water fully flushing, at May 27, 1998, about half of the inlets is effectively used. The channels are branching into a fine structure of pipes and half-pipes (diameter about 30 cm), reaching every house-garden in Barskoon (with 7000 inhabitants). The water is also used as potable water. Through small open V-shaped ploughed channels (ditches), irrigation water reaches the agricultural fields. The 'downtown' inhabited area of Barskoon was estimated to be about 2 km². It was mainly from the south-western part of this area that people started to claim to be ill as a result of the accident.

Map of Kyrgyzstan



The Kumtor Operating Company, a daughter of the Swiss/Canadian company Cameco, has reported on the accident to the local officials some 6 - 8 hours after the accident took place. In the meantime Kumtor had started to clean up the place of the spill in an attempt to decompose the spilled cyanide. Some people declared to remember a chlorine-like smell in the first days after the accident.

The Barskoon River is a pristine river, collecting melting and rain water from part of the Tien Shan massive. At the site of the accident, the river is about 10 meters wide and its depth of the river near the bridge is about 0.8 meter. The velocity of the water at the surface was estimated to be about 0.5 m/s. The river ends in Lake Issyk-Kul, a giant lake, about 30 km wide (on the average) and with a length of about 200 km. Its depth is said to be several hundred meters. Some people claimed to have seen some (but not many) dead fish in the lake near the mouth of the river.

2.2 Social and economic implications

Most of the people in Barskoon make a living of selling products from their gardens (fruit, vegetables), and meat and milk from their cattle. The idea that a highly toxic substance had been spread out in their gardens and on their agricultural fields caused a panic, as the base of their existence was falling apart. As the people considered themselves as rather poor, they claimed that Kumtor should compensate their losses.

Moreover, the environment in Kyrgyzstan gives an overwhelming impression of pure nature. So does the population feel. As their original way of living was nomadic, and many families are still half-nomadic, they were upset by the very idea that their land had been contaminated.

A number of people declared that the transport of chemical supplies by convoys of trucks uphill to the gold mine is daily practice. They feared a repetition of similar accidents.

Most of the peasants are probably not familiar with toxic chemicals, so their fear for their own environment was based on the association of 'cyanide' with 'highly dangerous'.

The population of Kyrgyzstan is predominantly Muslim. However, Islam never became deeply rooted in the Kyrgyz society. Nevertheless, while women also work hard in the agricultural activities, men predominantly responded to the organised mass meetings discussing the impact of the accident.

2.3 Geo-political situation

The Constitution of the Republic of Kyrgyzstan was adopted in May 1993, after the break up of the Soviet Union in December 1991. The capital, Frunze, has been renamed to Bishkek. Kyrgyzstan has become one of the most progressive countries of the former Soviet Union in carrying out market reforms. In the West, Kyrgyzstan is often referred to as an 'island of democracy' because of its active introduction of democratic and market-oriented reforms, initiated by (the first) president Askar Akayev. It is agreed that Kyrgyzstan is the leader in incorporating the free market system, although as with all post-Soviet states, the republic is still in the grip of the severe economic crisis. Drops in production have been severe since. By mid-1995 production began to recover and exports began to increase. Following a successful stabilization program, which lowered inflation from 88% in 1994 to 32% for 1996, attention is turning toward stimulating growth. Foreign assistance plays a

substantial role in the country's budget. In 1996 the economy showed strong signs that recovery was underway. An estimation of the purchasing power parity per capita, was \$1,290 in 1996. Of a total labor force of 1.7 million, the occupational activities are about 50 % in agriculture and forestry. Main export partners are China, United Kingdom and the Former Soviet Union. The currency: 1 Kyrgyzstani Som (KGS) = 100 tyiyn, with exchange rates of about 8 KGS per DM (in May 1998). Kyrgyzstan occupies the fourth position among all of the countries of the new Independant States (NIS) in minimum wages, despite the fact that the small republic does not possess its own strategic raw materials (oil, natural gas, etc.).

Kyrgyzstan is a small, poor, mountainous country with a predominantly agricultural economy. Due to the numerous very high mountain massives, only 4% of the country is arable land. Cotton, wool, and meat are the main agricultural exports products. Other agricultural products are tobacco, potatoes, vegetables, grapes, fruits and berries. Sheep, and goats form a main part of the cattle. Industrial exports included gold, mercury, uranium, and other rare earth metals, and hydropower. Kumtor, part of the Swiss/Canadian company Cameco, holds the world's seventh-largest gold reserves.

Kyrgyzstan is enclosed by land. The long border with China is characterized by spurs of the Himalaya, culminating to 7439 meter at the Jengish Peak in the East. The famous Karakorum highway (to the south-west) has to ensure Kyrgyz access to the ocean, allowing the republic to rid itself of its current transportation gridlock. The construction of the international sector of the Bishkek airport is completed. The planning is to extract 15 tons of gold annually from the three Kyrgyzstan's mining regions.

Over 80 nationalities are represented in the Kyrgyz Republic. The largest ethnic group is the Russian-speaking population. In 1990 Russians constituted 21 percent of the population. Massive emigration of non-native peoples from the republic to their historic lands began after the collapse of the USSR, which has caused a negative trend in Kyrgyz-Russian relations, as well as on the condition of the republic's industry. The deadline for the transfer of all official business into the state language has been set to the year 2005. However, the native language of large ethnic groups will be considered the official language in the places of 'concentrated residence' of that population.

The press (the 'fourth branch') is said to be most powerful in Kryrgyzstan. Freedom of speech, declared at the beginning of Kyrgyz independence, is not just a beautiful phrase but a reality. About a 100 newspapers and magazines are registred. The newspaper with the largest circulation is *Evening Bishkek* (circulation 50,000) which is self-financed. Due to the introduction of the national currency, the number of Russian newspapers sold on the republic's news stands has sharply declined.

3 CYANIDE IN THE ENVIRONMENT

Cyanide occurs in various organic and inorganic compounds containing a cyano-group ($-\text{C}=\text{N}$) as part of their molecule. Two groups of cyanides are distinguished here: free cyanide and complex cyanide. Cyanides enter the environment from both natural processes and human industrial activities. Cyanide is produced and used in various occupational settings where activities include electroplating, some metal mining processes, metallurgy, metal cleaning, certain pesticide applications, tanning, photography and gas works operations. Cyanide is also used in some dye and pharmaceutical industries. Many species of bacteria, fungi, algae and also of plants are able to utilise cyanide and degrade it to less toxic substances like CO_2 , NO_3^- , SCN^- and OCN^- . Cyanides do not persist or accumulate in soils under natural conditions. Industrial cyanide containing wastewater has frequently caused soil contamination. A historic source of cyanide contamination, in the form of Prussian blue, $\text{Fe}_4(\text{Fe}(\text{CN})_6)_3$, occurred in the production of coal gas. Properties of cyanide containing compounds with respect to their toxicity and environmental effects are abundantly described in common available literature (e.g.: 2,3). A compilation of human toxicity data is given by Meijerink (4).

In air, cyanide is mainly found as gaseous hydrogen cyanide; a small amount is present as fine dust particles. It takes about 1–3 years for half of the hydrogen cyanide to disappear from the air. Most cyanide in surface water will form hydrogen cyanide and evaporate. Cyanide does not build up in the bodies of fish. At high concentrations, cyanide becomes toxic to soil microorganisms and can pass through soil into underground water. Exposure routes are by breathing air, drinking water, touching soil, or eating food containing cyanide. Smoking cigarettes and breathing smoke-filled air during fires are major sources of cyanide exposure.

The Environmental Protection Agency (EPA) in the U.S. has set a maximum contaminant level of cyanide in drinking water of 0.2 mg/L. The EPA requires that spills or accidental releases into the environment of 1 pound or more of hydrogen cyanide, potassium cyanide, sodium cyanide, calcium cyanide or copper cyanide be reported to the EPA. The Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH) have set a permissible exposure limit of 5 milligrams of cyanide per cubic meter of air (5 mg/m^3) in the workplace during an 8-hour workday of a 40-hour workweek.

In the Netherlands, target values for free cyanides are for soil 1 mg/kg (ds - on the basis of dry solids), and for the dissolved fraction in groundwater 5 $\mu\text{g/L}$, whereas intervention values, for free cyanides and thiocyanides, are for soil 20 mg/kg (ds) and for ground water 1500 $\mu\text{g/L}$. In the Netherlands, waste containing more than 50 mg/kg (ds) is considered as dangerous waste (5).

For drinking water, and for river water used to prepare drinking water, the Dutch standards with respect to free cyanides is 50 $\mu\text{g/L}$, and the corresponding WHO standard for drinking water is 70 $\mu\text{g/L}$ (5).

Under aerobic conditions, cyanides are biologically degraded, also by plants and animals. There is no accumulation in the food chain. Long lasting exposure of organisms to low concentration is supposed to be harmless (6).

3.1 Background exposure

Cyanide occurs naturally in several plants that contain cyanogenic glycosides such as cassava, soybeans, spinach and bamboo shoots. Cyanide concentrations in cereal grains range from 0.001-0.45 µg/g; in soy protein products from 0.07-0.3 µg/g, and in lima beans from 0.1-3 mg/g (2). The root crop cassava can create a problem in West-Africa, since cassava is the most important food there. If not properly prepared, it can contain very high levels of cyanide. For a group of 73 Liberians consuming cassava, the mean daily intake was calculated to be 0.61 mg CN-/kg bw (bw - body weight) (7). Cyanide concentrations in canned unpitted fruits/peaches, apricots, plums and cherries range from 0-4 µg/g, depending on the glycoside content of the raw fruits and conditions of heat processing. The most likely source of general population exposure to cyanide are levels in inhaled smoke from cigarettes. These are ranging from 10-400 µg/cigarette.

3.2 Toxicity of free cyanide

Oral exposure

The cyanide ion is readily absorbed by the gastro-intestinal (GI) tract in animal species, and its highly poisonous effects are induced rapidly. Absorption of cyanide across the GI mucosa depends on the pH of the gut, the stability constant and lipid solubility of the cyanide compound. Cyanide blocks oxidative processes (by forming complexes with metal ions present in enzymes) in the cells, allowing anaerobic products, i.e., lactic acid, to accumulate in the cells, thus stimulating respiration. This is due to the combination of cyanide with the catalytic iron group of cytochrome oxidase, inhibiting its enzymatic activity. The absorption of oxygen by the cells is inhibited, i.e., cellular oxidation cannot proceed, and the main supply of energy to the cells ceases. Acute oral toxicity of cyanide for human beings is relatively high, with an immediate lethal dose for an adult of approx. 1-2 mg/kg bw (2).

Low oral exposures to cyanide (2.9-4.7 mg cyanide/day) are not fatal to humans who have an efficient detoxification system whereby the cyanide is converted, through the rhodanese and thiosulphate enzyme system, to thiocyanate ion (metabolite), which is non-toxic at low levels. Half-life for the conversion of cyanide to thiocyanate from a non-lethal dose in man is between 20 minutes and 1 hour. Following oral exposure, the highest levels have been detected in the stomach, lungs and blood. following chronic oral exposure. In humans, cyanide metabolites are excreted primarily in the urine (47-89% within 24 hours) with small amounts excreted through the lungs (approx. 4% in the form of HCN or CO₂). Once thiocyanate is formed, it is not converted back to cyanide. The minor pathway (15%) is the conversion of cyanide to 2-aminothiazoline-4-carboxylic acid and 2-iminothiazolidine-4-carboxylic acid (2,7).

Inhalation exposure

Hydrogen cyanide (HCN) is a colourless gas with a faint, bitter, almond-like odour. In humans a concentration of 200 mg HCN/m³ is fatal after 10 minutes, while a single exposure to concentrations upto 1 mg/m³ caused no adverse effects. Concentrations in the range of 5-50 mg HCN/m³ caused headache, dizziness and nausea after a few hours (8). No data on chronic toxicity, reproduction/teratogenicity, or carcinogenicity are available. From a thyroid hormone evaluation of workers working with cyanide compounds in a cable industry, it was concluded that occupational cyanide exposure primarily impairs the thyroid function.

3.3. Toxicity of complex cyanide

Dissolved cyanide ions can form complexes with a number of metal cations, especially those of the transition metals plus Zn, Cd and Hg, such as Fe(CN)₆³⁻ and Zn(CN)₄²⁻. Ca, K and Na-salts (bound to ferrocyanide complex) are used as food additives. Relevant exposure route in the present context is the oral one.

Ferrocyanides

Ferrocyanides (Ca, K, Na-salts) are used as food additives (anti-caking agent). The allowable daily intake of sodiumferrocyanide is 0.025 mg/kg bw/day, which equals 13 µg CN⁻/kg bw/day (9). In the Netherlands, background exposure to CN⁻, by consumption of cyanide containing additives in food, is 0.4 µg/kg bw/day (9).

The most prevalent types of cyanide compounds found at former manufactured gasplant (MGP) sites are ferriferrocyanides (Fe₄(Fe(CN)₆)₃) (approximately 97%). Soil at MGP sites has a low pH, in the range 2-4. This enhances cyanide stability and minimises environmental mobility. Ferriferrocyanide is not well absorbed from the gut. In a human study an oral dose of 500 mg (6.2-7.1 mg/kg bw) of ferriferrocyanide, in a gastric acid-soluble gelatine capsule, was given to three adult male volunteers. The average 7-day body retention was 0.03-0.07% for radioabelled iron and the amount of absorbed free cyanide was estimated to be 0.2-0.4% (= 0.03 mg CN⁻/kg bw) of the total cyanide administration, of which 70% will be excreted mainly as thiocyanate, according to Nielsen, as cited in Shifrin et al. (10). In humans ingestion of a single dose of Fe₄(Fe(CN)₆)₃ at a dose level of 6-7 mg/kg bw did not result in toxic effects.

The limited absorption from the gut and the only fractional dissociation of the absorbed ferriferrocyanide to toxic HCN or CN⁻ are indications of the low toxicity of ferriferrocyanide.

3.4 Speciation in soil

As part of the spilled cyanide in Barskoon will have contaminated soil in the irrigated gardens and agricultural fields, the behaviour of cyanide in soil is relevant. With respect to the toxic effect, the speciation of cyanides in soil is important (6). Of the forms of cyanide, the free cyanide ion is the most biologically active form. The ion CN⁻ is a base, that in water with pH < 9 is transformed to dissolved HCN_{aq}, that volatilizes easily to HCN gas (3). A second group of forms consists of metal cyanide complexes, such as Fe(CN)₆³⁻ and Zn(CN)₄²⁻. Generally, formation of metal complexes removes free cyanide from solution. The toxicity of these type of complexes is dependent on the ease of dissociation into the metal and free cyanide ion. Instable complexes, e.g. Zn(CN)₄²⁻ dissociate easily under

acidic conditions, are thus almost as toxic as the free cyanide ion.. However, the much more stable iron cyanide complexes, $\text{Fe}(\text{CN})_6^{3-}$ and $\text{Fe}(\text{CN})_6^{4-}$, are resistant to gastric acid, and are a factor of 1000 less toxic than free cyanide. Complexation of cyanide also affects its behaviour in soil, in particular its mobility.

In iron-containing soils, iron cyanide will react with iron hydroxide $\text{Fe}(\text{OH})_3$, forming, under acid conditions, a stable precipitate, Prussian blue, $\text{Fe}_4(\text{Fe}(\text{CN})_6)_3$, that is considered to be not toxic. The mobility of cyanide will depend on the pH, as Prussian blue is poorly soluble at $\text{pH} < 7$. In soils with $\text{pH} = 7$ iron cyanide will be observed, and the mobility of cyanide is higher. In daylight cyanide can be set free from iron cyanide. However, due to the biological degradation, the concentrations of cyanide may remain low (6). A serious pathway of cyanide through soil remains, by the ingestion by playing children of soil on which cyanides are adsorbed or precipitated.

3.5 Uptake by plants

Reported K_d -values of sodium cyanide (controlling the partitioning over the soil and water phase) range from 5.04 to 14.5, which means that cyanide are quite immobile, and thus not very available to plants. Most vegetated natural soils show a relatively low pH regime, and sodium cyanide will be transformed to hydrogen cyanide (11), or into Berlin Blue in the case of the presence of sufficient iron containing compounds (6).

As compared to the bulk pH value, rhizosphere pH is lowered by the carbon dioxide release from the plant root respiration. In the (rare) event that a tiny amount of sodium cyanide has been taken up by the plant roots, it will be rapidly converted to hydrogen cyanide by the buffered pH range maintained by plant tissues, between 6 and 7 for cytoplasm, intercellular space and the xylem sap ascending from the root. Being highly volatile, hydrogen cyanide can easily escape into the atmosphere through leaf stomatal openings. Any residual amount of hydrogen cyanide is not expected to cause problems (11).

Higher plants are endowed with the cyanide resistant pathway in mitochondria. The universally present cyanide insensitivity explains why native vegetation is relatively immune to soil cyanide. Sodium cyanide in the soil is not expected to trigger a disastrous chain reaction in the local food web by profoundly stressing native plants (11).

All higher plants are capable of assimilating free cyanide as a detoxification mechanism. Hydrogen cyanide can be metabolized by the action of β -cyanoalanine synthase into β -cyano-L-alanine which is then converted by β -cyanoalanine hydrolase into L-asparagine. The first enzyme is found to be present in all plants. The steady-state free cyanide concentration in plant tissues is likely to be very low (11). Many plants are capable of forming cyanogenic glucosides from amino acids, for which no external cyanide is needed. These glucosides are not metabolically inert in plant tissues, rather, they undergo active turnovers. When cyanogenic glucosides are hydrolyzed *in situ*, the released hydrogen cyanide is re-assimilated into L-asparagine. Soil microbes and some millipedes secrete hydrogen cyanide, in some cases as a chemical defense mechanism. Soil cyanide exposure has thus been a natural factor shaping the course of evolution and ecological adaptation of organisms (11). The chances on cyanide intoxication by plant consumption must be considered as minimal (12).

4 THE LOCAL ENVIRONMENT AFTER THE ACCIDENT

4.1 The first days

Immediately after the accident, the river water downstream must have contained very high concentrations of cyanide, as NaCN is very soluble in water. Subsequently, a large part of the dissolved cyanide must have been rapidly transformed into HCN, which will have been released into the air. People who were at the place of the accident, worked in the fields or had contact with the water at the first hours after the accident must have been at considerable risk for lifethreatening disease through inhalatory uptake of HCN (gas) or dermal or oral uptake of CN⁻ (in water). The weather at the time of the accident was 'good': a fair wind, no rain. Later, due to the decrease of free cyanide in water and soil through chemical and biological processes, the risk for substantial exposure will quickly have been diminished. A demonstration of the rather low cyanide concentrations in the irrigation water and on the soil was considered as urgent. Even the local authorities did not immediately believe the analytical results by Kumtor showing that about six hours after the accident the river was free of measurable concentrations of cyanide, after the 'peak-load' would have reached the giant Lake Issyk-Kul, since Kumtor had had much interest in these results. In Fig. 1 (on the next page), a graph is shown that has been handed over by Kumtor executives to suggest that the river - somewhat downstream the accident - was clean after 17:45h at May 20. In a Press Release of the Ministry of Environment, of May 25, 1998, it was stated that the Ministry was informed about the accident at 18:45h (on May 20, 1998). It also states that the container with its contents has been lifted from the river at 17:30h (on May 20, 1998). Another graph, of similar lay-out as Fig. 1, suggested a demonstration of the input of cyanide into Lake Issyk-Kul, covering the first 15 hours of May 21, 1998, with a highest level of 0.2 mg/L at 04:00h, thus about 10 hours after the lifting of the truck. It was not allowed for me (RC) to visit the laboratory of Kumtor.

We have been informed that two measures had been taken by Kumtor that very May 20, 1998: to 'clean' the environment with a cyanide decomposing substance, and to close to inlets of the irrigation channels.

Cleaning operation

The composition of the 'cleaning substance' was not provided. It was said to be 'chlorine-containing' compound. Later it appeared to be probably either hypochloric acid or sodium hypochlorite. This is a common cleaning procedure to oxidize cyanides in waste water. Some people indeed declared that they had smelled a 'chlorine-like' odour. Unfortunately, the application of some 'hypochloric compound' (by spraying it in the irrigation channels by 'men with masks') did increase rather than relieve the worries of the population. Moreover, the application of hypochlorics may evoke, depending on local pH, a number of new compounds, such as chlorine, cyanogen chloride and cyanates (13). Cyanates may then be further oxidized to nitrogen and carbon dioxide or carbonate (3). Although these compounds are either volatile or less toxic than cyanides, it complicated the impact of the accident, and thus the assessment of the complaints of the population. Under the specific conditions of the accident the benefit of the application of the 'cleaning substance' has to be doubted.

Closing of channels

Although the closing of the inlets of the irrigation channels, to prevent further contamination of the soil, is, at first glance, understandable, it is, under the specific

conditions of the accident, not wise. If some limited amount of sodium cyanide would indeed have entered the irrigation water works, any settling of that limited amount of cyanides can better be spread over an area as large as possible. This dilution principle can be applied, since the cyanide concerned will be decomposed both physico-chemically and biologically. The access of water and air will enhance the decomposition and degradation processes markedly. Initially, there existed strong resistance against my (RC) recommendation to 'flush' the contaminated area with wide open channel inlets. The fear existed that even more people would bear the risk to become intoxicated. Finally, after some days, the recommendation was adopted: during the second mission the water flushed freely again.

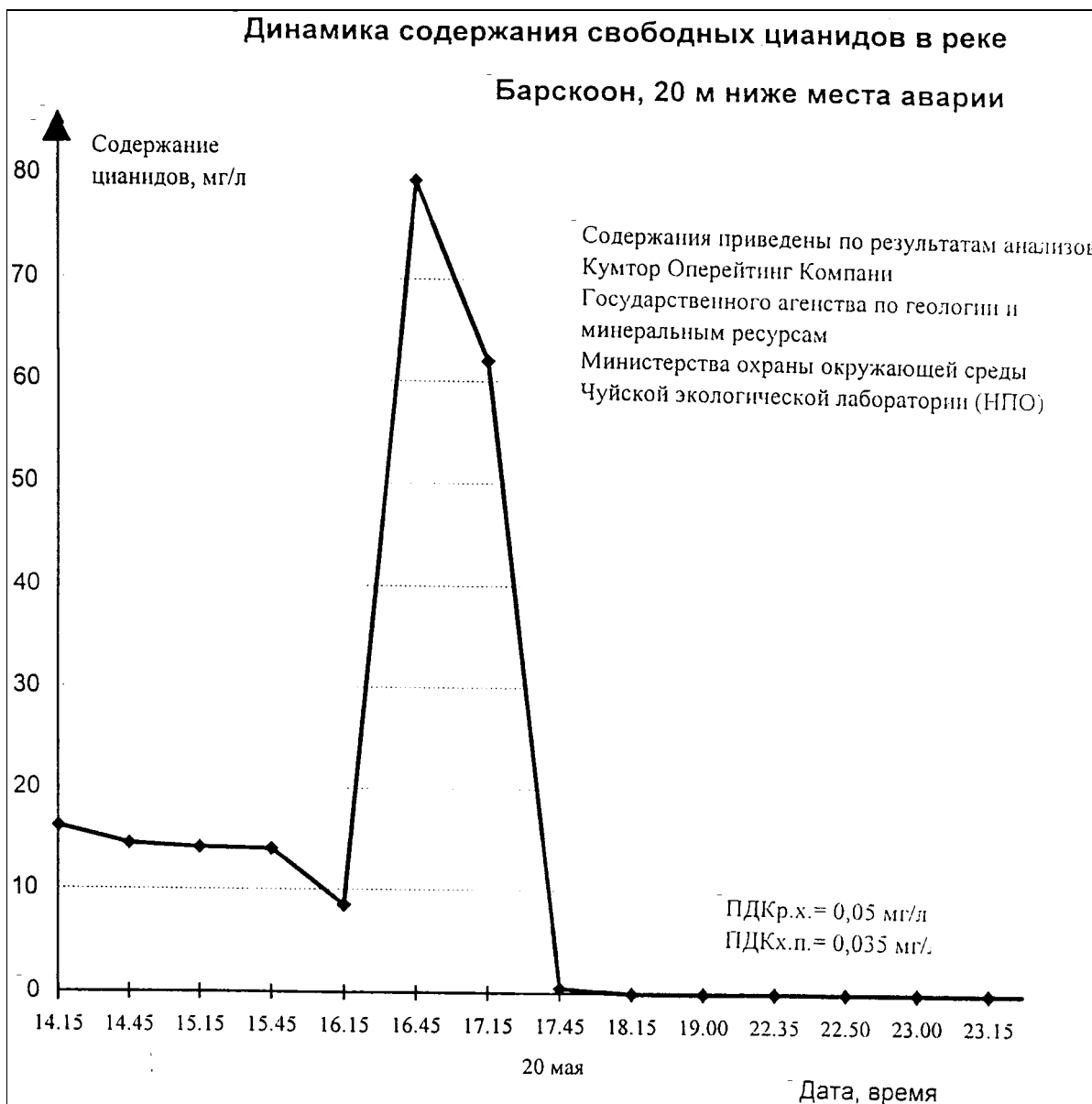


Figure 1 . Copy of a graph of the cyanide concentration in Barskoon River versus time (on May 20, 1998) as produced by Kumtor.

4.2 Worst-case calculations

- Assuming a (over-all, linear) water velocity of 0.5 m/s, and a distance from the place of the accident to Lake Issyk-Kul of about 14 km, and a very high and rapid solubility of NaCN in water, then it would take, without any delay or dispersion, 7-8 hours for the 'cyanide front' of the spilled NaCN to reach the Lake.
- Assuming 1900 kg NaCN, a safe level of 50 µg/L, and all spilled cyanide would remain in solution, then it would take $4 \cdot 10^7 \text{ m}^3$ of water to reach that dilution. The content of Lake Issyk-Kul (estimated size: $200 \times 30 \times 0.1 \text{ km}^3$) will be sufficient, being more than $6 \cdot 10^{11} \text{ m}^3$.
- Assuming 1900 kg NaCN, a 'fast' solubility of NaCN of 0.48 g/L in the river water (the 'real' value in the handbook (14) is: 480 g/L in cold water), then it would cost $4 \cdot 10^6 \text{ L}$ of river water to dissolve all the spilled NaCN. With an estimated throughput of river water of $4 \text{ m}^3/\text{s}$, it would then take less than 17 minutes to dissolve all the spilled NaCN.
- Assuming 1 m^2 of the transverse section of the river for each of the two irrigation water inlets, as compared to a total 8 m^2 waterfront, then, not more than say 20% of the river will have reached the inhabited area of Barskoon. Consequently not more than 400 kg sodium cyanide. If this amount is spread out in half of all the gardens of the village (estimated directly polluted area: 1 km^2), and a soil surface layer of 0.5 cm depth would initially have been contaminated, the 'concentration' would become about 25 mg/kg soil. This was a value of major concern, especially for its possible consequences in the first week after the accident, mainly with respect to the playing behaviour of small children, and the consumption of soil by cattle.

On the west side of the river, in the Tamga region, the situation was quite different, and less clear: the distance from the place of the accident to the inhabited Tamga area is much larger than to Barskoon, the population is much less dependent on 'home-gardening', many of them living in near a former military centre. The irrigation channels were not finely branched, and the water reaches primarily the agricultural fields.

4.3 Chemical analyses after one week

On May 27 and 28, 1998, on the first mission, I (RC) performed a sampling campaign, visiting locations just downstream the place of the accident, in several irrigation channels, in the garden of house in which people were said to be ill due to the toxic substances, and in Lake Issyk-Kul, close to the mouth of the river. In the channels (being dry, at that time) and in the gardens, soil samples have been taken, and water samples from river and lake.

Polyethylene (PE) sampling flasks have been used, that could be tightly closed. For the water samples, the flasks have been pre-flushed three times with the water to be sampled, and have been filled to the brim. For the soil samples, the brim of the flask was scratched over the top layer (about 0.5 -1 cm depth) of the soil in the gardens and in the channels. Additionally three subsamples of garden samples of the Kyrgyz authorities have been taken.

The (eleven) samples have been transported to RIVM on June 1, 1998, and have been analysed on June, 3, 1998, by J.H. van Staden, with respect to 'total cyanide', according to Standard Operation Procedure LAC/M361/00 of the RIVM Laboratory of Inorganic-analytical Chemistry (15). For the extraction of the soil samples, 40 g soil has been shaken with 200 ml NaOH (2.5 mol/L). The detection limit for soil total cyanide in soil samples is 0.5 mg/kg and in water samples 0.001 mg/L, using this procedure.

The results of the measurements for the eleven samples are:

1. Water, sampled at the bridge over the Barskoon River where the accident happened
Concentration cyanide (CN): < 0.001 mg/L
The sample pH = 7.6
2. Soil sample, taken in a dry irrigation channel near pumping device, about 1 km from the bridge to the south, at the right bank of the River
Concentration cyanide (CN): < 0.5 mg/kg (wet sample)
3. Soil sample (sandy) taken in a dry irrigation channel near water distribution station, about 2 km from the bridge to the south, at the left bank of the River
Concentration cyanide (CN): 0.5 mg/kg (wet sample)
4. Soil sample (clay-structure) taken in a dry irrigation channel near water distribution station pumping device, about 2 km from the bridge to the south, at the left bank of the River, close near position of sample no. 3.
Concentration cyanide (CN): < 0.5 mg/kg (wet sample)
5. Soil sample taken in irrigation channel in a field situated at about 2 km from the Lake on the east side of the main road from Lake Issyk-kul to Barskoon
Concentration cyanide (CN): < 0.5 mg/kg (wet sample)
6. Soil sample taken in irrigation channel in a field situated at about 3 km from the Lake on the east side of the main road from Lake Issyk-kul to Barskoon
Concentration cyanide (CN): < 0.5 mg/kg (wet sample)
7. Soil sample taken in the garden of a house (Gagarin street, No. 53, Barskoon) where a family lives of which both parents were said to be hospitalized
Concentration cyanide (CN): 0.7 mg/kg (wet sample)
8. Water, sampled at the bay shortly east from the outlet of the Barskoon River in the Lake Issyk-kul
Concentration cyanide (CN): < 0.001 mg/L
The sample pH = 8.5
- 9, 10 and 11: Subsamples (randomly taken) from soil samples taken in gardens in the village by personnel of the laboratory of the regional authorities. Details known to the personnel of the local laboratory
9. Concentration cyanide (CN): < 0.5 mg/kg (wet sample)
10. Concentration cyanide (CN): < 0.5 mg/kg (wet sample)
11. Concentration cyanide (CN): 0.6 mg/kg (wet sample)

The samples have been measured 'as taken'. On a dry weight basis, the concentrations may be some 20% higher. Losses by transport are expected to be minimal. When these results were achieved, they have been immediately e-mailed to the WHO liaison officer in Bishkek.

The cyanide concentrations in the top layer of the soils on suspect sampling sites are low, as appears for example from the results of samples 3 - 7. The relatively 'highest' result (No. 7) is found in the garden sample (in the Gagarin street). This applies probably also

for No. 11. The results for No. 7 and No. 11 are definitely positive: there is still some cyanide, however not in a harmful amount on these sites. The results for the two water samples are below our limit of detection (of 0.001 mg/L).

Although the results did not prove at June 3, 1998, that the whole, possibly contaminated area would be completely safe, since only 9 samples from a potential area of say 40 km² is a low number of samples, they strongly indicated that no 'worst-case' situation existed (by which soil cyanide concentrations of a possible 25 mg/kg had been estimated). From cyanide chemistry point of view, it is readily conceivable that most of the spilled sodium cyanide will have reacted with the river water (pH < 9), to form the gaseous HCN.

During the second mission, a new sampling campaign has been started, on a variety of 'suspect locations', including gardens, in Gagarin street and Lenin street in Barskoon, of people that had been hospitalized after the accident. These samples now included not only soil and water, but also fruits and vegetables from the area. They have been analysed in a local laboratory in Karakol, using a portable Microquant[®] 14789 (Merck), with visual (colour) detection. The detection limit of this semi-quantitative method is 0.03 mg/L in the water sample or in the extract (which corresponds to about 0.2 mg/kg soil). All results were below the detection limit.

Additionally, the air has been checked on the presence of cyanides, using a portable device (by courtesy of IEM), operating according to NIOSH test method 7904. The (validated) apparatus gave no signal in the area, which means that the HCN concentration in the ambient air was below 5 mg/m³. After several hours of exposure to 20-40 mg/m³, light symptoms occur.

Kumtor also performed a lot of cyanide analyses in their laboratory, using Orbeco-Hellige Model 975 MP instrumentation. Every now and then, fact sheets were handed over to me (RC). An example of one of these sheets is given in Table 1 (on the next page). According to results on the sheets that had been provided, all results of cyanide analyses for samples taken five days or more after the accident were '0.0'. As the reliability of the data could not be tested, we had to take them for granted. The highest cyanide concentration ever provided by Kumtor on one of the sheets was 78.60 mg/L free CN⁻, on the very day of the accident, May 20, 1998, which is also shown in figure 1.

Results of cyanide analyses by the Kyrgyz State and Oblast ('provincial') laboratories were said to be in sharp contrast with Kumtor results. 'High' concentrations were mentioned. An inspection of one of these (Oblast) laboratories, in Karakol, gave the impression of a old-fashioned measurement devices. Moreover, no sodium cyanides standard solutions were present. Hence, the reliability of the those data could not been tested either. The Kyrgyz authorities longed for independent analytical results, from WHO/RIVM.

Table 1. An example of the fact sheets with results of cyanide analysed by Kumtor.

Министерство охраны окружающей среды			
Результаты			
анализов проб воды и атмосферного воздуха,			
отобранных в районе с. Барскоон 26-27 мая 1998 года			
<p>В период 26-27 мая 1998 года специалистами Чуйской экологической лаборатории и ЦНИЛ АО КГРК производилось комплексное обследование состояния окружающей среды в районе с. Барскоон. Были отобраны и произведен экспресс-анализ проб воды и атмосферного воздуха на наличие содержания циан-иона и синильной кислоты. Параллельно были отобраны контрольные пробы воды и почвы для производства анализов в лабораторных условиях. Экспресс-анализы проводились на американском приборе Orbeco-Hellige. Ниже приведены результаты анализов по состоянию на 27 мая 1998 года.</p>			
Место отбора проб	Число (время отбора проб)	Содержание CN-иона в воде, мг/л	Содержание HCN в атмосфере, мг/м ³
1. Мост, место аварии	26 мая - 15 ⁰⁰ 27 мая - 8 ⁰⁰	26 мая - 0,0 27 мая - 0,0	26 мая - 0,0 27 мая - 0,0
2. 20 м ниже места аварии	27 мая - 9 ⁰⁰	27 мая - 0,0	27 мая - 0,0
3. Канал в с. Барскоон (3 м ниже моста через дорогу)	27 мая - 10 ⁰⁰	27 мая - 0,0	Не отбирались.
4. Устье реки на слиянии с озером	26 мая - 16 ⁰⁰ 27 мая - 11 ⁰⁰	26 мая - 0,0 27 мая - 0,0	26 мая - 0,0 27 мая - 0,0
5. Бухта, 60 м от устья р. Барскоон на восток	27 мая - 12 ⁰⁰	27 мая - 0,0	27 мая - 0,0
6. Бухта, 80 м от устья р. Барскоон на запад	27 мая - 13 ⁰⁰	27 мая - 0,0	27 мая - 0,0
7. Поливной канал и поле в 100 м ниже сельской управы с. Борскоон	27 мая - 14 ⁰⁰	27 мая - 0,0	27 мая - 0,0
28.05.98 г.			

4.4 The complaints

In the days following the spill, a substantial number of people presented itself to the local medical officers with complaints of eye-irritation, headache, dizziness, epigastric pain and convulsions. Some presented themselves with chemical burns on hands, neck or feet. Many of them were considered intoxicated as their symptoms matched those caused by CN-intoxication. Some of them were therefore treated as such with i.v. medication (such as sodium nitrite, and dimethylaminophenol -DMAP).

Although this reflects international views, the severity of the intoxication that prompts such rigorous treatment, was not always taken into account. We also found that as a whole there was perhaps not enough consideration for the interval between exposure and disease or between the accident and the occurrence of symptoms. It is therefore likely that more patients were regarded as being intoxicated – and treated as such – than could be expected on the basis of exposure alone.

5 DISCUSSION AND RECOMMENDATIONS

The first questions to ask in the investigation of the impact of the accident were: 'when, what and where'. The place of the accident was clearly defined due to the remainders of the damaged parapet of the bridge and the demonstrated photographs of the video of the damaged truck. No one had any doubt on the moment of the accident (May, 20, 1988 at about noon, although one newspaper mentioned 'May, 21'). Also the composition of the spill, sodium cyanide was not doubted. The intended goal of the transport, a gold mine, supported the reliability of the composition. The authorities did not doubt on the amount of the spill, about 1762 kg (from two ruptured packages). In an early Russian press report (see Frame 2), 8 tons have been mentioned. In the 'very-worst-case' of a spill of all the 20 tons sodium cyanide, the danger for a long-lasting pollution of the river and the lake would be still minor, due to fortunate geo-hydrological conditions. However, for the possibly contaminated soil (gardens and agricultural fields), the reality of such a 'very-worst-case' would have caused a nightmare to many persons involved.

(Frame 2)

(May, 22, 1998)

IS ISSIK-KUL CONTAMINATED FOLLOWING TRUCK ACCIDENT?

A truck carrying 20 tons of sodium cyanide drove into the Barskoon River near the Issik-Kul lake, which is Kyrgyzstan's biggest tourist attraction, RFE/RL correspondents and ITAR-TASS reported on 20 May. Reports vary as to the extent of the damage to the environment. A spokeswoman for President Askar Akayev said there were no "environmental consequences." But "Komsomolskaya Pravda" on 22 May reported that 8 tons of sodium cyanide spilled into the river. Independent ecological experts told RFE/RL correspondents in Bishkek that the Kumtor gold mining operation, located in the mountains not far from Issik-Kul, refused to allow them to the site. Kumtor is a joint venture between Kyrgyzstan's state gold company, Kyrgyzaltyn, and Canada's Cameco Corp. BP

Before the first WHO mission, there was already doubt on the impact of the accident on public health and the environment (see Frame 3), in spite of the fact that both the Kyrgyz Government and Kumtor had declared that there was no dangerous situation. It was said that already 250 people sought medical help in the period May 20-24, and dead fish and cattle had been observed.

Obviously, a very dangerous situation must have existed in the first hours after the accident. A number of fortunate conditions prevented in our view an ecological disaster. These conditions are:

- The contamination started from a well defined point source;
- Only a single chemical substance was involved;
- The spilled sodium cyanide first contacted highly aerated water, and will be fast transformed into HCN gas, with sufficient wind prevented the build-up of a 'cloud';
- Further transport of the spill was canalized, either to the giant Lake or through pipes and ditches;
- The transported sodium cyanide remained at the surface in contact with the air;
- Sodium cyanide is biologically degradable;
- Low concentrations cyanides naturally occur in a number of plants.

(Frame 3)

(May, 25, 1998)

OFFICIALS CLAIM NO DAMAGE TO ISSIK-KUL...

Following an accident in which nearly two tons of sodium cyanide leaked into a river close to Kyrgyzstan's biggest lake, Issik-Kul (see "RFE/RL Newslines, 22 May 1998), Deputy Environmental Minister Tilekбай Kyshtobayev said at the scene of the accident that "there are no grounds for panic. No ecological disaster is expected," ITAR-TASS reported. That viewpoint was echoed by Gerhard Glates, the head of the nearby Kumtor gold mine. Glates said there will be no serious environmental consequences and that his company will cover all expenses for the cleanup. BP

...BUT MEDIA REPORTS SUGGEST OTHERWISE

Both ITAR-TASS and RFE/RL correspondents report that dead fish and cattle have been found near the scene of the accident. They also say that residents of the area have been warned against drinking unboiled water or swimming in the river or lake. Minister of Ecology Kulubek Bokonbayev told RFE/RL correspondents that since the 20 May accident, some 250 residents of the Issik-Kul region have sought medical help. Issik-Kul is a major tourist attraction in Central Asia. BP

On the other hand, some factors were not fortunate:

- The initial concentration spilled cyanide must have been very high in the Barskoon river;
- The river water functioned for a number of inhabitants of Barskoon as drinking water;
- The information on the accident to both authorities and the population was, on the first day, late and incomplete;
- The 'hypochloric' clean-up, possible also resulting in the formation of cyanogen chloride, and other chlorine containing compounds;
- The transports of cyanide to the Kumtor gold mine was a daily routine: the accident could happen every day again.

The number of patients kept growing, even a week after the accident. At the start of the first mission, the number of patients was already about 1,000. See Frame 4.

(Frame 4)

(May, 28, 1998)

KYRGYZ PREMIER COMMENTS ON ISSIK-KUL DISASTER

Kubanychbek Jumaliev held a press conference in Bishkek on 28 May to report on the consequences to date of the sodium cyanide spill into the Barskoon River, RFE/RL correspondents reported. Jumaliev said more than 1,000 residents of the southern Issik-Kul area have sought medical treatment and at least 93 have been kept in the hospital. Two people have died, while eight are in a serious condition and have been moved by helicopter to better facilities in Bishkek, he noted. The previous day, Deputy Premier Boris Silayev said the Kumtor Mining Company was irresponsible in its handling of the situation, pointing to the company's failure to inform the Kyrgyz government or local residents for several hours after the spill. A team of experts from the World Health Organization is due to inspect the scene of the incident on 28 May. BP

An increase in the number of people feeling themselves patient, is a common finding in environmental incidents, where a lack of prompt and complete information leads people to believe that results have been tampered with. The best strategy in such cases is to concentrate on solutions rather than on a thorough analysis of who is ill, or who may have been more concerned than exposed. We therefore proposed a risk-communication strategy, based mainly on toxicological criteria and the qualified analyses of soil samples. We also advised to make emergency plans for the prevention and control of future accidents.

The provisional recommendations provided during the first mission to the Minister of Health of the Kyrgyz Republic, Dr. A. Kasiev, on May, 28, 1998 in the afternoon, included:

- Do not eat products that have been in direct contact with the polluted soil;
- Meat and milk of healthy animals can be consumed;
- Prevent children to play at or with the soil in the polluted area;
- Flush the polluted area with plenty of water, until reliable measurements are available that indicate safe levels.

These recommendations have been directly communicated to the population in a mass meeting in Barskoon. One of the recommendations, 'Prevent children to play at or with the soil in the polluted area', seemed to have triggered a massive and costly evacuation (1c). In Frame 5, the announcement of the planned evacuation, as it appeared in the international press. (In this press report, the amount of spilled sodium cyanide has erroneously been given as 2,000 tons instead of 2,000 kg)

The Kyrgyz authorities were facing that last days of May 1998 a dilemma: Doing 'nothing' seemed politically suicide, whereas the effect a decision to evacuate 'women and children' would probably quiet part of the population ("They do at least something"), however it would panic another part: ("They admit that it is very serious, but the reaction is too late"). An additional effect of evacuation was that the holiday resorts north of Lake Issyk-Kul would no longer be empty. After the recommendations, there was a reason at hand to evacuate, as you cannot prevent children from playing with soil in an agriculture-based society...

(Frame 5)

(June, 4, 1998)

EVACUATION OF BARSKOON BEGINS

Kyrgyz Deputy Prime Minister Boris Silayev on 4 June announced that 3,500 residents of the Barskoon area on the southern shore of Lake Issyk-Kul will be evacuated to the northern shore, RFE/RL correspondents reported. The village of Barskoon is located near the scene of the 20 May spill of sodium cyanide into the Barskoon River. More than 1,000 people received medical attention in the week following the spill, and one woman died from cyanide poisoning. Residents of the southern shore are demanding the Kumtor gold mining operation, which is responsible for the spill, be shut down. Concerns have also been raised about the storage of 2,000 tons of sodium cyanide in the town of Balykchy, on the western shore of Issyk-Kul. Despite mounting evidence of a major environmental disaster, government officials continue to say it is safe to swim in the lake. BP

Another dilemma came up on June 3, 1998, as it turned out that the highest total cyanide concentration measured by the Laboratory of Inorganic Analytical Chemistry of RIVM, was 0.7 mg/kg in a garden in Gagarin Street in Barskoon. This figure was considered low by the Kumtor Operating Company, and high by the Kyrgyz Government. The idea was: in a pristine environment, there should be no cyanide! Moreover, in spite of all rather low analytical results, the number of patients still kept growing.

It was decided to ask again for assistance from WHO. A physician, and analytical equipment was asked for. During the second mission the physician (MvB) visited a number of patients, and talked to several doctors and medical specialists in different hospitals. A new sampling and measuring campaign started. As a result of the second mission, our reports were delivered to the Vice Prime Minister of Kyrgyzstan at about noon on June, 9, 1998.

The complete original texts of those reports are given here:

To: Chairman of the Government Commission
Vice Prime Minister of Kyrgyz Republic, B. Silaev
c.c. Minister of Health
Minister of Environment

Bishkek, June, 9, 1998

The first main question: is there danger to life in the Barskoon area, here and now?

- Except for a possible exposure route through the consumption of some vegetables (that are not deeply rooted), there is now, more than two weeks after the accident in Barskoon, no danger to life in the area.
- Meat, milk, all kind of fruits, potato's and wheat can be consumed safely. Information on the consumption of plants that are not deeply rooted, such as lettuce, radish, onions will be given by e-mail to WHO-Bishkek later in this week.

The answer of this first main question is based on:

- our measurements of free cyanide in soil on different suspect places, at 6-7 June 1998;
- our measurements of total cyanide in soil and in water on suspect places in samples taken 27-28 May 1998;
- 'worst case' calculations of the concentration of cyanide in the surface layer of the soil in the polluted area;
- knowledge of chemical pathways of cyanides in the environment;
- knowledge of natural processes in aerated soils by which the cyanides are kept at harmless level.

The Lake Issyk-Kul and its Future

As Lake Issyk-Kul is very large the final concentration of Cyanides from the accident, even in the "worst case" assuming all spilled cyanide in the Lake, will be extremely low.

From measurements in a suspected place, in the bay near the outlet of the Barskoon river, no cyanide (this means < 0.001 mg/L) could be detected in a sample taken on 28 May 1998.

In conclusion : There is no longer any danger to forms of life in the Lake.

Air

No gaseous cyanide (HCN) could be detected by our portable cyanide-in-air measurement device, in the Barskoon region, on many suspect places, even not in acidified soil samples.

It is expected that as sodium cyanide is in contact with water, a large fraction of it will be transformed to cyanide gas (HCN). This process occurs immediately, and its extend depends on the pH of the water.

Cyanide gas levels may have been dangerous only the first day after the accident.

Any smell of cyanide gas after a week is highly unlikely.

Note : also the applied hypochloric salt that has been sprayed in the channels after the accident, has a 'chemical odour'.

Recommendations

1. Accept a concentration in soil of free cyanide lower than 1 mg/kg as a safe value for human, animal and plant life.
2. Accept a concentration in (drinking and surface) water of free cyanide lower than 0.1 mg/L as a safe value for human, animal and plant life.
3. Accept that complexed cyanide in soil although undesired, Is not harmful upon exposure to human, animal and plant life.
4. Accept that the uncertainty in the measurements of low concentration cyanide (< 1 mg/kg or 0.1 mg/L) if high, easily rising to over 100 %. Therefore it is advised to round all data for cyanide concentrations (free or complexed) to only one digit after the decimal point, in mg/kg (soil, solid samples) and mg/L (water).
5. Accept that low concentrations of cyanides (all forms of cyanide, below 1 mg/kg in soil and below 0.1 mg/L in water) can be part of natural processes.
6. Consider as polluted area only the soil that has been in contact with irrigation water.

At present, more that two weeks after the incident, the river water, the channel water, the water in the Lake and the air should no more be mentioned as "polluted".

There will be remains of soil pollution by cyanide at low, harmless levels for a long time.

7. Since the measured concentration of cyanide in soil suspected places in Barskoon are now (June 6, 1998) below 1 mg/kg, flushing is no longer a requirement.
8. Since the measured concentration of cyanide in soil on suspected places in Barskoon are now (June, 6, 1998) below 1 mg/kg, the restriction for children to be in contact with the soil, can be relieved.
9. Washing hands after contact with soil is to be advised for any soil.
10. In Gagarin street N 53 in Barskoon we measured a total cyanide concentration of 0.7 mg/kg (wet soil) after 7 days.

This means:

a. a strong indication of pollution in the days before, since the cyanide level will decrease daily

b. a level lower than 1 mg/kg, and thus - now- without any threat for life.

Although it will take a long time to reach background levels again, it is expected that in aerated soil the remaining (harmless) level of cyanides will decrease continuously.

To: Chairman of the Government Commission
Vice Prime Minister of Kyrgyz Republic, B. Silaev
c.c. Minister of Health
Minister of Environment

Bishkek, June, 9, 1998

QUESTIONS ABOUT PATIENTS, AFTEREFFECTS AND THEIR TREATMENT

Have all the patients (> 2000) really been poisoned?

During and immediately after the incident, there was a possibility for serious disease through (oral or dermal) contact with CN in the water and/or (possibly) HCN in the air. With the passing of time relevant exposure became less and less probable, because of the following reasons.

1. dilution of the CN -concentration in the soil and irrigation channels through flushing
2. decomposing of CN in soil through natural processes (sun, rain, bacteria).
3. combining of CN with metals to form stable complexes
4. use of hypochlorite which destroys CN

When there is no relevant exposure, there is no potential for disease. It should be kept in mind that CN is a substance which occurs in many natural products, like certain roots, fruits (apricots !) and certain vegetables. Please keep in mind that this is a natural process. CN is also a part of vitamin B12 which is essential for human beings. The human body can thus get rid of CN and does so by converting it to thiocyanate. This is a rapid process, after one hour only 50% of the original concentration can be found in the blood, after the second hour 25%, after the third hour 12,5%, etc.

Only when there is massive exposure, a serious and potentially lifethreatening situation occurs. In such a situation serious symptoms occur rapidly, because of lack of oxygen in the brain and the heart. Only then symptoms like palpitations, convulsions and coma occur. Generally speaking, if a patient still lives after four hours he will recover, even from serious exposure.

Without such a high concentration of CN in the body, symptoms are minor, if any, and will resolve quickly in the absence of exposure. Concentrations in the blood will also diminish quickly and symptoms will subside. The concentrations in the soil that have been found after a few days make it unlikely that so many patients were intoxicated.

This of course does not rule out that people have smelled the typical odour or have had dermal contact with CN some days after the accident. It should however be clear that no serious disease could have resulted from that exposure.

It is therefore also unrealistic to attribute the symptoms reported by the inhabitants of other villages, at a distance of some kilometers, to CN-intoxication. There is also no other potential route for CN e.g. via groundwater or via the air that could have resulted in their exposure. Only in sandy soils a very small quantity of CN may reach groundwater. In clay CN is bound by metals to form stable complexes and/or decomposed by micro-organisms; thus it cannot reach groundwater. CN that as HCN has been released to the air will disperse rapidly and can never reach toxic concentrations at such distances (See also previous remarks on HCN in air).

Aftereffects

There is no reason to be afraid of genetic or reproductive effects of CN, especially at low doses, because CN is a substance which is found in our food. There is thus a continuous (low) exposure, depending on the diet. As has been mentioned previously, CN is rapidly removed from the body by conversion to thiocyanate.

Treatment

The treatment schemes that we have seen seem appropriate and, especially step 1 – amylnitrite, NaNO₂- and thiosulfate – reflect the latest international views on the treatment of cyanide intoxication. However, they should be applied in serious cases and also immediately after exposure. When used later they are not very useful and probably not without risk.

Conclusions

It is unlikely that as many as 2000 (or more) patients have experienced a cyanide intoxication, due to the absence of possibilities of relevant exposure after the first few days. (See also previous remarks on soil-concentrations.) Knowing this, treatment schemes, although clinically spoken correct, may have been applied too rigorously. Aftereffects (genetic, reproductive, cancer) are not to be expected.

In stating that cyanide intoxication was not likely to be as wide spread as was felt by the patients or reported by the physicians, we should keep the following in mind.:

1. absence of information about the accident in the first few hours
2. general knowledge among people and physicians that cyanide is a potent toxic compound
3. overflow of patients at Barskoon outpatient department and resulting stream of patients to other hospitals
4. through lack of information about precise nature of cyanide intoxication, no clear statements from physicians who is a patient and who is not.
5. therefore any patient with concern about his/her own health or the health of their children becomes concerned and seeks medical advice.

This pattern we have seen in Holland quite often., when there was a lack of information.

Recommendations

1. Make plan for riskcommunication, local newspaper, massmedia etc.
2. Give information about nature of cyanide intoxication and absence of possibilities for further exposure.
3. Make clear that the lake and fish is safe. CN does not build up in fish.
4. Make clear that animals and animalproducts are safe. If necessary state that CN cannot build up in animals, because it is either broken down quickly or animals are dead immediately after exposure.
5. Open information centre where everybody can go with questions about health, food products or other.
6. Consider making emergency plans for factories in the vicinity of cities

During the second mission we had the opportunity to experience the Kyrgyz democracy. A mass meeting near Barskoon, with representatives of the government, of Kumtor, of the population and the authors, in the function of WHO experts, points of view have been exchanged very directly. We had the impression that everyone could tell what he really wanted to say.

Also in a scientific meeting, on June 9, 1998 in Bishkek, with representatives of the Ministry of Public Health, and of the Ministry of Environment, with experts from Kumtor, from the Russian Federation and the authors, scientific arguments have been changed openly in a firm dispute.

The day after our report, on June 10, 1998, the Kyrgyz president announced that the danger is over, and the evacuees were allowed to start to return home. See Frames 6 and 7.

(Frame 6)

(June, 10, 1998)

KYRGYZ PRESIDENT SAYS NO MORE DANGER FROM TOXIC SPILL...
Askar Akayev said on 10 June there are no longer any dangers posed by spill of sodium cyanide near Lake Issyk-Kul, Interfax and RFE/RL correspondents reported. According to Akayev, who was speaking in Astana, Kazakhstan, "the lake is alive and well and is looking forward to tourists." He added that Issyk-Kul is "absolutely not contaminated" as the chemical "dissolves into harmless components" when mixed with water. The same day, officials from the Kumtor gold mining project told a news conference in Bishkek that experts from Canada's Department of Foreign Affairs and the World Health Organization have reached the same conclusion. BP

(Frame 7)

(June, 16, 1998)

BARSKOON EVACUEES BEGIN RETURNING HOME

A local official in the Kyrgyz district of Issyk-Kul told RFE/RL's Bishkek bureau on 16 June that residents of the Barskoon village evacuated following the 20 May spill of sodium cyanide into the Barskoon River have started to return to their homes. Some 5,000 residents from the village were evacuated from 4-9 June. Three people have died from sodium cyanide poisoning, more than 2,500 have been poisoned, and some 800 have been hospitalized.

The aftermath

After the environmental problem was settled, the political aftermath began, and this was not yet ended in 1999. For instance, the department head of the Kumtor gold mining venture, which was being held responsible for the spill, was to be replaced by one of his predecessors. Also, the resignation of the Minister of Environment was demanded, see Frame 8. Also, ecological and human rights organizations started their own inquiries and investigations. The official number of people that died as a result of the accident in Barskoon stuck on 3-4. Some Kyrgyz politicians persist in higher numbers, up to 80 (16). Several commissions started to investigate the accident in Barskoon (see Frames 8 and 9).

(Frame 8)

(June, 15, 1998)

KYRGYZ PARLIAMENT DEBATES BARSKOON CYANIDE SPILL...

The Kyrgyz parliament on 13 June voted to create an international commission to monitor the aftermath of the 20 May spill of 20 tons of sodium cyanide into the Barskoon river, which flows into Lake Issyk-Kul. The previous day, deputies rejected the testimony of cabinet ministers who claimed that the cleanup of contaminated soil and water at the site of the accident has been completed, RFE/RL's Bishkek bureau reported. The deputies demanded the resignation of Ecology Minister Kulubek Bokonbaev and President of the State Gold Company Dastan Sarygulov. They also voted to revise the agreement between the Kyrgyz government and Canada's CAMECO corporation, one of whose lorries was involved in the accident, and to request that the Canadian government pressure CAMECO to pay compensation, estimated at \$1 million. Four people have died of cyanide poisoning and 790 are still hospitalized. LF

(Frame 9)

(June, 22, 1998)

ANOTHER COMMITTEE FOUNDED TO INVESTIGATE KYRGYZ CYANIDE SPILL Representatives of several Kyrgyz ecological and human rights organizations have founded a Committee to Protect the Environment, RFE/RL's Bishkek bureau reported on 17 June. The committee intends to conduct an independent investigation into the 20 May accident in which a lorry carrying 20 tons of sodium cyanide plunged into the Barskoon River. Kyrgyz parliamentary deputies and intellectuals founded a Committee to Protect Lake Issyk-Kul (into which the Barskoon River flows) on 22 May, and the parliament on 13 June voted to create an international commission to investigate the causes of the accident (see "RFE/RL Newswire," 15 June 1998). A State Customs Committee spokesman on 17 June said that the committee will sue the Kyrgyz-Canadian gold-mining joint venture whose lorry was involved in the accident for \$1.44 million in unpaid customs duties. LF

The future

The Cameco Corporation went to Kyrgyzstan looking for gold only 5 years ago. The Kumtor gold mine is located in the remote Tien Shan mountain range. A winding supply road scars the mountain. Every day, trucks make a treacherous 4,000 metre climb to the top, delivering men, equipment and sometimes the toxic chemicals used for gold mining. The possibility of another similar accident is real. There are more gold mines in Kyrgyzstan, operating under corresponding conditions, see Frame 10.

(Frame 10)

(December, 15, 1998)

KYRGYZ NEWS - CHEMICAL ACCIDENT IN NARYN REGION. Our correspondent in Naryn region reports that local authorities have determined that 70 liters of sodium cyanide have been spilt on the courtyard of the regional hospital in the town of Naryn. 56 tons of sodium cyanide have been transported from China to Naryn recently and it was found yesterday that 70 liters of the chemical had been lost. The chemicals will be used at the Makmal gold deposit in the Naryn region. The hospital had been taken in guarding and experts from the Ministry of Environment have been invited from Bishkek.

For the gold mines in Kyrgyzstan, being located high and isolated in pristine mountains, and operated by mostly western technicians, a more severe environmental control is urgently requested. Fortunately, some investors take their own responsibilities. The 'Overseas Private Investment Corporation' (OPIC) mentions in its Annual Environmental Report of April, 1999, that it took the lead in organizing a group of lenders and co-insurers to respond to the consequences of a chemical spill on locally affected communities. It was also leading a response to the accident in Barskoon. A citation from their report on the Barskoon accident: 'Immediately after the accident a panel of toxicologists from the World Health Organization, Canada and Russia visited the site of the spill and determined that there was no longer any cyanide in soils or waters. However, OPIC remained concerned about the causes of the spill and the company's response to it. To address these concerns, OPIC hosted a meeting of lenders and insurers with KOC in July. At that meeting the company responded to OPIC's concerns and made commitments to revise its emergency response procedures and examine the transportation route. Following the meeting, OPIC, along with other lenders and insurers, revisited the mine site, including the transportation route, the accident site and the downstream village that was affected by the spill. Improvements were made and OPIC is continuing to monitor the project's compliance with international environmental standards and best practices to minimize the risk of future incidents. An international panel of Russian and Canadian scientists subsequently conducted a detailed investigation and their published report (available at www.envirolab.nrcan.gc.ca) found no evidence of any direct linkages between the spill and illness or fatalities among the resident population' (17).

In the aftermath of the accident, it appeared that up to 17,000 people had been applied for medical assistance. One of the main items in the aftermath is the issue of the money. See Frame 11. Kumtor started to repair roads and construct drinking water supply systems in and near Barskoon.

(Frame 11)

(September, 13, 1998)

KRGYZ NEWS

GOVERNMENTAL MEETING ON BARSKOON ACCIDENT. According to sources in the Government, no decision was taken at the governmental meeting on chemical accident in Barskoon, held behind closed doors in Bishkek on 11 September. Sources say Prime Minister Kubanychbek Jumaliev had not been satisfied with the report on accident, prepared by the governmental commission together with the Ministry of National Security. Jumaliev demanded to soften some conclusions and announced next meeting on accident would be held on 24 September. It was announced at the Friday meeting that total damage to Kyrgyzstan from the accident is estimated as much as 91,279,467 som (about \$4.5 million). A truck with 20 tons of sodium cyanide crashed into the Barskoon river, which flows into the Issyk-Kul lake, on 20 May 1998. 4 people died, about 2,600 people were poisoned, more than 1,000 of them were hospitalized, more than 17,000 people (residents of the villages situated in the Barskoon valley) applied for medical assistance from 20 May till 1 August. About 5,000 residents of the Barskoon village were evacuated to the northern side of the Issyk-Kul lake for a week in June.

The Kumtor Operating Company (KOC), owner of the truck, announced last July it had spent more than 9 million som (about \$470,000) for compensations to 7,200 residents of the Barskoon village and to 3,600 residents of the neighboring Tamga village. 11 million som (about \$580,000) have been spent for rehabilitation of suffered people at the resorts and 10 million som (\$530,000) have been spent for constructing running water system in Barskoon. Also, 2 million som (about \$105,000) would be allotted for reconstruction of the road to Kumtor and 1,5 million som (about \$80,000) would be spent for tourism advertisement. Total sum of KOC expenditures would be about \$2 million.

In December 1998, Kumtor announced to open a diagnosis and monitoring center, too late to prevent acts of resistance in the population. See Frame 12. More than half a year after the accident, there are still actions against the way the aftermath of the accident has been handled. The information that will be given cannot outweigh the information that had to be given the first hours and days after the accident. There exists a long history of environmental accidents in which cyanide was involved. The chemistry of cyanides is well known. Moreover cyanide has the strong connotation of toxicity, fear and death.

(Frame 12)

(December, 15, 1998)

KYRGYZ NEWS

DIAGNOSIS CENTER WILL BE OPENED IN BARSKOON. The Canadian Kumtor Operating Company (KOC) announced in Bishkek today that a center of diagnosis and monitoring would be opened in the village of Barskoon (the Issyk-Kul region) on 20 December. The KOC bears all construction expences and will finance the center at least one year. The KOC is developing the Kumtor gold deposit. A truck with 20 tons of sodium cyanide, belonged to the KOC, crashed into the Barskoon river last May, spilling about 2 tons of the chemicals. 4 people died from poisoning in June. The Vecherni Bishkek daily writes in its today's edition, that residents of the Barskoon village have closed the road to the Kumtor for a week, demanding promised 6.5-million-som (about \$ 225,000) compensation for their contaminated agricultural products.

In the history of ore mining, numerous accidents with cyanide have happened, mostly occurring on remote locations without victims. The largest spill of cyanide known occurred in 1994 in Guyana, where an estimated 4000 tons of cyanide was said to be leaked out a gold mine's tailing pond into a 50-mile stretch of the Essequibo River, killing fish, domestic animals and wildlife by the thousands (18). In that case the Guyanese government stated that they had not the financial or technological means to cope with the cyanide flow. This represents the basic dilemma of developing countries: trying to push their economy by allowing the mining, whereas in cases of accidents, no own means can be provided to cope with dangerous situations. In such cases, relatively limited accidents may grow to disproportional incidents, like in Barskoon.

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Appendix 1: MAILING LIST

- 1 Director of the Directorate of Health Policy, mr. S. van Hoogstraten
- 2 Director-General of Public Health, dr. H. Schneider
- 3 President of the health Council of the netherlands, prof. dr. J.J. Sixma
- 4 drs. G.E.H. Houben, Ministry of Welfare, Public Health and Sports
- 5 dr. J Theunissen, WHO-Centre, Copenhagen
- 6 dr. F.X.R. van Leeuwen, WHO-Centre, Bilthoven
- 7 dr. B. Pesch, Medical Institute for Environmental Hygiene, Düsseldorf
- 8 Depot of Dutch Publications and Dutch Bibliography
- 9 Deputy Director-General and Director Public Health RIVM, dr. G. Elzinga
- 10 Director Environment RIVM, prof. ir. N. D. van Egmond
- 11 Director Division Risks, Environment and Health, dr.ir. G. de Mik
- 12 Laboratory of Ecotoxicology, dr. Canton
- 13 Laboratory of Soil and Groundwater ir. R. van den Berg
- 14 National Poisons Control Centre, dr. J. Meulenbelt
- 15 Centre for Substances and Risk Assessment, dr. W.H. Könemann
- 16 Inspectorate Research and Environmental Incident Services, ir. J.J.G. Kliet
- 17 Laboratory of Inorganic Analytical Chemistry, ir. H.J. van de Wiel
- 18 drs. J.A. Bakkes (RIVM/MNV)
- 19 F. Fortezza (RIVM/IEM)
- 20 ing. T. Knol de Vos (RIVM/IEM)
- 21 dr. M.G. Mennen (RIVM/IEM)
- 22 dr. ir. H.W.Köster (RIVM/LBG)
- 23 dr. R. Ritsema (RIVM/LAC)
- 24 dr. J.L.M. de Boer (RIVM/LAC)
- 25 drs. ing. S.E.J. Buykx (RIVM/LAC)
- 26 dr. ir. M.A.G.T. van den Hoop (RIVM/LAC)
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