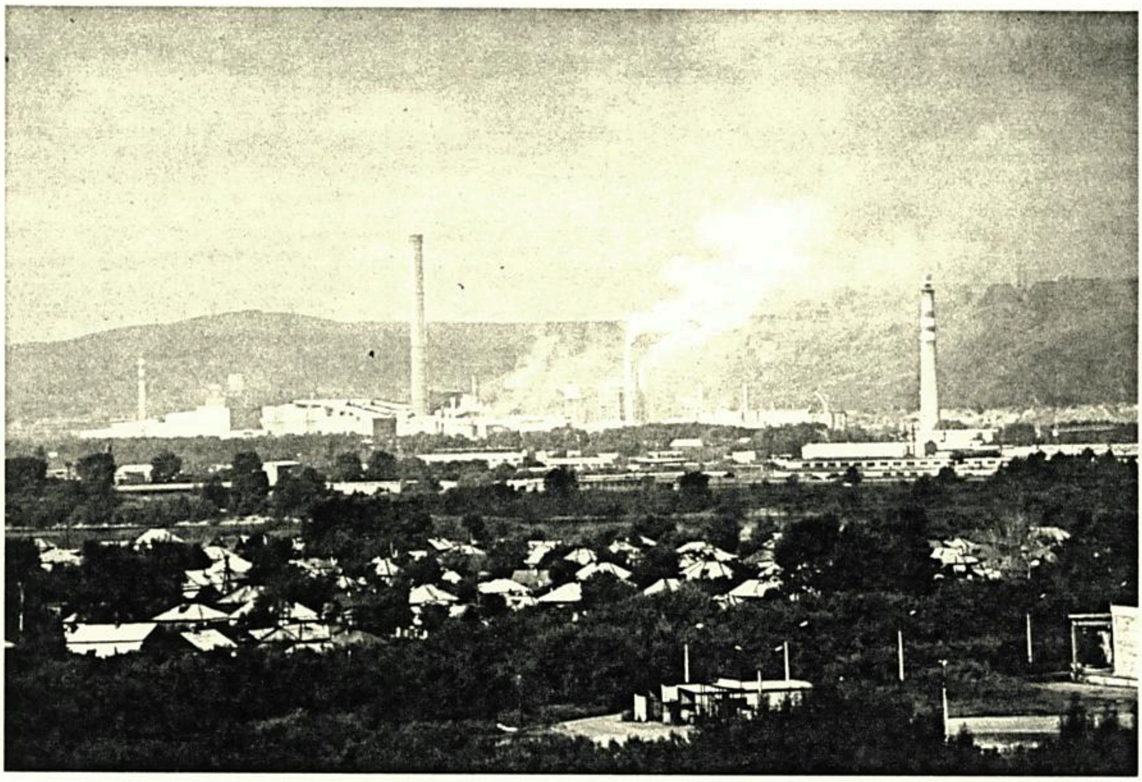
GREENPEACE

ENVIRONMENTAL POLLUTION IN THE KUZBASS, SIBERIA

A GREENPEACE REPORT



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Amsterdam, January 1993

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1. INTRODUCTION

1.1 The presented area

The area described here was visited in 1991 together with a group of journalists from different countries. The "expedition" started in the Kuzbass basin following the Tom river, continued in the part of central Western Siberia along the Ob river and ended in the northern part of Western Siberia in the Tundra, north of the Polar circle.

This paper deals only with the Kuzbass basin and its environmental problems. This region in the southern part of Western Siberia falls within the boundaries of the Kemerovskaya Oblast (district). Its administrative centre is the city of Kemerovo. The Oblast is located between the Altai Mountains in the East and South, and the Salairskii hills in the West which are the watershed between the Ob and Tom rivers. The Tom river and hundreds of smaller and bigger tributaries is the main waterway. It rises in the Kuznesker Alatou, runs through the Kuzbass and flows into the Ob river downstream from Tomsk in the Tomskaya Oblast (see Annex Figure 1).

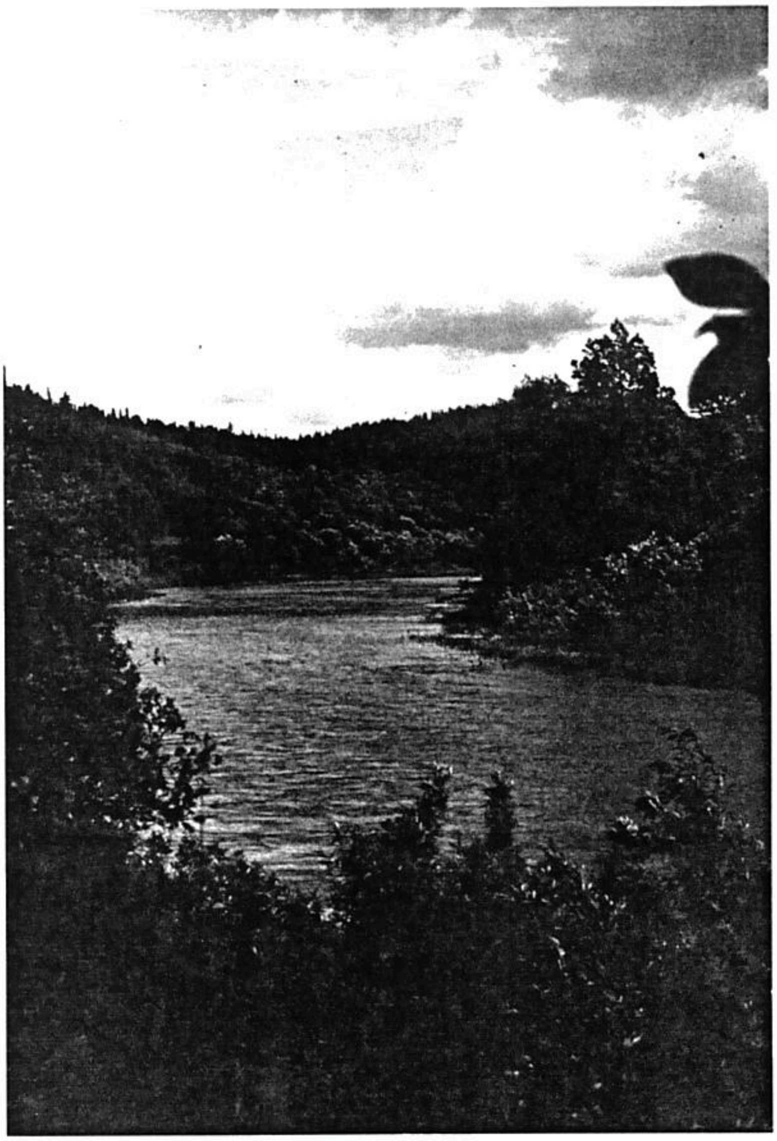

Photo 1: The River Tom rises in the Kuznesker Alatou and runs through the Kuzbass.

The Kuzbass is heavily industrialized: over 100 coal mines (including open pit mines) and numerous heavy industries like steel, aluminium and chemicals. As an example, the production rate for 1990 is listed here in tonnes (annual) for the most important industry branches in the Kuzbass (KASNIN, unpublished data, 1991).

coal	150,000,000
steel	12,300,000
steelplates	8,457,000
coke	7,538,000
cement	4,783,000
fertilizers	537,000
aluminium	286,000
zinc	10,000

The first major strikes in the USSR were in the coal mines in the Kuzbass in 1989. These were partly due to environmental problems. The heavy industry is often concentrated in the centre of cities like Kemerovo and Novokuznetsk.

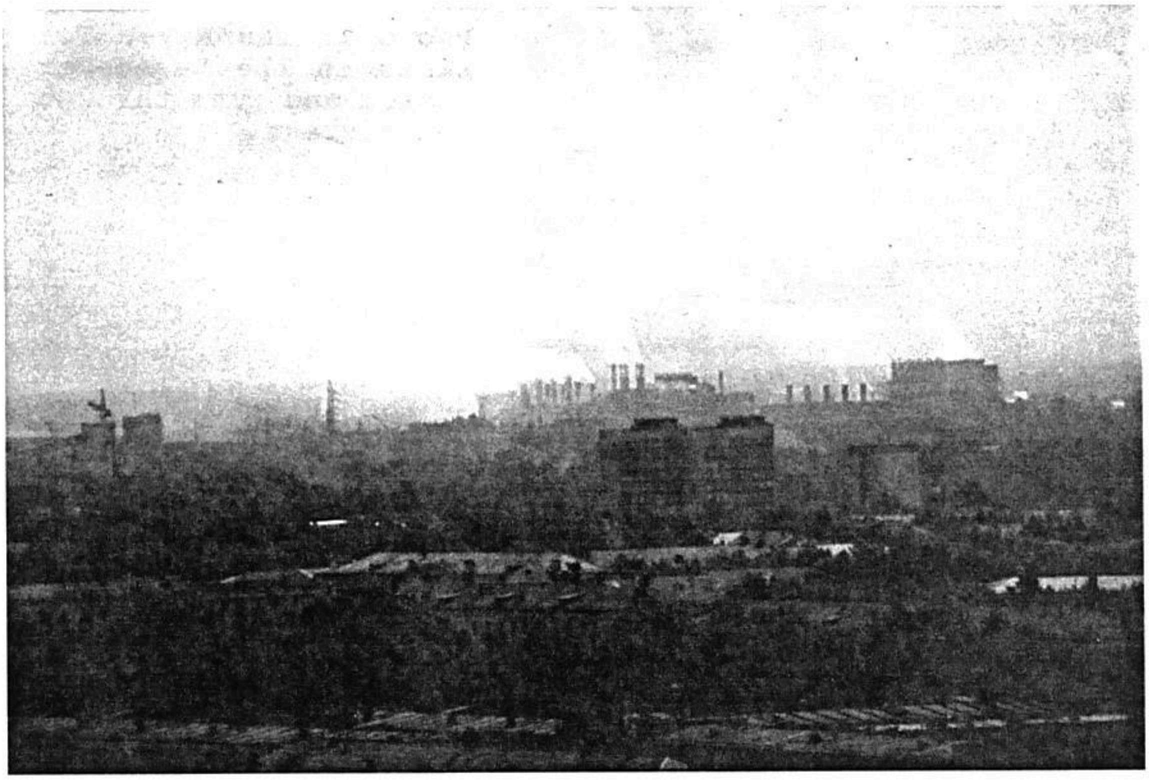

Photo 2: Heavy industry in Novokuznetsk.

1.2 Main environmental problems

There is a lot of SMOG formation in the cities because of the industrial emissions and because most of the cities are situated in valleys and the Kuzbass itself is surrounded by mountains. Smog formation occurs mainly in summer and winter times. In 1990 the city of Kemerovo had 165 days of smog, which led to a lot of complaints from the community. Permissible levels of concentration for several substances of air pollutants were exceeded in these periods. All information in this chapter was provided verbally in 1991 by ANDRAGANOVA from GOSKOMPRIRODA, Kemerovo (GOSKOMPRIRODA = State Committee for Nature Protection).

An additional point of concern is the car exhaust. About 20% of the cars violate rules. However, the control of cars is totally inadequate. A big problem is the lack of spare parts and the poor quality of gasoline.

The industrial WASTE WATER is discharged into the river Tom and its tributaries and flows through the river Ob into the Arctic ocean. Only about 50% of the waste water is treated, most treatment plants are overloaded and the cleaning efficiency is low.

RAINWATER is not treated at all and the run off from land contributes to an unknown extent to the water pollution. The melting of polluted snow in spring also contributes to water pollution.

The SOIL itself is polluted by atmospheric deposition near industrialized centres.

Other environmental problems are the lowering of GROUND WATER levels and drying up of small rivers by the coal mines. Large amounts of waste, especially ash and slack from metallurgy plants, are dumped on land and riverbanks. Leaching and run off probably pollute ground and river water, but no data were reported to us.

2. INVESTIGATION METHODS

In the cities visited, information was gathered from governmental authorities, scientists, members of ecological groups and from the population itself. One of the most important sources of information was the State Committee for Nature Protection (GOSKOMPRIRODA) which is in charge of environmental controls and accountable directly to the Russian Republic. It's task is the control and enforcement of air, water and nature, including waste control and enforcement of measures to curb pollution of air, water discharges and air emissions.

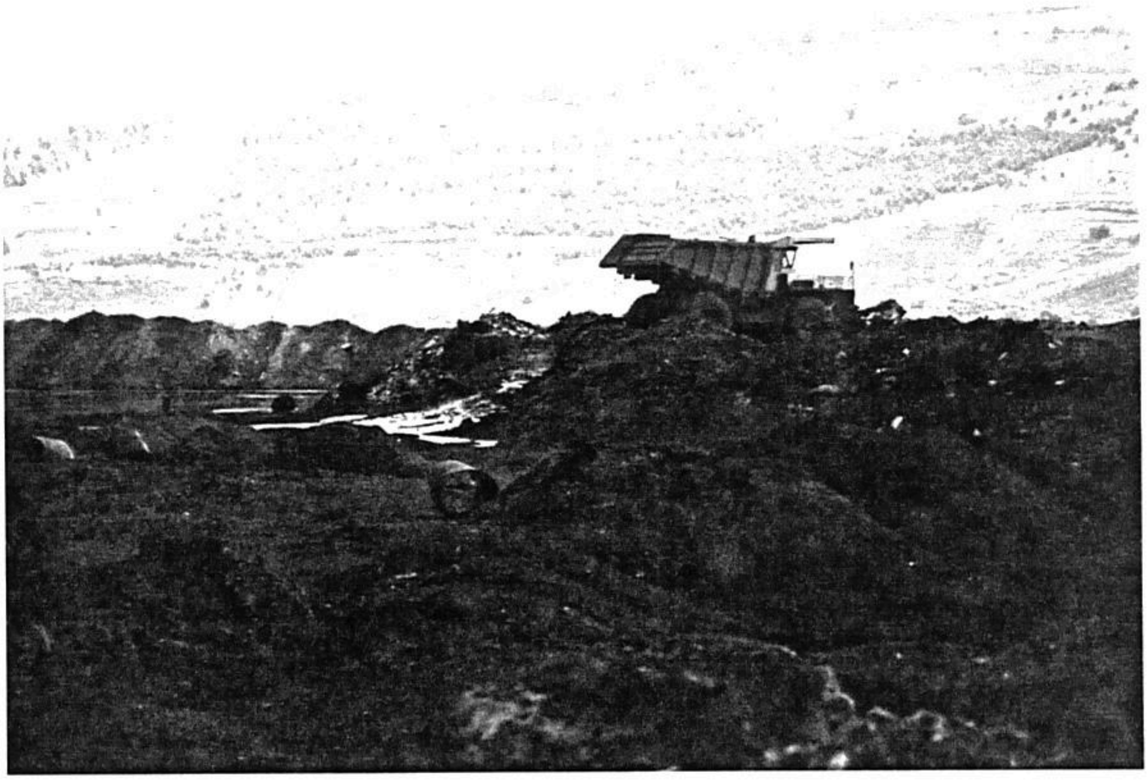

Photo 3: Large amounts of waste, especially ash and slack from metallurgy plants, are dumped on land and riverbanks.

On this basis, plans were made to visit the sites. We were only able to take measurements in the case of water quality investigations. Some parameters could be measured on site, but many more were measured later in the stationary GREENPEACE lab at the University of London (QMW). For this purpose, samples were taken and preserved. Nevertheless it took several weeks to transport the samples to the UK. Evaluating the results, one has to take into account that the water quality has changed in the meantime. In most cases, one has to expect that the concentrations had decreased in the meantime by degradation and evaporation (volatile compounds) and that our results are mainly too low(!). In the presence of strongly oxidizing chemicals like Cl_2, it is also possible that oxidation/chlorination of compounds still continued after sampling. The same can happen in the drinking water pipes.

3. INFORMATION ABOUT AIR POLLUTION

3.1 Official data

The air pollution in the industrialized cities is severe. The main sources of air pollution in Kemerovo are chemical plants, in Novokuznetsk and Belowo metallurgical plants and in Kopvoplesy

and other coal mining centres the coal mines. The annual amount of air emissions is 1.500.000 tonnes. About 60 % is treated with an efficiency of 70-75 %. About a quarter of all air treatment facilities are defective (ANDRAGANOVA 1991, press. comm.).

Therefore, the results of control measurements by GOSKOMPRIRODA for Kemerovo, Novokuznetsk and Prokopclak are not surprising. They are given in table 1. of the annexe. The maximum permissible levels are frequently exceeded, especially for benz(a)pyrene and dust.
In a single year the concentrations of the measured compounds exceeded the permissible levels by a factor of five or more, in Kemerovo 52 times and in Novokuznetsk 30 times.

Citizens reported a lot of complaints to GOSKOMPRIRODA in periods of smog formation. Investigations by the State Committee of Hydrometeorology Novosibirsk showed that sulphur compounds like SO_2 are the main cause of complaints.
They also identified 16 organic compounds e.g. naphthalene, organic acids and chlorinated compounds. But especially the volatile compounds are considered to be difficult to identify and to quantify. GOSKOMPRIRODA recommends that the list of controlled substances must be expanded to include at least by alkyl compounds and PAH's.
The heavy metal content in dust is high. In addition, lead aerosols (lead tetraethyl) can be found in the cities due to the traffic. About 80 % of the total amount of lead is released into the atmosphere by car exhaust gases. According to GOSKOMPRIRODA, as much in Novokuznetsk 20 % and in Kemerovo 40 % of the total air emissions come from car exhausts. Car engines peform badly because of a lack in modern technologies, spare parts and the use of only leaded petrol.
On data received from Chromomas Spectroscope, 175 individual organic compounds were identified in the air and 145 in the water and snow. Among them alkanes, naphtene, olifines, aromatic and polycyclic hydrocarbons, aldehydes, ketones, ethers, spirits, organic acids, nitrogen, sulphur and chloride containing organics, pesticides and others.

The biggest air polluters are the Coke Chemical plants AZOTE and Carbalite. Other big pollutors in Kemerovo are Chemprom, Aniline paint factory and the New Kemerovo Electrical Station.

3.2 Health effects

Air pollution can give rise to a broad range of effects. Many pollutants are known to be carcinogenic (such as benzene, arsenic, acrylonitril, chromium(IV), nickel, vinyl chloride and polynuclear aromatic hydrocarbons.

One of the most profound carcinogenics is benzo(a)pyrene. This organic compound is stable under normal conditions but it can react with nitric oxides in the air and with chlorine in drinking water. This leads to the formation of even more toxic substances.

Benzo(a)pyrene has a high tendency for bioaccumulation. Bioaccumulation factors of up to 10 000 have been found (for more details see KOCH and WAGNER 1989). WHO scientists calculated that a lifetime exposure to a concentration of one microgram per cubic meter (1 ug/m3) benz(a)pyrene gives an estimated cancer risk of 9 % (9 out of 100 persons will get cancer when exposed to 1 ug/m3). The effect is worse in the presence of sulphur dioxide (WHO 1987).

Sulphur dioxide and particulate matter can have serious health effects for the lung system, like bronchoconstriction and chemical bronchiteitis and tracheitis, bronchospasm in asthmatics, chronic bronchitis, pulmonary effects and increased mortality. SPANGLER et al. (1990) estimate that in the USA 4-9 % of mortalities may be associated with sulphate exposures (acid aerosols). The WHO advises a long term guideline value for sulphur dioxide of 50 ug/m3.

Another important air pollutant is lead. Lead is known to interfere with different enzyme systems and almost all organs or organ systems may be considered potential targets for lead, and a wide range of effects of lead have been documented. The most critical effects are those on haem biosynthesis, erythropoiesis, the nervous system and blood pressure (WHO 1987). Children have been found to be more sensitive to the effects of lead, particularly as far as the central nervous system is concerned. Lead exposure is known to be an important cause of behavioral dysfunction in children (FISCHBEIN 1983). The WHO recommends a guideline for lead of 0.5-1.0 ug/m3.

4. RIVER WATER POLLUTION

Information about river pollution was given by KAZNIN, SERGEJEV and ANDRAGANOVA 1991 (personal communication and unpublished data).

The annual amount of waste water is 2.555.000.000 m3. Only 1.272.000.000 m3 of waste water is treated. The waste water treatment plants are often not efficient enough. About 20 % of the untreated water is cooling water. About 765.000.000 m3 of untreated waste water runs into the river Tom. In recent years years, there has been only a 0.5 % decline in the amount of waste water.

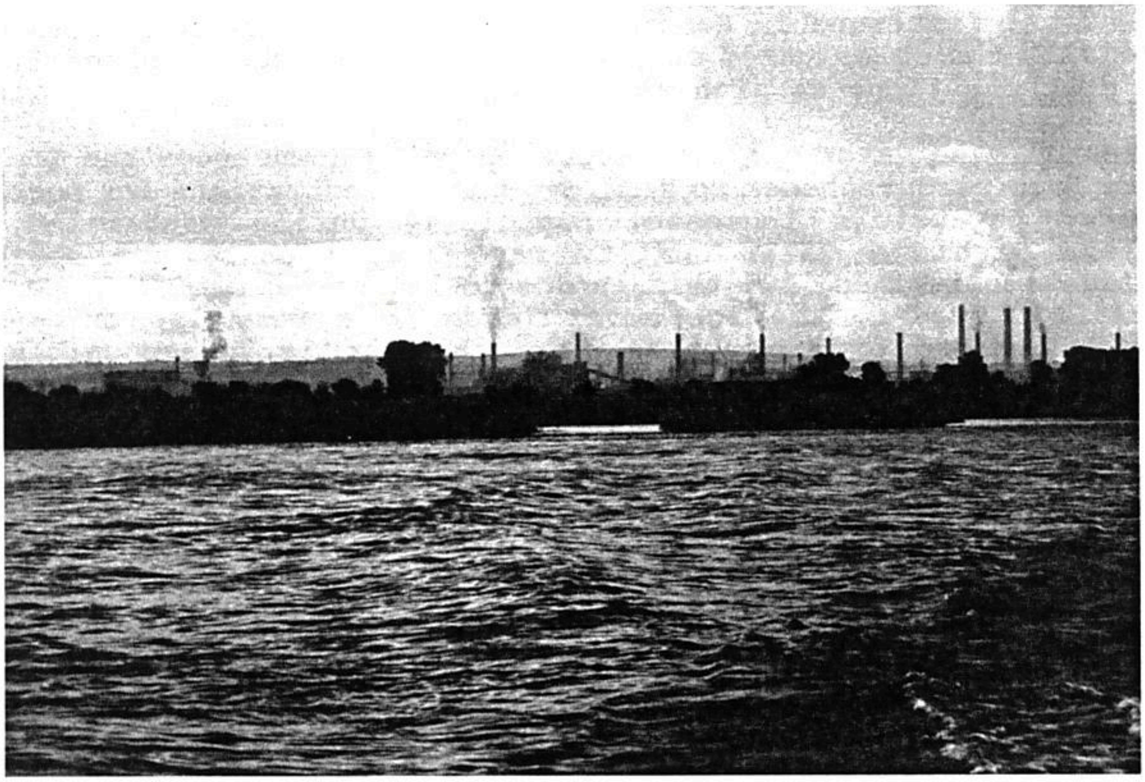

Photo 4: The annual amount of waste water discharged into the Tom river is 2.555.000.000 m3, of which 30% is not treated at all. (photo: Novokuznetsk).

A part of the industrial waste water is discharged into the municipal sewage system. We visited the treatment plants in Novokuznetsk and Kemerovo. Both treatment plants have a mechanical and a biological section. In winter the biological tanks have minimum temperatures between 15 'C (Novokuznetsk) and 10 'C (Kemerovo). We were not able to investigate the performance of the treatment plants. The waste water is chlorinated before it is discharged into the Tom river. The chlorination is prescribed and controlled by the sanitary service. A part of the industrial waste water is treated on site. We have got no information on the treatment facilities.

No records of spills were reported to us. According to locals, dead fish regularly float down the rivers, probably poisoned by industrial spills. Organisms that occur only in clean and oxygen rich waters, like sensitive species of stonefly larvae and gammaridae, do occur upstream in the Tom river where the water is clean but are absent downstream of the polluted cities of Novokuznetsk and Kemerovo.

The State Committee controls only a limited range of parameters in surface waters. Beside general parameters like oxygen demand and nutrients, only phenols, oil, copper and, in some places, the pesticides DDT, DDE, gamma-HCH and alpha-HCH are measured.

The Medical Institute in Kemerovo made additional measurements. Especially the chlorinated compounds often occurred in extremely high concentrations as high as the mg/L range.

In general, the water quality decreases going downstream the Tom river. From Mesdurechensk to Kemerovo the concentrations for most measured parameters increase. Especially during wintertime, problems with the water quality may arise because the self purification is then low; this is due to low temperatures. After some time however, the ice cover leads to a very low oxygen content because oxygen uptake from the air is not possible anymore. As an example, values were reported for Novokuznetsk to be as low as 0.1 - 0.2 mg/L.

5. DRINKING WATER POLLUTION

5.1 Technical preconditions and their evaluation

The Tom river and its tributaries are the main raw water sources for the drinking water supply. The raw water is taken directly from the river and pumped to the water works near the river banks. The water purification consists of:

a) extraction of river water
b) chlorination with CL2
c) chemical treatment for flocculation and sedimentation with iron, aluminium or manganese salts
d) filtration with sand
e) final chlorination.

Other technologies to purify drinking water, especially from polluted river water exist, e.g. river bank filtration prior to intake and filtration with active coal in addition to sand bed filter. Disinfection is usually done with ozone because disinfection with chlorine is known to form more toxic compounds, especially chlorinated hydrocarbons. The chlorination of the raw water (1st chlorination) in the Kuzbass is totally superfluous and probably forms high levels of toxic chlorinated substances that disturb the sand filtration later in the purification process. Analyses of the drinking water show high levels of chlorinated hydrocarbons that are typical for chlorination of drinking water. Use of biological activity of sanddunes or sand basins as a first step (if river bank filtration is not considered to be sensible) is recommended. A mininimal chlorination before distribution of the water may be, considering the economic situation, used for an interim period, from time to time, as far as necessary to protect people; but it is known that the use of chlorine, also in small quantities, raises health problems.

Chlorine dioxide, like chloramine, has been introduced into commercial use as an attempt to avoid the trihalomethane generation associated with chlorination. It is not in very widespread use. It is generated on site from sodium chlorite and chlorine or sodium hypochlorite. Sodium chlorate can also be used

under some conditions (BULL et al. 1990). Chlorine dioxide is one of the most expensive disinfectants (WOLFE 1990).
The generation of trihalomethanes is reported not to occur if pure chlorine dioxide is used, though chlorine may be present, leading to the desinfection by products as listed above. The majority of the organic byproducts formed by chlorine dioxide are polar and therefore difficult to identify using conventional gas chromatography/mass spectrometry. Thus no information is available in this area (BULL et al. 1990).

5.2 Results

The measured trihalogen content in the tapwater in Kemerovo and Yurga is extremely high, up to 6.4 mg/L (see appendix, table 4). As mentioned in chapter 2, it can not be excluded that a part of the trihalomethanes were formed during storage and transport of the samples. Nevertheless, the total chlorine content that can be estimated from the trihalomethane measurements indicates that the amount of chlorine added is extremely high, up to 10 mg/L. The laboratory of the Medical Institute of the university of Kemerovo also identified chlorine amines in the drinking water of Kemerovo. The amines can also be smelt in the tapwater. They give a typical strong chlorine smell.

5.3 Health effects

Chlorination of drinking water forms trihalomethanes, especially trichloromethane (chloroform), chlorodibromomethane and bromodichloromethane. Some of these are suspected carcinogens and chlorodibromomethane is a suspected teratogene. MORRIS et al. (1992) calculated that in the USA, where on a conservative estimate 54 % of the population consumes chlorinated water, 4200 cases of bladder cancer and 6500 cases of rectal cancer per year are associated with the consumption of chlorinated water.

The permissible level of trihalomethanes in drinking water in Holland is 50 ug/L with a target level of 10 ug/L. The WHO guideline for drinking water quality is 30 ug/L. This means that the chlorine content in the Yurga and Kemerovo tapwater is about 200-1000 times the maximum advised dosage in the Netherlands and by the WHO.

Because the trihalomethane problem is very well recognized in the Netherlands, chlorination is almost totally banned. Bacterial pollution is monitored in the transport system and only when necessary is chlorine added (occurs only once in several years). But for transport of raw river water over long distances, chlorine is still added (as a gas). A part of the trihalomethanes formed are lost through evaporation during aeration in large basins and sand filtration. Traces in the order of ug/L range are left as well.

Chlorine dioxide, like chloramines, have significant health effects. Prompted by research demonstrating mortality in rats, thyroid depression in rats and monkeys subjected to high concentrations and impaired brain development and altered behaviour in rats at lower dosage, the NRC Subcommittee on drinking water recommended that chlorine dioxide in drinking water should not exceed 0.06 mg/L. This is particularly aimed at preventing excessive exposure among children who are most vulnerable to thyroid injury and developmental effects. This stipulated level is far below that necessary to achieve disinfection and would seem, therefore, to preclude the use of chlorine dioxide in this context.
Chlorine dioxide also gives rise to chlorite and chlorate ions in the treated water. Chlorite produces molytic anaemia, both chlorite and chlorate cause methaemoglobinaemia. The NRC Subcommittee therefore put forward an upper boundary of 0.007 mg/L for both species, again based on the need to protect children. It would be necessary to include additional steps in a chlorine dioxide-utilising water purification train to achieve the recommended chlorite levels. Additional chlorate can be formed if chlorine is added as postdisinfectant after chlorine dioxide preoxidation (BULL et al. 1990).

Photo 5: The City of Yurga drove groundwater wells because the tap water is polluted with chlorinated hydrocarbons.

6. ENVIRONMENT HEALTH RELATIONSHIP

Medical statistics show significant differences between the cities in the region. Environmental factors may contribute to these differences. There are almost no exposure data. The data on environmental pollution are incomplete and often not based on standard sampling and analyses. The health statistics are based on very general parameters without good control groups. It is extremely difficult to relate reported increasing health problems to environmental pollution because there are several other factors that probably contribute to the health problems like the increasing poverty, alcoholism and food and medicine shortages. Existing medical statistics, as far as we could see, ignored to include such factors. However, the increasing health problems, also among children, are obvious and environmental factors, especially air and drinking water, are very bad and may contribute significant to the increased health problems.

According to researchers of the Medical Institute in Kemerovo, the poor drinking water quality is the main cause of environmental health problems in the Kuzbass. In the southern and northern part of the Kuzbass a higher rate of miscarriages than usual for the Kuzbass is caused, according to GROMOV (pers. comm. 1991), by the higher radioactivity in the coal mines in these regions. Among coal miners, higher rates of lung diseases and weakening of the immune system is reported by GROMOV with the first symptoms occuring after 3-4 years of work in the mines.

Photo 6 Health problems, also among children, are increasing and the pollution of air, water and drinking water may contribute significant to the health problems.

7. ENVIRONMENTAL CONTROL PROBLEMS

The State Committee for Nature Protection, GOSKOMPRIRODA, is in charge of environmental control. Its task is the surveillance of the natural state of air, water, soil and nature in general. They also have to control emissions polluting air, water and soils. The control programme is established together with the Ministry of Health. The results are reported every month to the district government, other control services and some research institutes. Citizens are informed through newspapers, but in a very rough form, usually without figures about concentrations of the toxics. GOSKOMPRIRODA has 234 employees in the Kemerovskaya Oblast (July 1991). It has a shortage of personnel, and also of money and material for adequate control and for the enforcement of measures against industrial pollution (ANDRAGANOVA, 1991 personal communication).

There are only two employees in the Mesdurechensk district and no local laboratory facilities. These two persons have to control 9 coal mines, timber industry and agriculture. In other districts it is no better, in some parts of the Kuzbass GOSKOMPRIRODA does not even have transport facilities. Adequate control and enforcement under these circumstances is simply not possible.

In Kemerovo air measurements are made at 9 sites. At six sites samples are taken three times a day, at three sites air measurements are made continuously. This control system was at the time of our visit (july 1991) not yet totally operational. The oxygen concentration in the water is measured every day. An automated water control system is under construction.

As an additional attempt to monitor environmental pollution factories have to control their own emissions and discharges. The results must be reported to the State Control. About once a year, the results are checked for reliability. The industrial control laboratories are visited without prior announcement. Incidentally, a control visit is announced to bigger companies. When the control measurements of GOSKOMPRIRODA differ from the results of the company, it can be sanctioned economically or financially. An economic sanction means that production must be stopped or the responsible management of the company is fined. A financial measure means that the company has to pay for all their emissions above the permissible level. When the committee started in 1987 the control measurements often showed great differences from the companies control results. This situation is improving. However, the control is not efficient because of a lack of employees, lack of modern equipment and technology and the control can not be carried out everywhere (ANDRAGANOVA, pers. communication).

The permissible emissions in the Kemerovo district are often exceeded, especially by the energy sector and the metallurgical companies. The coal mines do not exceed permissible levels for air emissions, but do exceed permissible levels for water emissions. During our trip we visited the Tomskaya coal mine in Mezhdurechensk and the facility where the mine waste water should be treated (July, 2 1991). The totally black waste water flouded across the facilities area and found its way into a side river of the Tom. According to a local spokesperson, a pipeline had broken 5 days earlier. This is just one example of a spill which was not detected or stopped.

The companies pay a fixed amount of money for the permissible emissions. In 1991, this amount totalled 200 million roubles in the Kemerovo district. From the first of January 1990, fines were imposed 152 times to a total of 17.5 million roubles. About 60 % were payed immediately, and 40 % were brought to an independent arbitrations commission. The State Committee won 9 out of 10 cases.

Most of the companies (most companies are owned by the state) claim that their financial situation is bad and that they can't pay the fines. Of the 17.5 million roubles only 2 million was actually payed. The remainder can not be paid because of bankruptcy of the companies and remains as a debt to the community.

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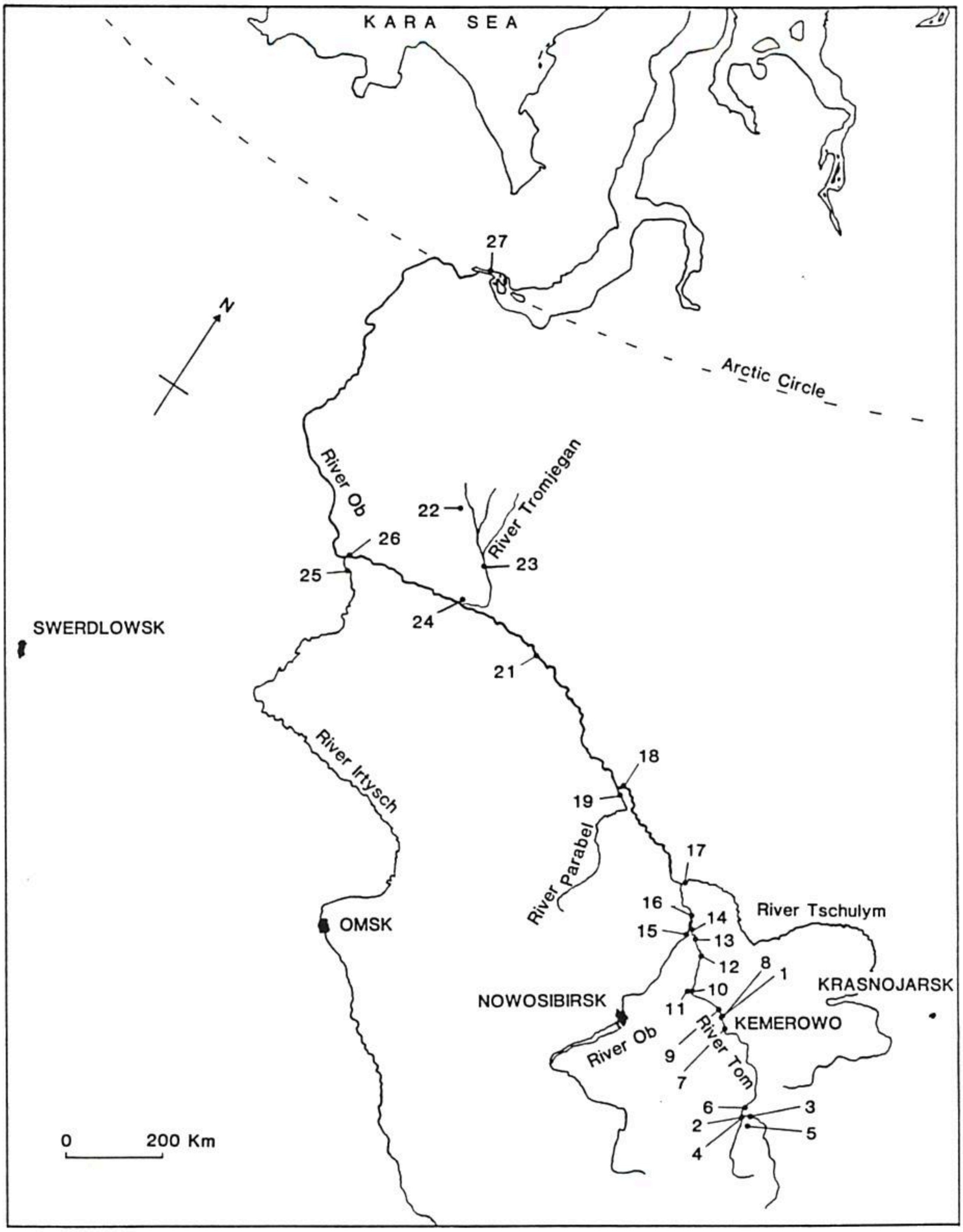
APPENDIX



Sampling Points of the River Ob and Selected Tributries

Figure 1 Map of Siberia and sample sites

List of sample sites

1 = TAP WATER KEMEROWO
2 = RIVER TOM, NOWOKUSNEZK
3 = RIVER TOM, UPSTREAM NOWOKUSNEZK
4 = TAP WATER NOWOKUSNEZK
5 = WASTE WATER OPEN PIT COALMINE
6 = RIVER TOM DOWN STREAM NOWOKUSNEZK
7 = RIVER TOM UP STREAM KEMEROWO
8 = WASTE WATER KEMEROWO, MUNICIPAL + INDUSTRIAL
9 = TOM RIVER, DOWN STREAM KEMEROWO
10 = TOM RIVER, JURGA
11 = TAP WATER JURGA
12 = TOM RIVER, UP STREAM TOMSK
13 = RIVER TOM, DOWN STREAM TOMSK
14 = RIVER TOM, 1 KM UPSTREAM MONDING INTO OB
15 = RIVER OB, 1 KM UP STREAM MONDING RIVER TOM
16 = RIVER OB, 1 KM DOWN STREAM MONDING RIVER TOM
17 = RIVER TSCHULYM
18 = RIVER OB, UPSTREAM MONDING RIVER PARABEL
19 = RIVER PARABEL
20 = RIVER YURGATCH
21 = RIVER RIVER OB, DOWN STREAM NISHNEWARTOWSK
22 = SWAMP WATER NORTH OF SURGUT
23 = RIVER TROMJEGAN
24 = STREAM NORTH OF SURGUT
25 = RIVER IRTYSCH
26 = RIVER OB, UPSTREAM MONDING RIVER IRTYSCH
27 = MONDING RIVER OB

Table 1. Water pollution in the Kuzbass region and 1988 (DDT, DDE, alpha-HCH and gamma-HCH in 1988). Source: GOSKOMPRIRODA of Kemerovskaya Oblast. (Figures in mg/L; up = upstream, down = downstream of the city)

	Mezhdurechensk		Novokuznetsk		Kemerovo	
	up	down	up	down	up	down
BOD5	1.95	1.53	2.72	2.66	2.44	2.86
COD	6.4	6.2	6.9	10.8	8.8	11.4
O2	11.4	11.4	10.8	10.9	9.04	9.92
P-ortho	23.7	17.3	15.1	10.5	15.7	16.8
NO2	0.002	0.005	0.008	0.015	0.012	0.018
NH4	0.03	0.04	0.47	0.57	0.97	1.03
NO3	0.31	0.35	0.32	0.29	1.11	1.30
phenol.	0.001	0.002	0.002	0.003	0.003	0.004
Cu	5	5	7	10	0	6
oil	0.04	0.00	0.04	0.07	0.32	0.33
DDT	-	-	0.000	0.018	0.000	0.000
DDE	0	-	0.000	0.000	0.001	0.003
a-HCH	-	-	0.004	0.002	0.000	0.000
g-HCH	-	-	-	-	0.000	0.000

Table 2. Air pollution in the Kuzbass region in 1989. Source: GOSKOMPRIRODA of the Kemerovskaya Oblast, 1990. Averages in mg/m3, maxima in brackets

	Kemerovo		Novokuznetsk		Prokopiev		Limits	
dust	0.1	(2.9)	0.3	(3.8)	0.2	(3.5)	0.15	(0.15)
SO2	-	(0.07)	0.03	(1.60)	0.00	(0.07)	0.05	0.5
CO	1	(35)	1	(17)	0.5	(35)	3	5
NO2	0.04	(1.04)	0.04	(1.29)	0.04	(0.47)	0.04	0.085
NO	0.06	(0.7)	0.01	(0.38)	0.02	(0.39)	0.06	0.4
H2S	0.000	(0.007)	0.000	(0.029)	0.001	(0.039)	-	0.008
CS2	0.005	(0.237)	-	-	-	-	0.005	0.03
phenols	0.002	(0.84)	0.003	(0.389)	-	-	0.003	0.01
soot	0.04	(0.4)	0.05	(0.73)	0.04	(1.21)	0.05	0.15
CL2	0.01	(0.23)	-	-	-	-	0.03	0.1
HCL	0.05	(0.36)	-	-	-	-	0.2	0.2
Pb	-	-	-	-	-	-	0.0003	-
NH4+	0.09	5.?	0.03	(1.99)	-	-	0.04	0.2
HSO4	-	0.2	0.005	(0.082)	-	-	0.1	0.3
formaldeh.	0.013	0.40	0.005	(0.082)	0.05	0.215	0.003	0.035
dimethyl.	0.001	0.067	-	-	-	-	0.005	0.005
methanol	0.1	0.7	-	-	-	-	0.5	1.0
HCN	0.001	0.052	0.001	(0.038)	-	-	-	0.01
isopropyl-ether	0.2	4.1	-	-	-	-	0.6	0.6

Table 3. Heavy metal concentration in the Tom and Ob river (analyses: Greenpeace QMW lab, London, 1991)

no*	chromium	copper	zinc	cadmium	lead	mercury	iron
2	9.7	--	8.3	--	--	--	
3	10.9	--	1.5	--	--	--	
5	6.4	101	137.3	--	27	--	
6	19.1	0.4	43.8	0.8	0.4	--	
7	18.6	--	--	--	--	--	
9	15.5	--	6.7	--	5.2	--	
10	19.7	--	0.1	--	--	--	
13	14.8	--	21.7	--	--	--	
14	20.5	--	--	--	--	--	
15	10.2	--	--	--	--	--	
16	14.4	--	--	--	--	--	
18	17.9	--	0.3	--	--	--	
22	2.1	--	28.1	0.6	--	--	353
23	9.0	--	8.9	--	--	--	2373
24	10.5	1.5	33.6	1.5	1.4	--	1616
25	10.1	--	--	--	1.4	--	
26	16.1	--	8.2	--	0.1	--	
Rhine	27.4	16	108	0.3	10	0.2	

* See Figure 1

Table 4. Organic compounds in Ob and Tom river and in drinking water. Not all of the sample sites of Figure 1 are included in Tables 3 and 4. In some of the samples none substances could be isolated or identified. These are not inculded in this Tables.

Sample site*	1	4	7	8	9	10
quantified:						
dichloromethane	<1.0					
trichloromethane	6400	6000				
chlorodibromomethane	180					
1,2-dichloroethane	<1.0			28.0	4200	
hexachlorobutadiene	<1.0					
bromodichloromethane	1400	<5.0				
1,2,4-trichlorobenzene	<1.0	<1.0				
identified:						
cyclohexane	+					+
trichloroethene	+					
1,2-dichloro-ethene				+		
trichloromethane				+		
trichloroethene				+		
methylbenzene				+		
tentatively identified:						
chloroethene						
dibromochloromethane	+					
1,2-dichloroethane						+
1,1,1-trichloroethane						
1,1,2-trichloroethane				+		
trichloroethene					+	
trichloromethane						
methylbenzene	+		+		+	+
ethylbenzene	+					
1,2-dimethylbenzene			+	+	+	
1,3,5-trimethylbenzene					+	
1-ethyl-3-methyl-benzene						
2,4-dimethyl-pentane	+					

Table 4 Continued

Sample site*	1	4	7	8	9	10
tentatively identified:						
methyl-cyclopentane	+					+
2-butanone	+					
cyclohexane	+					
tetrachloromethane	+					
heptane	+					
1,1-dimethoxy-propane	+					
2-methylpropanoic acid methyl ester	+					
5-ethyl-4-methyl-3-heptanone	+					
butanoic acid methyl ester	+					
tetrachloroethene	+					
1,2-dimethylbenzene	+					
undecane	+					
dichloroacetonitrile	+					
dimethyldisulfide	+					
1,3,5-cycloheptatriene	+	+				
diethylphtalate		+	+			
5-(1-methylethylide)-1,3-cyclopentadiene			+			
1,2,3-trimethylbenzene	+					
nonanal			+			
decanal			+			
phenanthrene			+			
1,2-benzeNedicarboxylic acid			+			
2-methylpropylester			+			
2-methyl-3-oxo-hexanoic acid ethyl ester						+
1,3,5,7-cyclooctatetraene	+					+
2-methyl-1-pentene						
2-methyl-1-propene						

Table 4 Continued

Sample location	12	13	14	15	25
quantified:					
1,2-dichloro methylbenzene	<1.0				
identified:					
1,2,3-trimethylbenzene			+		
tentatively identified:					
chloroethene		+			
1,2 dichloroethane		+	+		
111-trichloroethane		+		+	
trichloroethane				+	
trichloromethane		+			
methylbenzene	+	+			
ethulbenzene		+	+		
1,2-dimethylbenzene		+			
1-ethyl-b-methylbenzene				+	
methyl-cyclopentane		+		+	
cyclohexane			+		
ethylbenzene				+	
1,3,5,7-cyclooctatetraene			+		
2-methyl-1-pentene		+			
2-methyl-1-propene			+		
bis(2-methuxyethyl) ester					+