Human Health Risk Assessment of Pollutant Levels in the Vicinity of the 'Severstal' Facility in Cherepovets

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1. Qualifications

I am qualified to provide a professional opinion regarding the health risks of persons exposed to environmental air pollutants within the Sanitary Security Zone of Cherepovets. I possess a Doctor of Philosophy (Ph.D.) degree in biochemistry from Johns Hopkins University School of Public Health, Baltimore, Maryland, U.S.A. My doctoral studies and research focused on environmental toxicology. I possess a degree in law from the University of Oregon School of Law, Eugene, Oregon, U.S.A. Since 1992, I have served as Staff Scientist for the U.S. Office of the Environmental Law Alliance Worldwide. In this capacity, I provide requested scientific information to attorneys in more than 60 countries. On numerous occasions, I have advised attorneys about the human health effects of exposure to air pollutants, including exposure to hydrogen sulfide, hydrogen cyanide, naphthalene, formaldehyde, carbon disulfide, and particulate matter. My opinions on environmental matters have been cited favorably in judgments of the Supreme Court of India and the Supreme Court of Pakistan.[1]

At the request of Philip Leach and Kiril Koroteev, attorneys affiliated with the European Human Rights Advocacy Centre providing assistance to the applicant in the case of Fadeyeva v. Russian Federation (application no. 55723/00) before the European Court of Human Right, I reviewed various documents containing data of ambient air quality within the Sanitary Security Zone of Cherepovets impacted by emissions from the Severstal iron and steel manufacturing facility. These documents include:

- A document labeled "Monthly Account of Station 'Cherepovets 01' from July 1995" (Mesyatsniy Otchyet po Stants'iy 'Cherepovets 01' za 07.1995) that contains data on compliance with maximum permitted limits in 1995.

- A document labeled "Toxicants according to data in the Year 1997" (Toksikaktov po dannim AMSG za 1997 god.) that contains data on compliance with maximum permitted limits in 1997.

- A document labeled "Maximum of times maximum allowable concentrations of harmful substances to the ambient atmosphere at Post No. 1 according to data of the Cherepovets TTS GSEH (Maksimal'no rasovikh predel'no dopustimikh kontsentratsikh vradnikh veshchestv v atmosfernom vozdukhe na Postu No. 1 po dannim Cherepovetskovo TTS GSEH) that contains data on compliance with maximum permitted limits in 2001.

I understand that Post No. 1 lies within 300 meters of the residence of the applicant, Ms. Nadezhda Mikhaylovna Fadeyeva, and thus is highly representative of outdoor ambient air to which the applicant has been exposed to at her place of residence.

I understand that additional data and estimates of ambient air quality within the Sanitary Security Zone of Cherepovets exist but are not yet available to the public. These additional data and estimates of ambient air quality within the Sanitary Security Zone of Cherepovets, which would help this court obtain a far clearer understanding of the health risks the applicants have incurred and the adequacy of the emission controls employed by the Severstal facility, include:

[1] M.C. Mehta v. Union of India, 1999-(003)-CLJ 0361–SC, Shehla Zia v. WAPDA, PLD 1994 (SC) 693.

- Baseline emissions data for the Severstal plant from the Vologda Oblast Committee on the Environment. These data, from the year 1996, included both data on physical parameters of the stacks and the volume of chemicals emitted annually (tonnes/year) by each process at the Severstal facility.

- Dispersion modeling data for estimating the ambient air concentration of 13 toxic pollutants at each of the x,y coordinate locations on the city grid of Cherepovets based on the above emissions data.

These two data sets form the basis for a recent publication discussing this data in general terms.[2] It is my understanding that these data sets are in the possession of Viktor Kislitsin and other Russian scientists affiliated with the Center for Preparation and Implementation of International Projects on Technical Assistance (CPPI), Moscow, Russia.

- Ambient air quality data obtained in 1998-1999 within the framework of the Project on Environmental Management in the Russian Federation implemented with financial support of the World Bank for Reconstruction and Development. Such data was collected from two monitoring locations: 1) a station located near a school in the southern part of the city; and 2) a station located near the Severstal facility in the central part of the city. The monitoring stations collected data for two pollutants: 1) particulate matter (both PM-10 and PM-2.5); and 2) nitrogen oxides.

It is my understanding that these data are in the possession of American (Dr. Jack Spengler of the Harvard School of Public Health.), British (Dr. Tony Fletcher of the London School of Hygiene and Tropical Medicine) and Russian (Dr. Boris Kaznelson) scientists who collaborated to conduct the ambient air quality monitoring project funded by the World Bank.

2.1. Hydrogen sulfide

2.1.1 Human health effects associated with exposure to hydrogen sulfide

In 1992, health experts published a scholarly study showing that a community exposed over a two-day period to hydrogen sulfide levels of approximately 0.030 parts per million (ppm), suffered excessively from irritation of the eye and nose, cough, breathlessness, nausea, headache, and mental symptoms, including depression.[3] The hydrogen sulfide emissions originated from an industrial facility - a pulp mill. These health experts concluded that: “The strong malodorous emission from a pulp mill caused an alarming amount of adverse effects in the exposed population.”

Also in 1994, health experts published a scholarly study showing that children exposed to annual average hydrogen sulfide levels of only 0.006 ppm, but to daily maximum hydrogen sulfide levels of up to 0.07 ppm, suffered excessively from irritation of the nose, cough, and headache compared

[2] Lebedev, N.V. et al. (2002) "Economic efficiency of sanitation measures at the JSC 'Severstal' in the city of Cherepovets," Meditsina Truda I Promyshlennaia Ekologiia [Med Tr Prom Ekol] No. 4, pages 18-25.
[3] Haahtela T, et al. (April 1992) "The South Karelia Air Pollution Study: acute health effects of malodorous sulfur air pollutants released by a pulp mill." Am J Public Health. 82(4):603-5.

to children in a non-polluted community.[4] These health experts concluded that: "The results suggest that exposure to malodorous sulfur compounds may affect the health of children."

In 1996, health experts published a scholarly study showing that a community exposed to an annual average hydrogen sulfide level of only 0.0015 to 0.002 ppm, but to daily maximum hydrogen sulfide levels of up to 0.017 ppm, suffered excessively from cough, respiratory infections, and headache.[5] These health experts concluded that: "These results indicate that adverse health effects of malodorous sulfur compounds occur at lower concentrations than previously reported."

In 1999, health experts published a scholarly study showing that a community exposed to annual average hydrogen sulfide levels of only 0.004 to 0.008 ppm, but to daily maximum hydrogen sulfide levels of up to 0.08 ppm, suffered excessively from respiratory infections compared to a non-polluted community.[6] These health experts concluded that: "Our results suggest that exposure to malodorous compounds increases the risk of acute respiratory infections."

2.1.2 Comparison of the Russian standard for hydrogen sulfide with international, health-based ambient air quality standards for this substance

Under Russian law, the maximum allowable concentration (predel'no dopustimaya kontsentratsiya = PDK) for public exposure to hydrogen sulfide over a 24-hour period is 0.008 milligrams per cubic meter (mg/m^3). The Russian PDK for hydrogen sulfide is similar to other international health-based ambient air quality standards for this substance. In Arizona, U.S.A., the ambient air quality standard for public exposure over a 24-hour period to hydrogen sulfide is 0.011 mg/m^3.[7] In Alberta, Canada, the ambient air quality guideline for exposure over a 24-hour period to hydrogen sulfide is 0.004 mg/m^3.[8] The World Health Organization's Guideline Value for exposure to hydrogen sulfide over a 30-minute period is 0.007 mg/m^3.[9]

2.1.3. Health risk assessment of measured levels of hydrogen sulfide in the Sanitary Security Zone of Cherepovets

Air quality data I have reviewed from monitoring stations within the Sanitary Security Zone of Cherepovets indicate that persons residing within the zone possess a greater risk of suffering adverse health effects that result from long-term human exposure to low levels of hydrogen sulfide. According to the first document, in 1995, ambient air levels of hydrogen sulfide in July of that year reached as high as 0.089 mg/m^3. According to the second document, in 1997, ambient air levels of hydrogen sulfide exceeded the Russian PDK for this substance 8 separate days of that year at monitoring post Number 1. According to the third document, in 2001, ambient air levels of

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[4] Marttila, O., et al. (August 1994) "The South Karelia Air Pollution Study: the effects of malodorous sulfur compounds from pulp mills on respiratory and other symptoms in children." Environ Res., 66(2):152-9.
[5] Partti-Pellinen, K., et al. (July/August 1996) "The South Karelia Air Pollution Study: effects of low-level exposure to malodorous sulfur compounds on symptoms." Arch Environ Health, 51(4):315-20.
[6] Jaakkola, J., et al. (July/August 1999) "The South Karelia Air Pollution Study: changes in respiratory health in relation to emission reduction of malodorous sulfur compounds from pulp mills." Arch Environ Health, 54(4):254-63.
[7] http://www.adeq.state.az.us/environ/air/permits/download/ambient.pdf
[8] http://www3.gov.ab.ca/env/protenf/approvals/factsheets/ABAmbientAirQuality.pdf
[9] World Health Organization (2000) "Air Quality Guidelines for Europe, Second Edition, Chapter 6.6 Hydrogen Sulfide." http://www.euro.who.int/document/aiq/6_6hydrogensulfide.pdf

hydrogen sulfide exceeded the Russian PDK for this substance once over 63 days of measurements at post number 1 from July to September.

Russian scientists affiliated with the Center for Preparation and Implementation of International Projects on Technical Assistance (CPPI), Moscow, Russia found that baseline emissions of hydrogen sulfide from the Severstal facility caused an estimated 300,000 persons within Cherepovets to be exposed to hydrogen sulfide above the U.S. EPA Reference Concentration (RfC) of 0.001 mg/m^3.[10]

Considering these on-going exposures to hydrogen sulfide within the Sanitary Security Zone of Cherepovets, I would expect that the population residing within the zone suffers from excess incidences of odor annoyance, respiratory infections, irritation of the nose, cough and headaches compared to populations residing within areas not polluted by excessive levels of hydrogen sulfide.

2.2. Hydrogen cyanide

2.2.1 Human health effects associated with exposure to hydrogen cyanide

According to the California Environmental Protection Agency, long-term exposure to low levels of hydrogen cyanide gas adversely impacts the central nervous system (CNS) and the thyroid, an organ responsible for controlling the rate of human metabolism.

> "Occupational epidemiological studies of hydrogen cyanide exposure are complicated by the mixed chemical environments, which are created by synthetic and metallurgic processes. However, several reports indicate that chronic low exposure to hydrogen cyanide can cause neurological, respiratory, cardiovascular, and thyroid effects (Blanc et al., 1985; Chandra et al., 1980; El Ghawabi et al., 1975). Although these studies have limitations, especially with incomplete exposure data, they also indicate that long-term exposure to inhaled cyanide produces CNS and thyroid effects. El Ghawabi et al. (1975) studied 36 male electroplating workers in three Egyptian factories exposed to plating bath containing 3% copper cyanide, 3% sodium cyanide, and 1% sodium carbonate. Breathing zone cyanide concentrations ranged from 4.2 to 12.4 ppm (4.6 to 13.7 mg/m3), with means from 6.4 to 10.4 ppm (7.1 to 11.5 mg/m3), in the three factories at the time of this cross-sectional study. … Frequently reported symptoms in the exposed workers included headache, weakness, and altered sense of taste or smell. Lacrimation, abdominal colic, and lower stomach pain, salivation, and nervous instability occurred less frequently. Increased blood hemoglobin and lymphocyte counts were present in the exposed workers.… Twenty of the thirty-six exposed workers had thyroid enlargements, although there was no correlation between the duration of exposure with either the incidence or the degree of enlargement. Thyroid function test indicated significant differences in uptake between controls and exposed individuals after 4 and 24 hours."[11]

[10] Lebedev, N.V. et al. (2002) "Economic efficiency of sanitation measures at the JSC 'Severstal' in the city of Cherepovets," Meditsina Truda I Promyshlennaia Ekologiia [Med Tr Prom Ekol], Table 5, page 23.
[11] Chronic Toxicity Summary for Hydrogen Cyanide. http://www.oehha.ca.gov/air/chronic_rels/pdf/74908.pdf

2.2.2 Comparison of the Russian standard for hydrogen cyanide with international, health-based ambient air quality standards for this substance

Under Russian law, the maximum allowable concentration (predel'no dopustimaya kontsentratsiya = PDK) for public exposure to hydrogen cyanide is 0.01 milligrams per cubic meter (mg/m^3), which is roughly equivalent to 0.009 parts per million (ppm). The Russian PDK for hydrogen cyanide is similar to other international, health-based ambient air quality standards for hydrogen cyanide. In California, the inhalation reference exposure level for hydrogen cyanide is 0.008 ppm (0.009 mg/m^3).[12] The U.S. Environmental Protection Agency's Reference Concentration (RfC) for hydrogen cyanide is 0.003 mg/m^3.[13] In Arizona, U.S.A., the ambient air quality standard for public exposure over a 24-hour period to hydrogen sulfide is 0.040 mg/m^3.[14]

2.2.3. Health risk assessment of measured levels of hydrogen cyanide in the Sanitary Security Zone of Cherepovets

Russian scientists affiliated with the Center for Preparation and Implementation of International Projects on Technical Assistance (CPPI), Moscow, Russia found that baseline emissions of hydrogen cyanide from the Severstal facility caused an estimated 100,000 persons within Cherepovets to be exposed to hydrogen sulfide above 0.003 mg/m^3.[15]

Considering the extent of this exposure, I would expect that the population residing within the Sanitary Security Zone suffers from excess incidences of headache and thyroid abnormalities compared to populations residing within areas not polluted by excessive levels of hydrogen cyanide.

2.3. Naphthalene

2.3.1 Human health effects associated with exposure to naphthalene

Animal studies show clear evidence of exposure to naphthalene resulting in carcinogenic effects on the nose and respiratory tract. According to the U.S. Environmental Protection Agency:

> "B6C3F1 mice (75/sex/group) were exposed to naphthalene (scintillation grade, > 99% pure) at target concentrations of 0, 10, and 30 ppm (0, 52, 157 mg/m3) for 6 hr/day, 5 days/week, for 103 weeks (NTP, 1992a). .... Inflammation, metaplasia of the olfactory epithelium, and hyperplasia of the respiratory epithelium were noted in the noses of virtually all exposed mice of both sexes, but in only one control female mouse. These effects were slightly more severe in the high-concentration group. See Table 1 for incidence data. The lesions were focal or multifocal, occurred mainly in the posterior nasal cavity, and were minimal to mild in severity. Inflammatory lesions included substantia propria edema, congestion, mixed inflammatory cell infiltrates, necrotic debris, and intraluminal serous to fibrinopurulent exudate. Respiratory epithelial hyperplasia resulted in a thickened, folded,

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[12] Id. at page 1.
[13] http://www.epa.gov/iris/subst/0060.htm
[14] http://www.adeq.state.az.us/environ/air/permits/download/ambient.pdf
[15] Lebedev, N.V. et al. (2002) "Economic efficiency of sanitation measures at the JSC 'Severstal' in the city of Cherepovets," Meditsina Truda I Promyshlennaia Ekologiia [Med Tr Prom Ekol], Table 5, page 23.

irregular mucosal surface. Olfactory epithelial metaplasia often involved ciliated columnar or pseudocolumnar respiratory-like epithelial cells replacing the usual olfactory cell layer. The lesions were collectively considered features of a generalized inflammatory and regenerative process."[16]

"[The U.S. National Toxicology Program (2000) exposed groups of 49 male and female Fischer 344N (F344) rats to naphthalene by inhalation at concentrations of 0, 10, 30 or 60 ppm for 6.2 hours/day, five days/week for 105 weeks. Survival of the male and female exposure groups were similar to that of controls. These studies found clear evidence of carcinogenic activity in male and female rats, based on increased incidences of rare tumors, respiratory epithelial adenoma and olfactory epithelial neuroblastoma of the nose, in both sexes. Respiratory epithelial adenoma incidence occurred with a positive dose-response trend in male rats and was significantly increased in all exposed male rat groups. Male rat respiratory epithelial adenoma incidence as cited by NTP was 0/49, 6/49, 8/48 and 15/48 for controls, and the 10, 30 and 60 ppm exposure groups, respectively. Respiratory epithelial adenoma incidences in female rats exposed to 30 or 60 ppm were also increased, but the increase in the 60 ppm animals was not significant, and the increase in the 30 ppm animals was of borderline significance ($p = 0.053$ by Poly-3 test). Female rat respiratory epithelial adenoma incidence as cited by NTP was 0/49, 0/49, 4/49 and 2/49 for controls, and the 10, 30 and 60 ppm exposure groups, respectively. Olfactory epithelial neuroblastomas occurred in males exposed to 30 and 60 ppm naphthalene and in all dose groups of naphthalene-exposed females. Neuroblastoma incidences occurred with positive dose-response trends in males and females."[17]

The U.S. EPA Reference Concentration (RfC) for naphthalene is 0.003 mg/m^3.[18]

2.3.2. Health risk assessment of measured levels of naphthalene in the Sanitary Security Zone of Cherepovets

Russian scientists affiliated with the Center for Preparation and Implementation of International Projects on Technical Assistance (CPPI), Moscow, Russia found that baseline emissions of hydrogen cyanide from the Seversal facility caused an estimated 50,000 persons within Cherepovets to be exposed to naphthalene above 0.003 mg/m^3.[19]

Considering the extent of this exposure, I would expect that the population residing within the Sanitary Security Zone suffers from excess incidences of cancer of the nose and respiratory tract compared to populations residing within areas not polluted by excessive levels of naphthalene.

16 http://www.epa.gov/iris/subst/0436.htm
17 (2004) "Long-term Health Effects of Exposure to Naphthalene Background and status of Naphthalene as a Toxic Air Contaminant and Potential Carcinogen,"
18 http://www.epa.gov/iris/subst/0436.htm
19 Lebedev, N.V. et al. (2002) "Economic efficiency of sanitation measures at the JSC 'Severstal' in the city of Cherepovets," Meditsina Truda I Promyshlennaia Ekologiia [Med Tr Prom Ekol], Table 5, page 23.

2.4. Formaldehyde

2.4.1 Human health effects associated with exposure to formaldehyde

According to health experts, long-term exposure to low levels of formaldehyde may cause cancer of the nasal passages, headaches, and chronic irritation of the eyes, nose, and throat.

According to the California Environmental Protection Agency's Air Resources Board (ARB) and the Office of Environmental Health Hazard Assessment (OEHHA):

> 'The health effects of formaldehyde exposure have been reviewed and evaluated to determine whether formaldehyde meets the definition of a toxic air contaminant. … The OEHHA staff agrees with the International Agency for Research on Cancer (IARC) and the U.S. Environmental Protection Agency (EPA) classification of formaldehyde (IARC-Group 2A, EPA-Group B1) as a **probable human carcinogen** based on adequate evidence for carcinogenicity in animals and limited evidence in humans. Formaldehyde is carcinogenic in rodents, producing squamous cell carcinomas in the nasal passages of male and female rats and male mice. Several types of benign tumors, including polyploid adenomas and squamous cell papillomas, have also been observed. Epidemiological evidence for human cancer from exposure to formaldehyde is limited. Formaldehyde has been shown to cause a number of genotoxic effects in a variety of cell culture and in vitro assays, including DNA-protein crosslinks, sister chromotid enhances, gene mutations, single strand breaks, and chromosomal aberrations. … A number of adverse noncancer health effects have been associated with formaldehyde exposure. Acute effects include nausea, headaches, and irritation of the skin, eyes, and mucous membranes. Formaldehyde can also induce long-term allergic sensitization. For most individuals the lowest observed level of effects occurs at exposures ranging from 0.1 to 3 ppm. For sensitive individuals the effects may occur at exposure levels as low as 0.03 to 0.07 ppm. … The Environmental Protection Agency (EPA) concluded that there is no carcinogenic threshold level for formaldehyde."[20]

2.4.2 Comparison of the Russian standard for formaldehyde with international, health-based ambient air quality standards for this substance

Under Russian law, the maximum allowable concentration (predel'no dopustimaya kontsentratsiya = PDK) for public exposure to formaldehyde over a 24-hour period is 0.012 milligrams per cubic meter (mg/m3). The Russian PDK for formaldehyde compares favorably to international health-based ambient air quality standards for formaldehyde. In Arizona, U.S.A., the ambient air quality standard for public exposure over a 24-hour period to formaldehyde is also 0.012 mg/m^3.[21] In Alberta, Canada, the ambient air quality guideline for exposure over a one-hour period to formaldehyde is 0.065 mg/m^3.[22] The World Health Organization's Guideline Value for exposure to formaldehyde over a 30-minute period is 0.1 mg/m^3.[23]

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[20] California Office of Environmental Health Hazard Assessment (1992) "Final Report on the Identification of Formaldehyde as a Toxic Air Contaminant." http://www.oehha.ca.gov/air/toxic_contaminants/html/Formaldehyde.htm

[21] http://www.adeq.state.az.us/environ/air/permits/download/ambient.pdf

[22] http://www3.gov.ab.ca/env/protenf/approvals/factsheets/ABAmbientAirQuality.pdf

[23] World Health Organization (2000) "Air Quality Guidelines for Europe, Second Edition, Chapter 5.8 Formaldehyde." http://www.euro.who.int/document/aiq/5_8formaldehyde.pdf

2.4.3. Health risk assessment of measured levels of formaldehyde in the Sanitary Security Zone of Cherepovets

Air quality data I have reviewed from monitoring stations within the Sanitary Security Zone of Cherepovets indicate that persons residing within the zone possess a greater risk of suffering adverse health effects that result from long-term human exposure to low levels of formaldehyde. According to the second document I reviewed, in 1997, ambient air levels of formaldehyde exceeded the Russian PDK for this substance 9 separate days of that year at monitoring post number 1. According to the third document, in 2001, ambient air levels of formaldehyde neared or exceeded the Russian PDK for this substance 8 times over 63 days of measurements at post number 1 from July to September.

Considering these on-going exposures to formaldehyde within the Sanitary Security Zone of Cherepovets, I would expect that the population residing within the zone suffers from excess incidences of cancer of the nasal passages, headaches, and chronic irritation of the eyes, nose, and throat compared to populations residing within areas not polluted by excessive levels of formaldehyde.

2.5. Carbon disulfide

2.5.1 Human health effects associated with exposure to carbon disulfide

Long-term human exposure to low levels of carbon disulfide (CS_2) is associated with a number of serious, adverse health effects including adverse neurobehavioral impacts, including irritability and forgetfulness; adverse neurological impacts, including impaired vision; adverse cardiovascular impacts, such as increased risk of mortality and morbidity from heart disease and stroke; and adverse reproductive impacts, including decreased sperm counts and abnormal menstrual bleeding.

According to a report of the World Health Organization:

> "More subtle neurological changes at lower carbon disulfide concentrations have been reported; the symptoms are a reduction of nerve conduction velocities and psychological disturbances. In workers exposed for 10-15 years to carbon disulfide in concentrations of around 10 mg/m^3, sensory polyneuritis and increased pain threshold were reported. These neurological disturbances were accompanied by psychological and neurobehavioural disorders. At an exposure of between 100 and 500 mg/m^3 carbon disulfide has neurological, vascular and other effects on the eye: focal haemorrhage, exudative changes, optic atrophy, retrobulbar neuritis, microaneurisms and vascular sclerosis. These morphological changes are accompanied by altered functions (colour vision, adaptation to dark, pupillary light reaction, convergence, accommodation and visual acuity), altered motility (eyelids, bulb) and sensitivity (cornea, conjunctiva). Some changes in the eye may be influenced by ethnic differences. For example, "microangiopathia sulfocarbonica" is reported in young Japanese and Yugoslav workers, but not in Finnish workers. In chronic exposure to medium and lower carbon disulfide concentrations (20-300 mg/m^3), the effects of carbon disulfide on blood vessels in various organs and tissues, especially cerebral and renal arteries, producing encephalopathy and nephropathy, are well established. Reports from Finland and the United Kingdom have drawn attention to the association between occupational exposure to carbon

disulfide and coronary heart disease (CHD), even at lower exposures (30-120 mg/m^3). At low carbon disulfide concentrations (under 30 mg/m^3) the question of CHD risk remains to be resolved. …"[24]

According to a report of the California Environmental Protection Agency's Air Resources Board (ARB) and the Office of Environmental Health Hazard Assessment (OEHHA):

> "A primary target of carbon disulfide (CS_2) toxicity is the nervous system. The major neurotoxic action of carbon disulfide is the development of mental disturbances. These include change of personality, irritability, and forgetfulness, often with accompanying neurophysiological and neuropathological changes after prolonged exposure. Such changes include decreased peripheral nerve impulse conduction, motor and/or sensory neuropathies, cerebral or cerebellar atrophy, and neuropsychological organic changes. Vascular atherosclerotic changes are also considered a major effect of chronic carbon disulfide exposure. Several occupational studies have demonstrated an increase in the mortality due to ischemic heart disease in CS2 exposed workers (Hernberg et al., 1970; MacMahon and Monson, 1988; Tiller et al., 1968; Tolonen et al., 1979). A 2.5-fold excess in mortality from coronary heart disease in workers exposed to CS_2 was first reported by Tiller et al. (1968). A subsequent prospective study by Hernberg et al. (1970) found a 5.6-fold increased risk in coronary heart disease mortality and a 3-fold increased risk of a first nonfatal myocardial infarction in CS_2 exposed workers. Egeland et al. (1992) and Vanhoorne et al. (1992) have reported that human exposure to CS2 for more than one year causes increases in biochemical changes often associated with cardiovascular disease - diastolic blood pressure, low density lipoprotein cholesterol, and apolipoproteins A1 and B. Egeland et al. (1992) used cross sectional data on 165 CS_2-exposed workers (245 controls) collected in 1979 by Fajen et al. (1981). The affected workers were exposed for at least 1 year in a viscose rayon factory to an estimated median TWA (8-hour) of 7.6 ppm. The Egeland et al. (1992) study indicated that modest CS_2 exposure (range = 3.4 to 5.1 ppm, median = 4.1 ppm) was associated with increased low density lipoprotein cholesterol (LDLc), the type of increase associated with atherosclerotic heart disease. … Lancranjan et al. (1969), Lancranjan (1972), Cirla et al. (1978), and Wagar et al. (1983) studied male reproductive effects of occupational exposure to CS_2 and showed significant adverse effects on spermatogenesis, levels of serum FSH and LH, and libido; these effects persisted in 66% of the workers subject to follow-up. Zhou et al. (1988) investigated pregnancy outcomes and menstrual disturbances in 265 women occupationally exposed to CS_2 in five facilities and 291 controls. The CS_2-exposed women had a significantly higher incidence of menstrual disturbances versus the control group (overall 34.9% vs. 18.2%). CS_2 levels varied between the five facilities (exposure category means of low = 3.1 mg/m^3, intermediate = 6.5 mg/m^3, and high = 14.8 mg/m^3), but all workers from these CS_2 facilities had significantly higher incidences of menstrual disturbance. Irregularity of menstruation was the most common disturbance, followed by abnormal bleeding."[25]

[24] World Health Organization (2000) "Air Quality Guidelines for Europe, Second Edition, Chapter 5.4 Carbon Disulfide." http://www.euro.who.int/document/aiq/5_4carbodisulfide.pdf
[25] Chronic Toxicity Summary for Carbon Disulfide. http://www.oehha.ca.gov/air/chronic_rels/pdf/sum111401.pdf

2.5.2. Comparison of the Russian standard for carbon disulfide with international, health-based ambient air quality standards for this substance

Under Russian law, the maximum allowable concentration (predel'no dopustimaya kontsentratsiya = PDK) for public exposure to carbon disulfide over a 24-hour period is 0.005 milligrams per cubic meter (mg/m^3). The Russian PDK for carbon disulfide compares favorably to international health-based ambient air quality standards for this substance. In Arizona, U.S.A., the ambient air quality standard for public exposure over a 24-hour period to formaldehyde is 0.024 mg/m^3.[26] In Alberta, Canada, the ambient air quality guideline for exposure over a 1-hour period to carbon disulfide is 0.065 mg/m^3.[27] The World Health Organization's Guideline Value for exposure to formaldehyde over a 30-minute period is 0.1 mg/m^3.[28]

2.5.3. Health risk assessment of measured levels of carbon disulfide in the Sanitary Security Zone of Cherepovets

Air quality data I have reviewed from monitoring stations within the Sanitary Security Zone of Cherepovets indicate that persons residing within the zone possess a greater risk of suffering adverse health effects that result from long-term human exposure to low levels of carbon disulfide. According to one report, in 1995, ambient air levels of CS_2 in July of 1995, reached as high as 0.184 mg/m^3. According to a second report, in 1997, ambient air levels of CS_2 exceeded the Russian PDK for this substance 149 separate days of the year at monitoring post number 1. According to a third report, in 2001 ambient air levels of CS_2 neared or exceeded the Russian PDK for this substance 18 times over a 63 days of measurements at post number 1 from July to September.

Considering these on-going exposures to CS_2 within the Sanitary Security Zone of Cherepovets, I would expect that the population residing within the zone suffers from excess incidences of adverse neurobehavioral, neurological, cardiovascular, and reproductive impacts compared to populations residing within areas not polluted by excessive levels of CS_2.

3. Conclusions

The toxic pollutants found in excessive levels within the Sanitary Security Zone of Cherepovets are all gaseous pollutants specifically produced by iron and steel manufacturing plants (specifically by process units involved in metallurgical coke production) but not usually by other industrial facilities.[29]

It is therefore reasonable to conclude that inadequately controlled emissions from the Severstal facility are a primary cause of excess incidences of the above described adverse health effects of persons residing within the Sanitary Security Zone of Cherepovets.

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[26] http://www.adeq.state.az.us/environ/air/permits/download/ambient.pdf

[27] http://www3.gov.ab.ca/env/protenf/approvals/factsheets/ABAmbientAirQuality.pdf

[28] World Health Organization (2000) "Air Quality Guidelines for Europe, Second Edition, Chapter 5.4 Carbon Disulfide." http://www.euro.who.int/document/aiq/5_4carbodisulfide.pdf

[29] U.S. EPA (2000) "Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Section 12.2 - Coke Production." http://www.epa.gov/ttn/chief/ap42/ch12/final/c12s02.pdf