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Supplement of

Black carbon emissions from Russian diesel sources: case study of Murmansk

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On-road transport in Murmansk City and Murmansk Region.

Table S1. Bottom–up calculation of fuel consumption by on-road diesel vehicles in Murmansk Region.

	Quantity	Fuel consumption, t
Passenger cars	14,500	19,700
Light duty vehicles	2,600	11,100
Heavy duty trucks	3,900	31,300
Buses	260	3,000
Total	21,260	65,100

Based on adjusted data.

Table S2. Number and total length of roads in Murmansk City.

	Number of roads	Total length, km	Share, %
Category I – Arterial	22	37	27%
Category II – Highways	53	58	42%
Category III – Local	106	43	31%
Total	181	138	100%

(Murmansk City Administration, 2009)

Table S3. Average annual kilometers traveled per vehicle, different sources.

	NIIAT[a]	Avtostat[b]	MSTU inspection station[c]
Cars	15,000	16,700	17,000
LDVs	35,000	NA	NA
Trucks	35,000	NA	NA
Buses	45,000	NA	NA

[a]NIIAT, 2008;
[b]Avtostat, 2010;
[c]MSTU, 2012.

Table S4. Number of on-road vehicles by category in Murmansk City (based on video surveys).

	Cars	LDVs	Trucks	Buses
Euro 0	491	74	228	76
Euro 1	0	0	0	2
Euro 2	545	82	90	12
Euro 3	2,072	322	133	27
Euro 4	600	112	41	6
Euro 5	1,745	339	50	1
Total	5,453	929	546	124

Table S5. BC emissions from on-road vehicles in Murmansk City based on COPERT with NIIAT emission factors (t per year).

Vehicle class	Number of vehicles, based on video surveys	PM cold start, t/year	PM hot emissions, t/year	Total PM emissions, t/year	BC/PM ratio	BC emissions, t/year
Cars						
Euro 0	491	0.87	1.47	2.34	0.55	1.29
Euro 1	0	0	0	0	0.70	0.00
Euro 2	545	0.29	0.49	0.78	0.80	0.62
Euro 3	2,072	0.73	1.24	1.98	0.85	1.68
Euro 4	600	0.06	0.11	0.17	0.87	0.15
Euro 5	1,745	0.05	0.08	0.13	1	0.13
Total cars	**5,452**	**2.00**	**3.39**	**5.40**		**3.89**
Light duty vehicles						
Euro 0	74	0.35	0.60	0.95	0.55	0.52
Euro 1	0	0.00	0.00	0.00	0.70	0.00
Euro 2	82	0.12	0.20	0.32	0.80	0.26
Euro 3	322	0.33	0.56	0.90	0.85	0.76
Euro 4	112	0.07	0.12	0.19	0.87	0.16
Euro 5	339	0.01	0.02	0.04	1	0.04
Total light duty vehicles	**929**	**0.89**	**1.50**	**2.39**		**1.74**
Trucks						
Euro 0	228	-	5.89	5.89	0.50	2.94
Euro I	0	-	0.07	0.07	0.65	0.05
Euro II	90	-	0.60	0.60	0.65	0.39
Euro III	133	-	0.64	0.64	0.70	0.45
Euro IV	41	-	0.05	0.05	0.75	0.04
Euro V	50	-	0.04	0.04	0.75	0.03
Total trucks	**546**	**-**	**5.89**	**5.89**		**3.90**
Buses						
Euro 0	76	-	3.39	3.39	0.50	1.69
Euro I	1	-	0.03	0.03	0.65	0.02
Euro II	12	-	0.46	0.46	0.65	0.30
Euro III	27	-	0.23	0.23	0.70	0.16
Euro IV	7	-	0.01	0.01	0.75	0.01
Euro V	1	-	0.00	0.00	0.75	0.00
Total buses	**124**	**-**	**3.39**	**3.39**		**2.18**
Total Murmansk	**7,051**	**2.89**	**16.31**	**19.20**		**11.7**

The starting point in emission calculations is the analysis of the vehicle registry. Traffic police is responsible for registering all on-road vehicles in Russia. However, vehicle registries, particularly in countries where registries are out of date, are inadequate for emission calculations.

As a result, we decided to use a video survey method developed for IVE to study the traffic flows in Murmansk. We compared data from video survey with vehicle registry and found that the differences are very significant. The registry is outdated and shows many vehicles that are not in use anymore, mostly old heavy duty truck and buses. For example, the share of vehicles without emission controls (Euro 0) on the roads is much lower than is shown in the registry. As a result we rely on video survey to estimate the number of vehicles in use in the city.

We adjusted the vehicles registry to correct the information about the vehicle distribution by Euro class. For cars and LDV, we adjusted the information on Euro class distribution based on the parking lot surveys and data from a vehicle inspection station. For trucks and buses, we adjusted the numbers based on data from the largest bus company and other commercial vehicle companies.

We used COPERT model to calculate emissions from on-road transport. COPERT is a free software program developed by Emisia SA. The development of COPERT is coordinated by EEA, in the framework of the activities of the European Topic Centre for Air Pollution and Climate Change Mitigation. COPERT has been developed for official road transport emission inventory preparation in EEA member countries. COPERT can be downloaded for free at http://emisia.com/copert

NIIAT methodology is designed to calculate emissions from on-road transport in urban conditions. Main provisions are harmonized with the international methodology inventory of emissions EMEP /CORINAIR. NIIAT provided copies of the methodologies. There is no software developed for NIIAT methodology. We developed an Excel spreadsheet for emission calculations.

For emission calculations of vehicular emissions in Murmansk Region, we adjusted vehicle registry in two ways:

1) We apply the distribution by Euro class we found in the city to registered vehicles in the region.
2) We apply the ratio between registered and observed vehicles to eliminate from the registry vehicles that are not is use.

Table S6. BC emissions from on-road vehicles in Murmansk Region, (based on universal NIIAT methodology) (t per year).

Vehicle class	Number of vehicles	PM cold start, t/year	PM hot emissions, t/year	Total PM emissions, t/year	BC/PM ratio	BC emissions, t/year
Cars						
Euro 0	1,309	0.01	3.93	3.94	0.55	2.17
Euro 1	0	0.00	0.00	0.00	0.70	0.00
Euro 2	1,454	0.01	1.31	1.31	0.80	1.05
Euro 3	5,526	0.02	3.32	3.33	0.85	2.83
Euro 4	1,600	0.00	0.29	0.29	0.87	0.25
Euro 5	4,653	0.01	0.21	0.22	1.00	0.22
Total cars	**14,542**	0.05	9.05	9.10		6.53
Light duty vehicles						
Euro 0	238	0.02	1.92	1.94	0.55	1.07
Euro 1	0	0.00	0.00	0.00	0.70	0.00
Euro 2	264	0.01	0.65	0.65	0.80	0.52
Euro 3	1,005	0.02	1.76	1.77	0.85	1.51
Euro 4	291	0.00	0.31	0.31	0.87	0.27
Euro 5	846	0.01	0.06	0.07	1.00	0.07
Total light duty vehicles	**2,645**	0.06	4.69	4.75		3.44
Trucks						
Euro 0	1,628	0.68	71.77	72.45	0.50	36.22
Euro I	29	0.00	0.20	0.21	0.65	0.13
Euro II	638	0.02	1.93	1.95	0.65	1.27
Euro III	961	0.05	2.56	2.60	0.70	1.82
Euro IV	395	0.02	0.21	0.23	0.75	0.17
Euro V	251	0.01	0.12	0.14	0.75	0.10
Total trucks	**3,902**	0.78	76.80	77.58		39.72
Buses						
Euro 0	139	0.03	5.90	5.93	0.50	2.97
Euro I	4	0.00	0.02	0.02	0.65	0.01
Euro II	48	0.00	0.71	0.71	0.65	0.46
Euro III	57	0.01	0.78	0.79	0.70	0.55
Euro IV	13	0.00	0.02	0.02	0.75	0.01
Euro V	2	0.00	0.00	0.00	0.75	0.00
Total buses	**262**	0.04	7.43	7.47		4.01
Total Murmansk Region	**21,351**	**0.94**	**97.96**	**98.90**		**53.70**

Off-road mining vehicles and equipment

Table S7. PM emission standards for off-road diesel vehicles in the U.S. and EU (g/kWh).

Rated Power (kW)	EPA (U.S.)			EEA (Europe)		
	EPA(U.S.) Tier	Model Year	PM (g/kWh)	Stage	Year (transient load)	PM (g/kWh)
				Pre stage		
kW<8	Tier 1	2000	1.0	Stage 1	-	-
	Tier 2	2005	0.80	Stage 2	-	-
8<kW<19	Tier 1	2000	0.80	Stage 1	-	-
	Tier 2	2005	0.80	Stage 2	-	-
19<kW<37	Tier 1	1999	0.80	Stage 1	-	-
	Tier 2	2004	0.60	Stage 2	2001	0.80
	-	-	-	Stage 3A	2007	0.60
37<kW<75	Tier 1	1998	-	Stage 1	1999	0.85
	Tier 2	2004	0.40	Stage 2	2004	0.40
	Tier 3	2008		Stage 3 A	2008	
75<kW<130	Tier 1	1997	-	Stage 1	-	-
	Tier 2	2003	0.30	Stage 2	2003	0.30
	Tier 3	2007		Stage 3 A	2007	
130<kW<560	Tier 1	1996	0.54	Stage 1	-	-
	Tier 2	2003	0.20	Stage 2	2002	0.20
	Tier 3	2006		Stage 3 A	2007	
kW>560	Tier 1	2000	0.54	Stage 1	-	-
	Tier 2	2006	0.20	Stage 2	-	-
	Tier 3	-	-	Stage 3 A	-	-

Table S8. $PM_{2.5}$ emission factors for off-road machinery, g/kg of diesel fuel.

Sector	<1981	1981-1990	1991-Stage I	Stage I	Stage II
Mobile combustion in manufacturing industries and construction land-based mobile machinery; Commercial and institutional land-based mobile machinery	6.207	4.308	3.551	0.967	1.031

(EEA, 2013)

Table S9. Diesel fuel consumption by the largest mines in Murmansk Region, tons.

Company	2010	2011	2012
Apatity	65,954	67,509	64,469
Kovdorskiy GOK	35,277	42,262	47,395
Olenegorskiy GOK	16,635	18,661	21,233
Kolskaya GMK	5,766	9,786	5,457

Sources: Apatity - http://www.e-disclosure.ru/portal/company.aspx?id=645,
Kovdorskiy GOK - http://www.e-disclosure.ru/portal/company.aspx?id=3406,
Olenegorskiy GOK - http://www.e-disclosure.ru/portal/company.aspx?id=5740,
Kolskaya GMK - http://www.e-disclosure.ru/portal/company.aspx?id=7833,

Table S10. Technical characteristics of BELAZ trucks.

Model	Payload, tons	Engine	Rated power capacity, kW
7547	45	YaMZ-240NM2	368
75473	45	Cummins KTA 19-C	448
7555B	55	Cummins KTTA 19-C	522
7555D	55	Cummins KTTA 19-C	522
7555E	60	Cummins QSK 19-C	560
7555F	55	Cummins QSK 19-C	522
75570	90	Cummins QST 30-C	783
75571	90	Cummins QST 30-C	783
75121	120	Pielstick 8PA4-185	882
7513	130-136	Cummins QSK 45-C	1193
7513A	130-136	MTU DD 12V4000	1194
75131	130-136	Cummins KTA 50-C	1194
75137	130-136	MTU DD 12V4000	1193
75135	110-130	Cummins KTA 38-C	895
75139	130-136	Cummins KTA 50-C	1194
7514	120	Cummins KTA 38-C	895
75170	154-160	Cummins QSK 45-C	1491
75172	154-160	MTU DD 12V4000 (Detroit Diesel)	1400 (1875)
75174	154-160	MTU DD 12V4000 (Detroit Diesel)	1400 (1875)

(BELAZ, 2014)

Table S11. Technical characteristics of foreign-made mining trucks.

Model	Payload, tons	Engine	Rated power capacity, kW
CAT 777D	90	Caterpillar 3508B EUI Tier I emissions standard	746
CAT 777F	90	Cat® C32 ACERT™ Tier 2	758
CAT 785C	136	Caterpillar 3512B-EUI Tier I emissions standard	1082
Komatsu HD-1200-1	136	KTTA 38C-1350 Cummins KTA-38-C1200	1007/895
Komatsu HD785	91	SAA12V140E-3 EPA Tier 2	895
Terex Mining Unit Rig MT 3300 AC	136	MTU/DDC 12 V 4000 / Cummins QSK45	1286/1193
HD-1200	120	Cummins KTA-2300C	895

We assumed that 88% of mining equipment has no emission controls. If we increase the share of equipment which meets Tier 1 standard from 12 to 18%, BC emissions from mining would decrease by 13 tons per year, or more than from all on-road transport in Murmansk City.

Construction equipment

Table S12. Construction equipment and machinery in Murmansk Region.

	2007	2008	2009	2010	2011	2012	2013
Excavators	221	206	228	218	192	213	217
Cranes	39	28	25	19	18	14	21
Graders	65	70	71	82	70	80	74
Bulldozers	195	185	218	216	200	249	244
Special cranes	11	15	19	12	13	13	9
Tower cranes	24	14	11	5	5	4	3
Mobile cranes	128	125	152	131	114	113	138
Lifts	46	42	52	45	41	47	54
Loaders	113	173	152	129	142	221	227
Tractors	97	80	130	122	128	143	126
Drills	4	3	5	2	7	7	9
Rollers	67	58	56	55	46	43	37
Cement mixers	26	32	18	11	8	10	8
Construction and finishing equipment	160	140	252	263	545	551	376
Hydro hummers	28	30	32	27	27	43	32

(MBS, 2012)

There are many uncompleted construction sites that have remained in this state for many years. Only 32,600 square meters of residential buildings and 34,100 square meters of non-residential buildings were built in 2012. Industrial construction is growing, but diesel consumption in this sector appears under industrial consumption, so we did not consider it separately here. There are 16 major building construction companies, and 3.8% of the labor force or 12,000 people work in the construction industry. Currently, construction creates 3.4% of the gross regional product.

Fishing and marine transport in Murmansk Region

Table S13. Number of fishing vessels registered in Murmansk Region.

	2000	2006	2007	2008	2009	2010	2011	2012
Fishing vessels	279	270	270	265	247	225	219	214
Super trawler	20	12	11	11	11	12	12	12
Large	37	26	20	17	15	14	14	12
Medium	203	169	164	156	145	133	125	122
Small	19	63	75	81	76	66	68	68
Fish transport vessels	24	25	33	21	18	16	13	12
All	303	295	303	286	265	241	232	226

(Zabolotsky, 2012)

Table S14. Age structure of the fishing fleet, 2012 (years).

	Up to 20 years		20 years or more		Average age, years
	number	%	number	%	
Fishing vessels	30	14.0	184	86.0	26.2
Extra-large	2	16.7	10	83.3	23.1
Large	2	16.7	10	83.3	25.8
Medium	16	13.1	106	86.3	26.8
Small	10	14.7	58	85.3	25.9
Fish transport vessels	1	8.3	11	91.7	30.7
All	31	13.7	195	86.3	26.5

(Committee for the Fishery Complex of Murmansk Region, 2013)

Table S15. Distribution of fishing vessels by engine power (based on the Murmansk Fishing Port calls).

Engine power, kW	Share of port calls
< 240	34%
240-300	5%
300-400	1%
400-500	4%
500-600	12%
600-700	2%
700-800	2%
800-900	16%
900-1000	4%
1000-1100	11%
2000-3000	4%
3000-4000	2%
4000-5000	2%
Total	100%

(Murmansk Port, 2014)

Table S16. Bottom-up calculation of fuel consumption by medium and small fishing vessels (based on the Murmansk Fishing Port calls).

Engine power, kW	Number of port calls	Engine load %	Time, hours	Fuel eficiency, kg diesel /kWh	Fuel consumption, kg
220	542	0.6	7	0.203	100,351
232	7	0.6	7	0.203	1,385
272	73	0.6	7	0.203	16,929
294	48	0.6	7	0.203	12,032
331	20	0.6	7	0.203	5,644
368	36	0.6	7	0.203	11,295
241	15	0.6	7	0.203	3,082
265	25	0.6	7	0.203	5,648
590	143	0.6	7	0.203	71,934
596	9	0.6	7	0.203	4,573
618	19	0.6	7	0.203	10,011
626	7	0.6	7	0.203	3,736
736	44	0.6	7	0.203	27,611
860	302	0.6	7	0.203	221,437
970	74	0.6	7	0.203	61,200
1120	30	0.6	7	0.203	28,647
1325	12	0.6	7	0.203	13,556
1470	9	0.6	7	0.203	11,280
1500	32	0.6	7	0.203	40,925
1620	46	0.6	7	0.203	63,536
1650	22	0.6	7	0.203	30,949
1760	9	0.6	7	0.203	13,505
1800	17	0.6	7	0.203	26,090
1950	24	0.6	7	0.203	39,902
2005	7	0.6	7	0.203	11,966
2040	15	0.6	7	0.203	26,090
2160	21	0.6	7	0.203	38,674
2200	6	0.6	7	0.203	11,254
2800	7	0.6	7	0.203	16,711
3000	10	0.6	7	0.203	25,578
3080	28	0.6	7	0.203	73,528
4350	9	0.6	7	0.203	33,379
5300	39	0.6	7	0.203	176,232
Total	1707				1,238,672

(Murmansk Port, 2014)

The distribution of gross tonnage of the ships calling into the Murmansk Port

Table S17. Tankers

Gross tonnage, t	Number of calls	Share, %
< 2000	27	6%
2000-4000	47	11%
4000-10000	7	2%
10000-20000	37	9%
20000-30000	108	26%
30000-40000	7	2%
40000-50000	171	41%
> 50000	16	4%
Total	420	100%

(Murmansk Port, 2014)

Table S18. **Cargo ships**

Gross tonnage, t	Number of calls	Share, %
< 2000	38	6.3%
2 000-4 000	128	21.2%
4 000-10 000	85	14.1%
10 000-20 000	120	19.9%
20 000-30 000	26	4.3%
30 000-40 000	87	14.4%
40 000-50 000	103	17.1%
> 50 000	17	2.8%
Total	604	100.0%

(Murmansk Port, 2014)

Table S19 **Passenger ships**

Gross tonnage, t	Number of calls	Share, %
< 3000	7	8%
4000-5000	64	77%
5000-10 000	3	4%
10 000 -15000	3	4%
15 000-20 000	2	2%
>20 000	4	5%
Total	83	100%

(Murmansk Port, 2014)

Diesel generators in Murmansk Region

Table S20. Diesel generators using subsidized fuel in remote areas of Murmansk Region.

Settlement	Quantity	Capacity, kW	Fuel consumption, tons per year
Krasnoschele	2	400	341
	1	500	
Kanevka	2	90	30
Sosnovka	1	90	30
Varzuga	1	60	
Kashkarantsy	1	30	62
Tetrino	1	30	13
Pyalitsa	1	30	7
Chavanga	1	100	117
Chapoma	1	100	42
TOTAL	12	1430	642

(Ministry of Energy of Murmansk Region, 2012)

We also obtained a registry of back-up diesel generators from the Murmansk Ministry of Energy. According to the registry, there are 540 diesel generators in the region, which are used as back-up sources of electrical power. We assumed that this is a very small source of emissions because power supply on the Kola Peninsula is very stable, so each back-up generator appears to operate at most a few hours per year. As a result, we did not calculate fuel use or emissions from these generators.

Uncertainty estimates of BC emissions in Murmansk Region

Uncertainty estimates include uncertainty in activity data - uncertainty in fuel use and existence of emission controls. Activity data uncertainty is based on expert judgments.

We used a summary analysis of BC uncertainty ranges for the BC emission factors from the Bond inventory (Bond et al (2004).

Table S21. Emission factors uncertainty (%)

Source Category	Low/Mid, %	High/Mid, %
Mining	50	230
On-road transport	50	180
Construction	50	230
Agriculture	50	230
Locomotives	50	230
Diesel generators	50	230
Fishing	50	230

The algorithm for uncertainty calculations was adopted from:

IPCC: IPCC good practice guidance and uncertainty management in national greenhouse gas inventories, Institute for Global Environmental Strategies, Hayama, Japan, 4-88788-000-6, 2000.

Activity data uncertainty (U activity) is a combination of uncertainty on emission controls (U controls) and uncertainty in fuel consumption (U fuel).

$U\ activity = (U\ fuel^2 + U\ controls^2)^{1/2}$

The relative uncertainty in the emission for each activity and fuel combination is calculated as the square root of the sum of squares of the relative uncertainties in both activity data and the emission factors. The absolute uncertainty in the emission of each activity and fuel combination is derived by multiplying the relative uncertainty with the emission value.

We built two scenarios which reflect possible minimum and maximum BC emission in the region. Minimal emissions scenario reflects possible decrease in fuel consumption in the sectors and higher use of emission controls. Maximum emissions scenario show possible increase in emissions due to large diesel consumption and lack of controls. Tables S22 and S23 show calculations of low/middle and high/middle relative uncertainty of the inventory.

Table S22. BC emissions uncertainty, low /middle estimate

Source Category	BC emissions (t)	Fuel use,%	Assumptions on control,%	Activity data uncertainty (%)	Emission factor uncertainty (%)	Combined relative uncertainty (%)	Absolute uncertainty, (t)
Mining	279.3	5	50	50.2	50	70.9	198.0
On-road transport	53.7	10	10	14.1	50	52.0	27.9
Construction	12.0	50	30	58.3	50	76.8	9.2
Agriculture	3.9	10	20	22.4	50	54.8	2.1
Locomotives	22.3	10	20	22.4	50	54.8	12.2

Diesel generators	27.1	50	100	111.8	50	122.5	33.2
Fishing	5.3	5	30	30.4	50	58.5	3.0
Total	403.7					195.06	203.31

Table S23. BC emissions uncertainty, high /middle estimate

Source Category	BC Emissions (t)	Fuel use (%)	Assumptions on control (%)	Activity data uncertainty (%)	Emission factor uncertainty (%)	Combined relative uncertainty (%)	Absolute uncertainty, (t)
Mining	279.3	20	5	20.6	230	230.9	645.0
On-road transport	53.7	200	30	202.2	180	270.7	145.4
Construction	12.0	30	5	30.4	230	232.0	27.8
Agriculture	3.9	10	0	10.0	230	230.2	8.9
Locomotives	22.3	30	0	30.0	230	231.9	51.7
Diesel generators	27.1	20	0	20.0	230	230.9	62.6
Fishing	5.1	200	0	200.0	230	304.8	15.6
Total	403.42					658.37	667.00

The relative uncertainty in BC emissions in Murmansk region is from -50% to +165%.

On-road diesel fleet in Russia

Table S24. Diesel consumption by on-road vehicles in Russia in 2010.

Fuel consumption	Share, %	Diesel, million tons
Cars	4.4	0.550
Trucks	81.1	10,144
Buses	14.5	1,814

Source: (Donchenko, 2013)

Table S25. Diesel fleet distribution by environmental class in Russia in 2010 (%).

Ecological class/Vehicle type	Euro 0	Euro 1	Euro 2	Euro 3 and higher
Cars	44	2	17	37
Trucks	51	9	20	20
Buses	40	12	25	22

Source: (Donchenko, 2013)

References

Avtostat: Average mileage of cars in Russia is 16,700 kilometers per year (in Russian). Avtostat, Togliatti, Russia, , 2010. Available at http://www.autostat.ru/news/view/6069 (accessed 15 January, 2015).

BELAZ: Mining Dump Trucks, 2014. Available from http://www.belaz.by/en/catalog/products/dumptrucks/ (Accessed August 11).

Donchenko, V.: Environmental performances of motor vehicles and fuels in Russian Federation, Scientific Research Institute of Automobiles and Transportation (NIIAT), Moscow, 2013.

EEA: EMEP/EEA Air Pollutant Emission Inventory Guidebook – 2013, European Environment Agency, Copenhagen, Denmark. Available at http://www.eea.europa.eu/publications/emep-eea-guidebook-2013. Accessed July 15, 2014, 2013.

Murmansk Port: Information System on State Port Control: http://www.portcall.marinet.ru/table/, access: July 30, 2014.

IPCC: IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Institute for Global Environmental Strategies, Hayama, Japan, 2000. Available at http://www.ipcc-nggip.iges.or.jp/public/gp/english/. Accessed May 1, 2015.

MBS: Murmansk Region. Statistical Yearbok-2012 (in Russian), 2012. Available from http://murmanskstat.gks.ru/wps/wcm/connect/rosstat_ts/murmanskstat/resources/7050d7804df676adbd1bbfbfd1fdfb40/03003_2012.rar (Accessed August 8, 2014).

Ministry of Energy of Murmansk Region: Fuel consumption by diesel generators in remote settlements (in Russian), Murmansk, Russia, 2012.

MSTU: The Annual Report of the Vehicle Inspection Station of the Murmansk State Technical University (in Russian). Murmansk State Technical University, 2012.

Murmansk City Administration: Classification of Streets in Murmansk City, Murmansk, Russia 2009.

NIIAT: Calculation instruction (methodology) for emission inventory from vehicles on the territory of the largest cities (in Russian), Scientific Research Institute of Automobiles and Transportation, Moscow, Russia, 2008.

NIIAT: Calculation instruction (methodology) for emission inventory from vehicles into the air (in Russian), Scientific Research Institute of Automobiles and Transportation, Moscow, Russia, 2008.

Zabolotsky, O.: Fishery - traditional activity of the population in Murmansk Region (in Russian), Fish and Sea Food, 1 (57), 3-13, 2012.