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NEGATIVE IMPACT OF RAILWAY TRANSPORT ON THE AMBIENT ENVIRONMENT

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Abstract: Unfortunately, most of the technologies applied and currently used by mankind, to a lesser or greater degree, negatively influence and lead to the degradation and degeneration of the planetary ecosystem, with rail transport being no exception. The railways, together with the positive influence on the economic development of the regions in which they were built, have caused irreparable damage to the environment. They destroyed natural landscapes, led to the death and reduction of wildlife populations, polluted the air and created an unbearable noise. The pollution of the environment by the use of railway transport is also present for the Republic of Moldova. The article describes the main components of the impact of railway transport on the environment: pollutants, electromagnetic fields and rolling stock noise.

Keywords. *transport, railway, electromagnetic field, exhaust gases, environment, toxic substances, waste water, noise of rolling stock, noise pollution.*

Introduction

From the moment of its appearance, the railways, together with the enormous positive effect that they provided due to the rapid development of the areas they were passing through, acted negatively with a number of factors on adjacent territories. The noise of rolling stock, which, compared to animal-powered vehicles, proved to be terrifying, frightening the animals, not allowing them to cross the railroad, thus diminishing their population. In North America, the buffering and death of animals under the wheels of the train, both wild and domestic, were usual. This is the reason why the „animal scraper” was invented – a special grid in the lower part of the locomotive, not only for the protection of the animals, but also for the prevention of the train's exit. Serious problems began later when the railways began to expand rapidly not only the line network but also the infrastructure – the locomotive and wagon depots, railway stations etc. Over time, the railway stations that were built on the outskirts of the cities, „wake up” right in the center, and the railroads passed through the residential districts, which created discomfort for the residents of nearby houses. The development of electric traction, although it has

contributed to the reduction of noise and harmful emissions, has caused another problem – the influence of the magnetic fields created by the contact suspension.

Table 1.

Length of railways in general use, inventory rail transport and freight transport by means of transport at the end of the year

The year	2010	2011	2012	2013	2014	2015	2016	2017
The length of railways in service for general use, km	1157	1157	1157	1157	1156	1151	1151	1151
Diesel locomotives	152	150	139	138	138	138	138	134
Freight wagons	7835	7606	7433	7035	6866	6866	6741	5582
Passenger carriages	411	399	399	388	381	381	346	268
Goods transported – total, thousands of tons	27781,2	30717,6	30022,6	35674,1	37143,1	36711,8	36992,2	42928,2
Rail transport	3852,1	4554,0	4163,8	5430,6	5008,4	4157,9	3493,0	4793,9
Road transport	23800,6	26012,9	25713,0	30079,6	31906,7	32401,3	33363,1	37998,4
River transport	127,2	149,1	144,2	162,6	227,2	152,0	135,6	134,8
Air transport	1,30	1,60	1,57	1,28	0,81	0,58	0,49	1,06
Goods flow – total, million tons-km	4193,1	4795,5	4916,3	5651,6	5489,7	5182,0	5484,3	5996,6
Rail transport	958,6	1196,0	959,5	1226,9	1181,4	963,5	789,9	987,1
Road transport	3232,4	3597,3	3954,7	4423,1	4306,5	4217,3	4693,4	5008,4
River transport	0,4	0,5	0,4	0,5	0,8	0,4	0,3	0,3
Air transport	1,7	1,7	1,7	1,1	1,0	0,8	0,7	0,8
Passengers transported – total, thousands of passengers	232455,2	237099,6	240378,7	237237,6	237156,1	248727,2	248315,2	251793,4
Rail transport	4963,7	4711,3	4340,9	4092,4	3838,2	3268,3	2258,1	1813,7
Buses	105984,5	115270,6	118090,6	114800,3	108279,4	102641,6	102121,5	100325,7
Taxi	4085,5	4085,5	3724,4	3761,7	3048,0	4950,8	4960,3	6463,2
Trolleys	116476,6	112209,2	113434,1	113811,8	120951,1	136641,7	137708,1	141420,2
River transport	118,8	122,6	115,7	116,4	141,6	139,4	138,7	130,2
Air transport	649,2	700,4	673,0	655,0	897,8	1085,4	1128,5	1640,4
Passengers' journey – total, millions of passengers-km	3993,4	4349,7	4472,3	4574,4	4631,8	5071,9	5302,1	6212,6
Rail transport	398,8	363,1	347,2	329,8	256,9	180,8	121,5	99,0
Buses	2416,7	2733,4	2835,5	3003,6	2720,3	2834,4	3005,7	3123,0
Taxi	80,1	80,5	74,5	76,0	62,5	100,5	107,8	139,4
Trolleys	346,8	335,1	340,1	342,3	366,9	413,2	415,5	427,0
River transport	0,2	0,3	0,2	0,2	0,3	0,3	0,3	0,3
Air transport	750,8	837,3	874,8	822,4	1224,9	1542,7	1651,3	2423,9

Railway transport, currently widely used around the world, is a land transport vehicle in which freight and passengers are carried out on railways with wheeled vehicles. The length of the railways operating in the world is approaching 1 million kilometers and

continues to grow rapidly in the Republic of Moldova being 1151 km (table 1). Inventory rail transport equipment at the end of 2017 consists of 134 diesel locomotives, 5582 freight wagons and 268 passenger wagons (table 1). Railways are considered one of the main inalienable signs of a developed civilization. In the Republic of Moldova the share of rail transport accounts for about 13% of freight transport (20% for freight) and about 1,5% of passenger traffic (5,8% for passengers) (table 1) being in a continuous decrease particularly in passenger traffic. The impact of railway transport on the environment is assessed by the level of consumption of natural resources and the level of pollutants emitted in the environment in the regions where the railway undertakings are located. All sources of environmental pollution, according to the nature of the operation, are divided into stationary and mobile. Stationary sources include locomotive and wagon depots, repair plants and preparation points of rolling stock, boiler rooms etc. Mobile and maneuvering locomotives, operating and repair vehicles, industrial transport, refrigerated wagons, freight and passengers etc. are hung to mobile sources. In turn, stationary sources of complexity and number of technological processes can create pollutants of several types.

In general, factors affecting the environment, the objects of the railway transport, can be classified according to the following criteria:

- mechanical action (solid waste, road action on the soil);
- physical action (thermal emissions, electromagnetic fields, ultrasound and infrared radiation, vibrations, radiation);
- chemical action (acids, bases, metal salts, hydrocarbons, paints and solvents, pesticides);
- biological action (macro and microorganisms, bacteria, viruses);
- landscaping, drainage etc.

1. Rail transport – source of pollution of the environment with toxic emissions

The environmental advantage of rail transport consists, in general, of the significantly small amount of harmful emissions in the atmosphere per unit of work performed (table 2). The main source of air pollution is the exhaust gases of locomotive diesel engines and the toxic substances emitted by the thermoelectric power plants producing electricity for electric transport, as well as the rolling stock production and repair enterprises. Among the most important pollutants are: soot, carbon oxides, sulfur and nitrogen, hydrocarbons, lead. Accumulation of these substances in the air leads to significant damage to vegetation (acid rain) as well as to human health (smog). The content of sulfur compounds depends on the amount of sulfur in diesel, and the the content of other components – on the method and quality of the combustion process, as well as the type of overcharging and the load on the engine. The high amount of toxic substances in the

Table 2.

The ratio of the specific action indicators on environment and population by different types of transport

Specific action indicator	Type of shipment		
	railway	auto	aerial
Energy consumption	1	8	3,5
Emissions of toxic substances	1	73	600
The area occupied	1	1,3	4,8

exhaust gases of diesel engines in idle mode is conditioned not only by poor mixing of the fuel with the air, but also by combustion of fuel at lower temperatures.

Diesel engines installed on locomotives and those installed on cars in principle do not differentiate, but the working process of diesel locomotives is more stable, because the amount of harmful gases is much lower. The operating mode of the maneuvering locomotives is less stable than the main ones, which is why the emissions of toxic substances to them are several times higher. In the Republic of Moldova it is more complicated to reduce the amount of harmful gases emitted into the atmosphere, due to the small distances between the stations because, as it is known smoke and gas emissions are higher in the use of permanent stationary transport than at larger distance at constant speed. With this, fuel consumption also increases, as a result of this, these factors play an important role not only in the environment but also in the fuel economy.

During the period 2010-2017, 19,11 thousand tons of fuel were used annually by rail transport in the Republic of Moldova (table 3). The amount of annual emissions of pollutants into the atmosphere, as a result of combustion of spent fuel, is 3,06 thousand tons, including: carbon dioxide 1,03 thousand tons, nitrogen dioxide – 0,37 thousand tons, hydrocarbons – 0,78 thousand tons, sulfur – 0,30 thousand tons, aldehydes – 0,33 thousand tons, solid substances – 0,20 thousand tons.

Table 3.

**Air pollutant emissions from rail transport and fuel consumption during 2010-2017
(thousand tons)**

The year	The amount of fuel	Mass of total emissions	Including:					
			CO	CH	NO ₂	SO ₂	aldehydes	solid substances
2010	21,55	3,64	1,10	0,42	0,88	0,32	0,72	0,20
2011	23,86	4,01	1,19	0,46	0,98	0,36	0,80	0,22
2012	19,12	2,68	1,01	0,37	0,78	0,28	0,07	0,17
2013	20,17	2,85	1,09	0,39	0,82	0,30	0,07	0,18
2014	19,20	2,66	0,98	0,37	0,78	0,29	0,06	0,18
2015	15,93	2,81	0,95	0,32	0,65	0,23	0,52	0,14
2016	---	2,90	1,00	0,40	0,90	0,30	0,10	0,20
2017	13,96	2,39	0,87	0,27	0,57	0,33	0,05	0,30

Atmospheric air pollution is characterized by the following data: a section of the diesel locomotive emits in the atmosphere 28 kg of carbon monoxide, 17,5 kg of nitrogen oxides and up to 2 kg of soot per hour. At the rail welding industry, 3060 g of aerosols containing manganese, silicon oxides and fluorides are emitted into the atmosphere while using 1 kg of welding wire. When processing a rail welding joint, after welding, up to 60 g of dust, containing silicon, magnesium and aluminum oxides are emitted. When painting on products with ventilation emissions, up to 30% of paint and varnish materials (acetone, toluene, alcohol and different resins) are emitted. When washing the rolling stock alkaline, surface active substances etc. are hit into atmosphere.

In order to carry out the transport operations, the loading and unloading operations, the storage of the goods and the technical maintenance and repair of the rolling stock and

the upper rail structure, the railway transport consumes not only natural resources such as water, air and soil, but it also pollutes them.

Every year, up to 200 m^3 of waste water, containing pathogenic micro-organisms, is poured out of passenger wagons every year and up to 12 t of garbage is dumped. This leads to the pollution of the railways and the environment. This problem can be solved by the use in the passenger wagons of storage tanks for the storage of waste water and garbage or treatment devices.

From the ecological point of view, the most dangerous railway enterprises and objects are the stations for flushing and steaming bulk rolling stock, disinfection points for animal transport wagons and biologically hazardous substances, gravel and macadam impregnation plants, depots of locomotives and wagons, rolling stock, carrying petroleum products and explosives. Environmental safety can also be disturbed by physical factors that are created during railway transport (noise, vibration, electric and electromagnetic fields, explosions, fires).

When washing the railway vehicles in the soil and the water basins water, together with the waste waters, penetrate synthetic substances, petroleum products, phenols, hexavalent chromium, acids, bases, organic and inorganic substances in suspension etc. Much more than waste water, there is soil pollution in the area near the cleaning and washing points of the rolling stock.

At the repair plants, in the depots of locomotives and wagons, waste water is formed by washing the rolling stock, cleaning components and parts in washing machines and baths, galvanic machining of parts, washing of batteries, regenerating filters, washing and blowing boilers, hydraulic testing of various vessels, discharge of water from oil storage facilities, washing of floors, visiting channels etc.

Waste water at passenger wagon washing points is formed during external body and chassis washing, containing petroleum products, metal corrosion products, dust, various organic impurities, and detergents used to wash wagons. In the places of preparation of the freight wagons, where they are washed inside, in the waste water there are remnants of the shipped goods: cement, chalk, bricks, mineral fertilizers, cereals, vegetables, animal feed, meat, fish etc.

At the disinfection-washing stations where the wagons are processed after the transport of animals, birds, raw material from leather, wool, bones, waste water are polluted with manure, straw, disinfectants (bleach, caustic soda etc.) and causative agents of various diseases.

2. Railway transport – source of electromagnetic pollution of the environment

Electromagnetic field generators, which, for autonomous traction, are primary high voltage back-up lines. In the case of electric traction, a network of contacts is added. Although *DC* current (*Edison*) and *AC* current (*Westinghouse*) electric air lines appeared at the end of the nineteenth century, there is still no shared view of the impact of the electromagnetic fields created by them on the human body. This is reflected in the sanitary rules, which differ in different countries.

The general view that scientists from different countries have come to is the belief that electromagnetic fields of direct current and alternating current of industrial frequency affect the human nervous system, alter blood pressure, possibly, inhibit hematopoietic function, but to what extent and with what values the opinions vary greatly.

3. Railway transport – a source of environmental noise pollution

One of the major sources of pollution is the noise produced by rail transport. It is highlighted in the following aspects: the noise of wagon movement resulting from the interaction between the wheel and the rail, being the main source of noise for a train running, the locomotive noise due to the operation of the diesel engine, traction motors, transmissions, auxiliary motors and gears and aerodynamic noise, which is lower than rolling noise.

The noise pollution during the rolling stock exploitation, taking into consideration the state of the locomotives operated on the territory of the country, has a negative impact on the health of the people living near the railway stations.

One of the creators of the steam locomotive, *George Stephenson*, enjoys the imposing sound of his creation. The inventor assumed that the strong sound, symbolizing power and speed, attracts people's attention. Times, have changed instead. At the moment the noise produced by locomotives is a disadvantage.

Considering that for a large part of the developed countries, rail transport has become the main source of transport, such as subway, tram and suburban trains, such a parameter as noise is very important. It has a number of negative factors such as sleep disturbances, behavioral change and increased drug use. Noise can cause direct reactions to the ear and even to the entire body. The intensity of the noise disturbance is directly related to its intensity, frequency and duration. Noise causes impaired circulatory function, stomach neurosis, insomnia etc.

The noise produced by the railway stations in the dwelling areas is more painful than the one at the outskirts of the city, the noise produced by the railway stations and the triage stations located in the dwelling areas have a greater negative effect than a mere movement of the train. Train noise has been shown to be more obstructive to speech perception than vehicle noise. This process is primarily due to the duration of the sound effect produced by the train movement.

The noise produced by the railway vehicle is composed of the noise produced by the locomotive and wagons. During the operation of diesel locomotives the highest noise is produced by the exhaust pipes of the engine, which reaches 100-110 *dB*. Even at a distance of 50 *m* from the railway, the external noise of the railway vehicle is 83-89 *dB*.

The main noise source of the wagons is the blows of the wheels at the points of union and the irregularities of the rails, as well as the friction of the running surface and the wheel flange with the rail. The track joints cause shock noise with a level increase of up to 10 *dB*. The basic factor leading to the increase of noise is the vulnerable state of the railway, the rails in particular. Rail surface defects cause vibrations and strokes, reduce rail stability, lead to rolling stock wear and increased noise levels up to 15 *dB*.

Noise also occurs from suspension strokes, from vibration of brake rods, clutches, couplings etc. Air propagation can occur through any existing and unprotected openings (doors, windows, passageways, ventilation ducts, wagon communications).

Aerodynamic noise is produced by the air currents which wash the walls of the locomotive and the wagons, in particular the front walls and the wings of the wagon. In the range of speeds of up to 160 *km/h*, the main noises that predominate are rolling noise, locomotive engine noise and braking noise. Aerodynamic origin noise mainly targets high-speed trains (over 300 *km/h*).

4. Proposals for improvement

The condition of the rolling stock and the equipment generally operated by the Moldovan Railways is in deplorable condition, that leads to frequent failures during use, that is why it can not be the case about minimizing the gas emissions. Not worrying about the state of the road infrastructure, which is also in poor condition and poorly maintained, a colossal investment is needed to bring it to normal. As a result of above mentioned we have: excessive fuel consumption, increased gas and emissions to the atmosphere, increased noise and obviously poor rolling stock condition. According to Moldova's Railways 2014-2020 Investment Plan, rail infrastructure in the Republic of Moldova would require an investments of almost 300 million euros in order to improve its quality and safety. This must be the first step towards solving the economic, as well as ecological problem of Moldovan Railways.

For the Republic of Moldova the increased reduction of harmful emissions can be solved by electrifying the roads or equipping the Moldovan Railways with locomotives and wagons of the latest generation, which will help minimize the harmful emissions in the atmosphere. Another way to reduce harmful emissions from railway transport is to equip diesel engines with exhaust-gas neutralization systems similar to those of cars, or to drive locomotives on other more environment friendly fuels.

The main measures for protection of the water basins from the pollution with the waste waters of the railway transport are the construction and reconstruction of the treatment plants, the implementation of the water recycling, the normalization of the consumption and the reduction of the polluted emissions, the improvement of the laboratory control etc.

For noise protection in the design of the railways it is necessary to provide for bypass routes for trains in transit, without entering the city, for sorting stations outside the localities. In the construction of the new railway it is necessary to separate the railway lines and the stations from the residential area at a distance of at least 300 m.

In order to reduce the noise level of the trains, a series of measures, mainly aimed at protection against rolling noise, which is the main source in the range of up to 300 km/h, are used. The complex of these measures has been named *LNT-technology (Low-Noise Technology)*, including the following:

- ✓ the use of disc brakes instead of drum brakes on all wheel pairs, which allows for a longer duration of maintenance of the smooth running surface of the wheels, thus reducing the noise;
- ✓ grinding of rails;
- ✓ use of damping plates on wheels;
- ✓ installation of noise protection aprons, against the treadmill of the rolling stock;
- ✓ construction of low-noise protection screens near the railway station.

The use of *LNT-technology* measures at the design stage of rolling stock and the construction or reconstruction of railways allows for the reduction of costs that will be needed to compensate for the negative impact of the noise produced by the rolling stock on the environment.

Another way to reduce the noise of railway transport is to use green space. Green areas (trees and shrubs) disperse and absorb the energy of the waves that propagate through them. As a result of these measures, the effects of noise propagation through a strip of green space are reduced compared to a treeless area. To achieve a significant effect,

the green stripe along the noise source should not have free spaces, ie the tree crowns should be closed to one another and the space under the crowns should be filled with dense bushes. Coniferous trees offer the best results. Using a green planting strip of about 60 m in width can provide an additional reduction in rolling stock noise of approximately 12 dB. The need to reduce the noise of a train by more than 20 dB requires the use of noise protection tunnels (galleries).

Practice has shown that an effective method of protecting the population against noise is the construction of industrial objects or garages along the railway.

Conclusion

1. The influence of railway transport, although it is a source with negative impact on the environment and the population, it is much lower than other sources of pollution.
2. The environmental advantage of rail transport, compared to other modes of transport, is the significant small amount of harmful emissions in the atmosphere per unit of work performed.
3. The impact of magnetic fields created by the railroad contact network and high voltage self-propelled power lines on the population living near the railways according to measurements is significantly lower than the existing sanitary standards.
4. Rail transport is a source of noise, which causes dissatisfaction with the population living near railways. Applying the described solutions can significantly reduce the impact of rail transport noise.

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