CRITERIA OF ENVIRONMENTAL SAFETY OF RAILWAY TRANSPORTATION

Ovanesova, Elena A., *Russian University of Transport, Moscow, Russia.*

ABSRACT

The article describes the case when railway transport complex is presented as an element within structured concept of national economy's transition to sustainable development. A question of formulating objective criteria of environmental safety of freight and passenger transportation is discussed. Environmental aspects of operation of railways are developed, and criteria-based approaches to safety of railway-related infrastructure, rolling stock and environment are suggested.

Keywords: railways, transportation, carriage, sustainable development, ecological aspects, criteria of environmental safety.

Scientists have no unity of opinion on whether or not investments into the development of the transportation network are the foundation of economic growth; and whether economic growth leads to increased intensity and volume of transportation. It is evident, however, that economic growth and the growth of «transportation load» are related processes, and, as noted in the transportation strategy of the Russian Federation, «along with further development of the country, expansion of its internal and external transportation and economic links, increased production volumes, and improvement of the nation's standard of living, the importance of the transport sector and its role as a systemic factor will only go up» [1].

A well-developed transport network that has sufficient throughput capacity and a high quality of transportation processes is an indispensable part of economic, sociopolitical, and cultural progress of any nation.

Its current state makes transport one of the key links in the transition to a new environmental world order. As the science of ecology was maturing, it was becoming increasingly clear that humans are capable of making persistent changes in the structure of the biosphere. However, such changes have had mostly negative consequences not only for the natural environment, but also for humans themselves [2]. As a result, the old concepts of treating the planet merely as a set of resources to be consumed are increasingly superseded by a paradigm of more careful and rational treatment of the Nature: ideas of sustainable development have gained universal recognition in the academic community, and such concepts as the Gaia hypothesis and the «theory of the golden billion», etc. are explored.

The Russian academic tradition views the transition to sustainable development as a stage in the evolution of the biosphere into the noosphere, rather than an end in and of itself: sustainable development, in the view of western academics, has to do with problems addressed by economics, science, engineering, and novel environment-friendly technologies; whereas the ideas of transitioning to the noosphere are primarily associated with spiritual growth, morals, and the emergence of new aesthetics.

Such an approach is well illustrated by V. A. Vanyushin and O. L. Kuznetsov, who write, «Noospheric development (the genesis of the noosphere) and sustainable development are essentially very close notions. The noosphere is a stage of maturity and completion in the transition to sustainable development» [3, page 68]. Construed like this, the restructuring of the global economy in line with the dicta of sustainable development as a general concept, i.e. the transition to a state of harmonious growth that bears no threat to the lives of future generations, is an existential need, a required condition, and the foundation of further evolutionary progress. Economic growth is necessary; it must, however, involve a transition to qualitatively new technologies that would reduce the specific load on the natural environment per unit of product or service.

Any element of the technosphere, including rail transport, is a system that interacts with its environment. It is critically important that we identify all aspects of this interaction, assess their significance, and determine possible methods of their control and regulation. What poses the greatest problem is that to-date, the limits of the biotechnosphere's stability have not been studied and understood sufficiently, and therefore there are no objective criteria to make a judgment on their significance. That said, the development and application of ecological criteria that are based on the principles of transition to a new sustainable state is unarguably necessary in order to decide on the most optimal way to develop the railway complex and its individual components.

Today, experts recognize rail transport as one of the most environment-friendly modes of transportation. In transportation by rail, emissions of carbon dioxide per passenger per kilometer are about one third of those in automotive transportation and one fourth of air transport emissions [4]. On the other hand, we still cannot say that railways' environmental safety is at a sufficiently high level. A whole range of problems remain unsolved.

Our analysis of the transportation process as a source of negative impacts on the environment reveals the following factors:

- *noise emissions;*
- *electromagnetic emissions;*
- *bacterial contamination of the rail track and adjacent areas;*
- *contamination of adjacent areas with heavy metals and other organic and non-organic hazardous substances (oils and other lubricants, electrolytes);*
- *emissions of fuel combustion products by locomotives that use coal-fired heating boilers;*
- *consumption of electricity;*
- *consumption of water, coal, and other resources;*
- *generation of dangerous non-organic waste;*
- *fragmentation of ecosystems;*
- *taking up land for the construction of railways and associated infrastructure.*

Given that, in the absence of complete input information, an objective and comprehensive set of criteria for the assessment of the above factors can be defined only partially, we suggest only those criteria for the assessment of the rail transport's environmental safety that lend themselves to practical application:

- *specific energy consumption per unit of freight or per passenger;*
- *total use of energy by the rail transport complex;*
- *share of alternative energy sources and environmentally friendly types of fuel;*

Table 1

Significance analysis of some environmental aspects of passenger railway transport by the coefficient of normative (background) value violation

No.	Factor	Actual value	Normative (background) value	Violation coefficient (N)	Source of input data
1	Contamination of soils with heavy metals (at a distance of 100 m from the primary traffic axis)	–	–	up to 130*	[6]
2	Magnetic field intensity (at a distance of 2 m from the track axis and at the current of 1,000 A), in A/m	86.7	16	5.4750	[7, 8]
3	Noise (at 100 m from the track axis), in dBA	76.5	55	1.3909	[9, 10]
4	Specific emission of greenhouse gases in freight transportation (diesel locos), in g/t·km	35	–	0.0534**	[12]
5	Specific emission of greenhouse gases in freight transportation (electric locos), in g/t·km	18	–	0.0247**	[12]
6	Electric field intensity (at 3 m from the track axis, at a height of 1.8 m), in V/m	1.9	1000	0.0019	[7, 11]

* Cumulative value of contamination with heavy metals: $Zc = \sum_{i=1}^{n} \frac{C_i}{C_{bi}} - (n-1)$,

where $\frac{C_i}{C_{bi}}$ is the ratio of element content in the research sample to the mean background content of the element.

** Adopted as the background value is the specific emission of greenhouse gases for air transport.

• specific emissions of contaminants per unit of freight or per passenger (as determined by inventorying emissions of rail transport facilities);

• cumulative emissions of contaminants by the rail transport complex;

• specific emissions of greenhouse gases per unit of freight or per passenger;

• total emissions of greenhouse gases by the rail transport complex;

• violations of admissible quality criteria of atmospheric air, surface and ground waters, and soil resulting from processes involved in the operation of the railway complex;

• degree of ecosystems' fragmentation;

• alienation of land for transportation infrastructure;

• accessibility and attractiveness to customers on the market of transportation services.

It should also be taken into account that environmental aspects and environmental safety criteria can be different for different ecosystems. For example, when measures are designed to reduce the negative environmental impact of transport in populated areas, such factors come into the foreground as transport-related noise, contamination of the atmosphere with fuel combustion products, alienation of land (in the conditions of a densely built-up urban areas), increased intensity of electromagnetic fields, and contamination of soil. For specially protected nature reserves, such factors become key as the noise from transport facilities and ecosystem fragmentation that have the decisive impact on the change of habitats and migration of biological populations. For agricultural lands, contamination of soils with heavy metals and other harmful or dangerous substances is the most significant.

In view of the current limited understanding of biotechnosphere stability, and the impossibility of determining the quantitative indicators for all of the proposed criteria, it is customary to proceed from the principle of «zero impact», meaning that the normal (ideal) state is the absence the potentially damaging factor. This approach, although the most accepted one today, may however lead to a certain distortion of the results obtained through the process of environmental risk assessment.

To evaluate the significance of environmental aspects in populated areas, the integral assessment model based on the Liebig's law of the minimum is suitable with certain qualifications. The model is described in the paper A model of integral ecological and hygienic assessment of the industrial environment [5].

The following procedure is suggested for environment quality assessment:

1. Determine a set of parameters by which to perform the assessment. The parameters are selected in view of the specific features of the object to be studied.

2. Determine the normative (background) values of the selected parameters in view of the category of the object and the purpose of the study.

3. Perform the quantitative evaluation of the selected parameters.

4. Determine the relative indicator of the environment quality by the formula

$E = max(N_1, N_2 \ldots N_n)$,

where N_i is determined by the identified dependencies:

– for environmental parameters that have a ceiling of admissible values

$$N_i = \frac{C_i}{P_i},$$

where C_i is the actual value of the n^{th} environmental parameter, P_i is the normative (background) value of the n^{th} parameter;

– for environmental parameters with a floor of admissible values

$N_i = \frac{P_i}{C_i}$;

– for environmental parameters with a range of admissible values [a, b]

$N_i = \left\|2\frac{C_i - a}{b - a} - 1\right\|$	at	$C_i \in [a, b]$;
$N_i = \frac{C_i}{b}$	at	$C_i > b$;
$N_i = \frac{a}{C_i}$	at	$C_i < a$.

Table 1 is an example analysis of the significance of contributions made by some environmental aspects of rail transport operation. The input data for the analysis were taken from published sources. The aspects were ranked by the coefficient reflecting the degree of violation of the normative (background) value of the parameter. The analysis shows that, out of the reviewed factors, the greatest significance was associated with the contamination of the soils with heavy metals, excessive levels of magnetic fields intensity in the vicinity of electric railway sections, and acoustic contamination of adjacent areas.

Conclusions

The problem of developing a set of objective criteria to be used for assessing environmental safety of the transport sector, as well as any other sector of the economy, remains unsolved. Today, only paths to its solving have been outlined. A conceptual strategy for the development of the railway complex must include certain effectiveness indicators based on the environmental safety criteria rather than be merely declarative. The criteria suggested in this article can, among others, be laid in the foundation of the effort to develop such a conceptual strategy. However, the question of a methodology to be used for their validation remains open.

REFERENCES

1. Order of the Government of the Russian Federation dated 22.11.2008 No. 1734-r (ed. 11.06.2014) «On the Transport Strategy of the Russian Federation» [*Rasporyazhenie pravitel'stva RF ot 22.11.2008 № 1734-r (red. ot 11.06.2014) «O Transportnoy strategii Rossijskoy Federatsii»*]. Legislative acts of the Russian Federation, 15.12.2008, No. 50, art. 5977 [*Sobranie zakonodatel'stva RF, 15.12.2008, № 50, st. 5977*].

2. Ovanesova, E. A. Notion of ecological and hygienic safety in the system of interdisciplinary interactions [*Ponyatie ehkologo-gigienicheskoj bezopasnosti v sisteme mezhdistsiplinarnykh vzaimodejstvij*]. Modern problems of social, economic and ecological safety of Volga region. Proceedings of VIII international scientific and practical conference [*Aktual'nye problemy sotsial'no-ehkonomicheskoy i ehkologicheskoy bezopasnosti Povolzhskogo regiona: Sb. materialov VIII mezhdunarodnoj nauchno-prakt. konferentsii*]. Kazan branch of MIIT University, Kazan, Mir bez granits publ., 2016, pp. 8–10.

3. Drobzhev, M. I. Vladimit Vernadsky; noosphere and sustainable development [*V. I. Vernadskij: noosfera i ustojchivoe razvitie*]. *Voprosy sovremennoy nauki i praktiki*, 2013, Iss. 3, pp. 65–75.

4. Brown, Lester R. World on the Edge: How to Prevent Environmental and Economic Collapse. N.Y., W. W. Norton & Company, 2011, 327 p.

5. Ovanesova, E. A. Model of integral ecological and hygienic assessment of industrial environment [*Model' integral'noj ehkologo-gigienicheskoy otsenki proizvodstvennoy sredy*]. [Electronic resource]: http://fcrisk.ru/forums/node/386. Last accessed 22.05.2017.

6. Zhuravleva, M. A. Ecological assessment of distribution of heavy metals in railways' right of way. Ph.D. (Eng) thesis [*Ekologicheskaya otsenka raspredeleniya tyazhelykh metallov v polose otvoda zheleznykh dorog. Dis... kand. tehn. nauk*]. Moscow, 2015, 209 p.

7. Belinsky, S. O. Methods and tools of protection of personnel against electromagnetic fields of traction power supply facilities tools [*Metody i sredstva zashhity personala ot ehlektromagnitnykh polej ob»ektov tyagovogo ehlektrosnabzheniya*]. In: Modern approaches of providing hygienic, health and disease, environmental safety of railways. Collection of works of young researchers and staff of transport sector [*Sovremennye podkhody k obespecheniyu gigienicheskoj, sanitarno-ehpidemiologicheskoj i ehkologicheskoj bezopasnosti na zheleznodorozhnom transporte: Sb. trudov molodykh uchenykh i spetsialistov transportnoj otrasli*]. Gen. ed. Udaeva, O. S., Ovanesova, E. A. Moscow, 2015, pp. 18–31.

8. Hygienic specification GN2.1.8/2.2.4.2262–07 «Maximum permissible levels of electromagnetic fields of 50Hz frequency in the rooms of residential and public buildings and in the territories intended for building [*GN2.1.8/2.2.4.2262–07 «Predel'no dopustimye urovni magnitnykh polej chastotoj 50 Gts v pomeshheniyakh zhilykh, obshhestvennykh zdanij i na selitebnykh territoriyakh»*].

9. Ovanesova, E. A. Protection against noise on railways: identification of th necessary width of sanitary protective zone [*Zashhita ot shuma na zheleznodorozhnom transporte: opredelenie trebuemoj shiriny sanitarno-zashhitnoj zony*]. In: Modern approaches of providing hygienic, health and disease, environmental safety of railways. Collection of works of young researchers and staff of transport sector [*Sovremennye podkhody k obespecheniyu gigienicheskoj, sanitarno-ehpidemiologicheskoj i ehkologicheskoj bezopasnosti na zheleznodorozhnom transporte: Sb. trudov molodykh uchenykh i spetsialistov transportnoj otrasli*]. Second issue. Moscow, VNIIZH, 2016, pp. 104–109.

10. Collection of rules SP 51.13330.2011 «Protection against noise. Revised edition of construction standards and rules SNiP 23–03–2003» [*SP 51.13330.2011 «Zashhita ot shuma. Aktualizirovannaya redaktsiya SNiP 23–03–2003»*].

11. Sanitary rules and standards SanPiN2.1.2.2645–10 «Sanitary and disease control requirements to the conditions of habitation in residential buildings and rooms» [*SanPiN2.1.2.2645–10 «Sanitarno-ehpidemiologicheskie trebovaniya k usloviyam prozhivaniya v zhilykh zdaniyakh i pomeshheniyakh»*].

12. Environmental strategy of the JSC Russian Railways till 2017 and towards 2030 [*Ekologicheskaya strategiya OAO «RZHD» na period do 2017 goda i perspektivu do 2030 goda*]. [Electronic resource]: http://doc.rzd.ru/doc/public/ru?id=6415&layer_id=5104&. Last accessed 22.05.2017.

Information about the author:

Ovanesova, Elena A. – assistant lecturer at the department of technosphere safety of the Russian University of Transport, Moscow, Russia, e-toloknova@rambler.ru.

Article received 22.05.2017, accepted 15.07.2017.