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ANALYSIS OF THE ENVIRONMENTAL CONDITION OF RAILWAY TRACKS

Theses of a PhD dissertation

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1. Antecedents, goals

At present the proportion of railway transport in comparison to other transport branches in Hungary is more favourable than in Western Europe. In accordance with the EU directives our transport policy aims at preventing the declining of this proportion.

The Third All-European Transport Conference held in Helsinki in 1997 approved the European transport corridors, and Hungary undertook the liability of the construction of the Helsinki-corridors, thus, the improvement of the network has been continuous. The improvement and reconditioning works of the railway goes hand in hand with the change of the old railway ballast. The modern-type ballast screening machines put the substance screened out first to a band transporter and then into storage trolleys. Next it is transported from the site, thus, the screening remainder of the ballasts of different age and quality is often mixed, and it is impossible to know, whether this remainder means a real hazardous waste or not. To find it out, laboratory tests are needed. The waste-qualifying tests were not performed on a uniform technology, but rather on occasional samples, and since the reconstruction works had to be finished on time, the screening waste substances were often let in the waste banks in railway wagons or on the area of the station until the results of the tests came out. This is not only because of the occupation of the field unfavourable but, without knowing the rate of contamination, the later laying in deponies is not solved, either. By virtue of the results of the laboratory tests the author observed that certain line segments of the railway track indicated the same contamination rate, irrespective of the geographical area. The samples taken from the waste banks proved to show worse results as if they had been taken separately from the tracks, the ballast taken from some sidings could contaminate the whole waste bank.

An expectation of the European Union is that the commercial and the infrastructure-operating divisions of the railways must be separated in every member state. Furthermore, by paying the adequate fee the railway lines have to be made available to every enterprise providing railway services. Among the diverse tasks of the infrastructure-operator the environmental protection plays an important role. In order to be able to compose the environmental expectations towards the service provider (maintained fleet, decontaminated use of line), and to call somebody to account for his/her fault in the form of costs, a comprehensive environmental state monitoring system would be necessary, which could show the updated state of the line and which would screen the undesirable results influencing the environment. At present, such a monitoring system is not operating neither

on the area of the MÁV Co, nor on the railway network of the European railways. Its development would be beneficial from the point of view of the reduction of waste, the reutilization of the remaining substances, and would also result in a significant cost saving during the waste elimination.

The dissertation gives a reply to the question how and with what kind of a simple and easily manageable method the environmental state of a railway track could be presented, how the change of state could be followed and what results it would bring into the environmental management of the MÁV Co.

By the way of the environmental analysis of the railway track, it aims at laying the ground of such an environmental state monitoring system, which, if it would be introduced, would bring a solution of the problem scheduled above, since an enormous amount of remaining and waste substances arises during the track reconstruction works.

2. Applied research methods

To the presentation of the environmental state of railway tracks and the verification of the feasibility of the planned monitoring system the author came through the application of the following methods:

- *Bibliographic research*

  Overview of English, German and Hungarian language bibliography. Since the theme was quite limited, the author examined the literature referring to the environmental state of the railway track not only in the journals and on the Internet, but firstly dealed with the issues related to the reutilization of the railway ballast. In order to have an insight the research reports of the international railway companies were sent to the author from the Documentation Centre of MÁV.

- *Use of the experience from research work prepared earlier*

  During her engineering work earlier the author had continuous contact to the technical services of the tracks of MÁV Co. She participated as theme leader or a member of the working group in the research made on the relevant changes of the railway track. Along with the environmental protection coming to the fore it became more and more evident that one must deal with the environmental issues of railway ballasts. The participation in the works made it possible for her to get to know a number of relevant laboratory test results related to this, from which the assumptions needed for the preparation of the present essay originated.

- *Survey*

  It seemed to be reasonable to visit other European railways with a questionnaire to find out whether any similar idea came up on the development of a railway monitoring system.

- *Theoretical assumption – practical demonstration*

  From the knowledge received from the practice of railway construction and maintenance the author of the essay had the assumption that

  a) the old railway ballast could also be ecologically not dangerous, or rather it could be characterized by the numerical rates of the activities done on the track;

  b) the received rates could be checked by laboratory tests;

  c) with the support of the above mentioned a monitoring system could be formed.

  By virtue of this a research-development project started with the leadership of the author at the predecessor of today's university,

namely at the Széchenyi István College, in 1998, by the commission of the MÁV Co. Railway Infrastructure Directory. The laboratory examination of the samples taken from the tracks during the three-year work confirmed the assumption mentioned above, and provided the ground for the preparation of the present dissertation.

- *Statistical examinations*

  The examination of the laboratory results of the substance samples happened with the method of mathematic statistics, proving that the contaminating substances do not depend on the place but rather on the manufacturing technology, and the results can be extended to the whole country. The help for the tests and the preparation of the figures necessary for the presentation of the results was provided by the statistical software STATA 8.2.

- *Technics of system building*

  The monitoring system forms a sub-system to the Environmental Control System (ECS, Környezeti Irányítási Rendszer, KIR, hereinafter referred to as ECS). The widespread development of the ECS is included in the strategy of the MÁV Co. One computer system (PÁTER) has already existed for the control of the geometric state of the railway tracks and the indication and planning of the necessary interventions, to which, with a small-scale improvement, an environmental control system could also be attached. After the complete building-up of the ECS it can become an objective system based on the same hardware, supporting each other and planning the intervention.

  Some help for the building of the environmental monitoring system applicable on the railway track was provided by the experience made during the preparation of the Ph.D. dissertation in which the candidate made a proposal of a similar system-based application.

3. Theses

3.1. The idea of the environmental state of a railway track was introduced by the author. According to this the environmental state of a railway track includes the rate of the ecological ballast quality which takes effect on the environmental elements located in the direct surrounding of the rail ballast.

This is an uncommon definition, since the environmental state is characterized by the ballast quality. The reason for that is that the ballast includes that path element which takes up and transfers the contamination, or rather which keeps it. Consequently, the environmental quality of this element has a significant effect on the quality of the soil and the ground water to be found there. It logically results from this that if we managed to keep the ballast clean then the state of the railway track would also be good and we would not endanger the environmental elements, either. In the essay, the contaminating activities of the railway transport, the environmental loading arising from these and the assessment of the degree of these were collected by the author through detailed examination. From the impact matrix she demonstrated that we really had to deal with the ballast if we wanted to assess the ecological quality. The monitoring system planned by virtue of the tests will, of course, observe much more elements of the environment of the railway track. The highest significance of the monitoring system put forward in the dissertation is that we get to know the updated state of the railway track, and we do not have to decide through urgent laboratory tests afterwards, during the demolition works what ecological hazard the demolished substance includes. This also makes the work of the manufacturers doing the track updating works during the tendering time period easier, and last but not least, real budgets can be prepared if we have information about the expected contamination or cleanness or the further predestination of the screenings.

3.2. During the railway track reconditioning works the contamination is collected by the ballast stone or rather its close-grained parts, the screenings. It is well-known from the bibliography and as well from the professional experience that the track has parts of different contamination rates. The author at first demonstrated through statistical methods what correlation can be found between the environmental state of the open-lined segments, of the station line segments and of the ballast stone under the sidings.

There is a significant discrepancy between the distribution diagrams of the laboratory results of the three sample queue. The average oil content of the samples from the stations are four times as much as that of the samples from the open lines, and that of the sidings is more than tenfold. This could justify the separate handling of the individual parts. In the opinion of the candidate

the railway tracks have to be divided into three different environmental categories.

3.3. The author establishes the categories K_A, K_B and K_C, and she also provides the definition of the individual categories. Depending on the expected contamination category K_A is the cleanest, and all open-lined tracks would be included here, K_B would mark the middle-contaminated ballast of the station tracks, while K_C would indicate the oil-contaminated ballast of the line segments surrounding the sidings, the rail greasers and –signallers.

The basis for the division into three categories was not only provided by the statistical data mentioned before. The candidate tested those substances which had been transported from sites of different categories to the waste bank. When comparing the waste bank, the open line and the whole (K_A+K_B+K_C) sample queue, she discovered that the samples taken from the waste bank nearly correspond to the whole sample queue. This is not surprising since substances from the sites of all three categories get to the waste bank. However, the samples taken from the waste bank are of 42 per cent more contaminated than the whole sample queue, even though this deviation is not significant, i.e. it probably comes from the default made by the sampling. This underpins that idea of the author that the railway tracks have to be divided into three different environmental categories, and the substances arising from the demolition have to be collected on different sites and they have to be handled by separate processes. Otherwise, even the ballast substance demolished from under one single siding can contaminate the whole waste bank, or rather, it can lead to wrong assessments because of the sampling uncertainty. For the division into three environmental categories sampling during the circulation and laboratory tests is needed.

3.4. By virtue of the statistical principles known on the sampling of the screenings taken from the railway track, the theory on the process and the samples has been worked out and presented in the essay by the author. The samplings were prepared with this process during the research.

The sampling has to be carried out in a way that the stability of the track is kept as well by the demolished ballast. About the method of this a plot and cross-sectional figure provides details in the essay. The number of pieces of the samples is of importance, for which the standard on the samples taken from the waste bank has to be taken as a basis. Thus, such a long segment has to appointed for the sampling, from the demolishing of which we would take as many screenings into the waste bank as many the standard specifies to the sampling. As for an approach, the essay took an average cross-section as a basis, and also that professional experience - which is as well underpinned by bibliographic data - that from a mechanically clean track of one linear meters only 10 per cent include the screenings. Thus, one average

sample has to be drawn up from a track length of 1.5 km. The average samples are composed of the mixture of patterns taken every 500 metres. In this way 177 average samples were formed during the research, from about 704 patterns, since there were places where 5 patterns were mixed in order to get a more exact composition.

3.5. The author defined the list of the possibly least but still sufficient laboratory tests. Through these tests, the ecological condition of the track can be well characterized. She found out that it was superfluous to carry out the whole waste-qualifying test range, and she also deems the test range of the screening samples taken from the waste banks of foreign examples to be exaggerated. The author stated that the test range for the division into environmental categories could be simplified further. The environmental state of a railway track is mainly determined by the amount of oil derivatives to be found in them (the screenings), thus, it is sufficient to deal with the examination of these when we carry out statistical tests for the categorisation.

This assumption is built upon the fact that she let heavy metal tests, indication of agent remainders and PCB-tests to be made, however, no sample showed excess of the limit value, not even in category K_C. The widespread examination of the contamination, which could get in touch with the railway track, verified that the PCB could only imply contamination in the case of wood-bedded rails - just as it occurs at railways of a similar structure by virtue of our bibliographic examples -; and the herbicides could be excluded if we let a monitoring system operate on the railway and accorded the time of the track demolition and the drizzling. Thus, she decided to carry out the following tests:

- determination of the pH-rate,
- examination of the ecotoxicology by Daphnia-test,
- examination of the ecotoxicology by seedling test,
- determination of the KOI,
- examination on the ammonia content,
- examination on the oil content (SZOE),
- amount of the soluble substance.

If the results of this tests are negative then we can characterize the screenings with certainty as ecologically adaptable, and we can plan the usage in accordance with this.

With regard to the whole sample multitude the correlation of the individual contaminating materials shown in the laboratory results indicated that the SZOE-rate correlated positively with the amount of the KOI and the soluble substances. It also came out from the results that the correlation of the KOI-

rates was stronger, it was 0.674. The test on the chemical oxygen demand usually indicates with an efficiency of 80 per cent the whole oxidating organic substance in the sample. It could occur that the correlation was not so strong and the reason for that could be that there are a lot of such substances in the sample which can be oxidized on the one hand but which doesn't come from an oil derivative on the other hand. In the opinion of the candidate, the significant synkinesia of the KOI-rates with the SZOE-rotes implies that the basic contamination of the railway ballast is in reality generated by the oil contamination and not by other materials.

3.6. The author examined what hazardous material-concentrations could be found in the screenings at the SZOE-rate of 1000 mg/kg. She stated, with reference to the most hazardous substance, which SZOE-rate was the highest at which the contamination-concentration is yet hazardous, and thus, the ballast could not be considered as ecologically acceptable. From the calculation on the concentration of hazardous components the candidate provides a new limit value. This value coincides with the operative legal regulation, and at the same time it simplifies that process through which the contamination of the screenings by virtue of the SZOE-rate can be determined.

The total amount of the oil derivatives to be found in the screenings is shown by the organic solvent extract test. The test does not provide information by what amount of the hydrocarbon-component this amount was formed. Thus, the candidate collected the list of those substances and then the security forms specified for their transport from the traffic, haulage and track maintenance technical service which occur the most time in the ballast. According to the European Union and the national legal regulation the sentences 'R' and 'S' of the security forms refer to the danger of the substances. Also these papers show the amount of the hazardous components occurring in the transported substances. For the sake of the security she assumed that the most hazardous substance from the available list got into the ballast, and the hypothetical SZOE-rate of 1000 mg/kg to be found in the given sample indicated this. She chose this rate because at the time of the validity of the old regulations this contamination had yet been under the limit value. From this she calculated the hazardous substance concentration. The most hazardous substance was the gas oil used as fuel for diesel locomotives. From the calculations it came out that the concentration of the hazardous components would be unacceptable if they had a SZOE-rate of 110,000 mg/kg in the screenings and this would solely originate from gas oil. It is clear to the author that this rate is not acceptable from the point of view of the environment. Also because of this she considers it highly important to order as well a toxicology test at the monitoring control tests because the other results would already indicate the ecological danger at

such high contamination; the Daphnia- or alga- and germ-tests would indicate that there was a substance which was ecologically unacceptable.

From the distribution diagram of the samples it can be proven that the SZOE-rate of the screenings originating from the open line fully coincided with the limit value of 1000 mg/kg so far. But at the same time, from the calculations on the concentration of hazardous components it became obvious that a much higher SZOE-rate than this was also allowable. The author determined this rate as a concentration of 3000 mg/kg. With this limit value 80 per cent of the station tracks of the Hungarian railway network could be moved to category K_A if the ballast emerging from the surrounding of the sidings and the signals could be segregated during the demolition. This is important because category K_A is an ecologically adaptable category and the substances coming out from this can be used in other fields without any other measure, in accordance with its technical eligibility. All these ensured by a monitoring system could save the manufacturer or the MÁV Co. from significant costs, depending on what kind of contract for the handling and utilization of the remaining substances has been concluded.

3.7. The laboratory tests certifying the environmental state of a railway track are expensive. The candidate examined the possibility whether there were such typical characteristics through which the laboratory tests could be replaced or the number of them could be reduced. As a result of the examination the extent of the freight traffic going through the ballast stones of the track during its whole life time came out. The development and the operation of the monitoring system would be simplified if we had an assessment function available which would on the first hand indicate the degree of the contamination and on the other hand which would show the estimation certainty. This function is presented in the essay by the author.

Since the appearance of contamination in the track can always be deduced from technical (operational) reasons, the correlation examination of the following parameters and contaminating substances was included in the essay: age of the ballast, nature of the haulage, aggregate loading, freight proportion in the loading. The annual loading goes with the recurrent contamination of the ballast, thus, when estimating the state of the environment, the time elapsed can be an important factor. In the regression analysis there was no significant correlation between the age of the ballast and the SZOE-rate. Surprisingly, nor between the diesel haulage and the SZOE. This implies that the most hazardous substance mentioned before, i.e. the fuel of the diesel motor can be a typical contamination resource at the haulage sites but not on the open lines, where the fuel weeping during the operation wouldn't be really fortunate. The aggregate loading indicated weak correlation, while the freight loading showed a significant positive impact. According to the regression equation of the SZOE-contamination

depending on the freight traffic a 10 per cent increase in the freight traffic indicates a contamination increase of 4 per cent. With the help of the STATA 8.2 programme a function could be produced which assigns the estimated SZOE-contamination to the freight traffic. During its use the expected SZOE-rate can be read off along with an estimation certainty of 99 per cent or rather 95 per cent, if the gross ton freight traffic gone through is known. The estimating function has been prepared by virtue of samples taken from the area of different lines across the country. In order to expand it to the whole MÁV network only samples from the South-Eastern part of the country not included in the examination would be necessary, the laboratory result of which should be processed so that the estimating curve can be used with full certainty to the lines of MÁV. Accordingly this shows the expected SZOE-rate at the time of an eventual track demolition, and we get a good estimation on the ecological quality. If no reconditioning works are expected then the importance of the use of this curve is that the loading data have to be read off to the SZOE-rate of 3000 mg/kg given as a limit value, and one have to be aware that before reaching this it is worth doing some ballast screening because later category K_A will be exceeded and the substance emerging from the track won't be clean.

3.8. As a result of the tests made so far the author makes a proposal on an environmental state monitoring system on the lines of the MÁV Co. At the European railways there hasn't been a system of such kind.

An advantage of the system, beyond the knowledge of the environmental condition and the advantages of this, is inherent in its simple feasibility. In the network of the MÁV Co. a geometric controlling, planning and decision-making computer system (PÁTER) has already existed. In the development of this the author also participated actively. The hardware and software elements of the system can also be utilized in the development of the new, environmental monitoring and later environmental control system. The elements of this and the phases of the implementation are included in the essay.

The demolished ballast substance is included in the European Waste Catalogue (EWC) in a way that it can get two codes: one must be registered as hazardous material because of the hazardous components, while with the other code the ballast bed of non-hazardous materials of the railway track may be supplied. This delimitation indicated that tests always had to be carried out implying under which code signal the demolished material should be added, when we demolish ballast. As a result of the research done, Nr. 27 of the Notice of MÁV Co. placed the code of the screenings under number 11 when classifying the waste, and thus, it does not range the demolished ballast screenings to the non-hazardous substances. In order to

make this always reliably acceptable on a delivery note and that no separate laboratory tests have to be carried out on the verification of the credibility, the development of the monitoring system and its operation to be included in a legal measure is essential. The author aimed at carrying out the preparation of this by writing this essay, too. After the development of the monitoring system the solution of the reutilization of the substances emerging from the track at national level is considered as important, with regard to the remarkable amount of these materials.

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