Influence of Wooden Cross Ties on the Surrounding Medium at Operation of Transport Objects in Cold Regions

E V Rusanova¹, M S Abu-Khasan¹, V V Egorov¹
¹Emperor Alexander I St. Petersburg State Transport University, 9, Moskovsky pr, Saint Petersburg, 190031, Russia

E-mail: pgups1967@mail.ru

Abstract. In article questions of influence of wooden cross ties on a surrounding medium in the course of their operation on the railroad and after their replacement are considered in cold northern regions. The biggest negative impact on the environment comes from wooden sleepers impregnated with coal oil, oil pollution and heavy metal ions. Some ways of isolation of waste wooden cross ties by means of the geoeco-protective spreading materials are shown. Insulation technology has been proposed to minimize the environmental impact of spent wood sleepers for cold areas.

1. Introduction
Railways represent a complicated structure. The operation of such transport facilities in cold regions is extremely important. Therefore, the structure of operation includes services that maintain the railway track in good condition. These services are responsible for the condition of the railways themselves, for the lands that are occupied by railways, adjacent roadbed, as well as buildings and structures that provide railway transport activities. The company owning railways is obliged to maintain these lands in accordance with the legislation of the Russian Federation. Operation of transport facilities should not cause damage to the land as a natural object, prevent pollution of the environment by industrial wastewater and other waste from the production activities of railways, littering and waterlogging of land, taking into account environmental and sanitary-epidemiological requirements [1-5].

2. Practical Application and Results
From time to time there are repair works made on the railways. Land allotment lanes are often used in the repair of railways as storage spaces for used wooden and reinforced concrete sleepers (figure 1), worn-out rails, oil-polluted building materials such as rubble, sand, greasy rags, and others. This leads to environmental pollution. Organic contaminants enter the soil from objects contaminated with various chemicals - for example, from spent wooden sleepers, during asphalting of crossings, with the introduction of chemical additives to strengthen the soil, from waste fuels and lubricants, oily washing waste, etc. [6-10].
Currently, spent wood sleepers must be processed. This is done to prevent pollution of the environment. The list of main technologies that allow to utilize waste wooden sleepers: burning, pyrolysis, recycling with the production of secondary raw materials, biological decomposition, use as building materials, use as reinforcement in building materials and more [11-14].

Spent sleepers must be transported to temporary storage immediately after their removal. This is done according to the rules that apply to the organizations responsible for the operation of the transport infrastructure. Temporary placement and accumulation of old-fashioned wooden sleepers should be carried out on a paved area. Sleepers should be stacked. But this method of temporary placement does not take into account the isolation of spent wooden sleepers from the environment. This leads to a negative impact on the environment, on water and on the soil through washouts of pollution by atmospheric precipitation.

Evaluation of the influence of swabs was carried out by determining the concentration of contaminants. Determining the concentration of phenols and petroleum products in water extracts from sleepers is most indicative of the environmental impact assessment of wooden sleepers [15-17].

Research was conducted on the example of water extracts from spent wooden sleepers. The technique was following:

1) samples were taken from spent wooden sleepers, while considering: the weight of the samples, the volume of the samples, the surface area of the samples was calculated;
2) the samples were placed in 1.0-liter glass cylinders and filled with distilled water in a volume of 500 ml;
3) analysis of water extracts was done at regular intervals.

The chromatographic method of analysis was chosen for qualitative analysis, the fluorescence method was chosen for quantitative analysis.

Chromatographic analysis (for qualitative composition) of water extracts from spent wooden

| Substance                      | %  | Substance     | %  |
|--------------------------------|----|---------------|----|
| Naphthalene and its homologues | 14 | Fluorene      | 3,42 |
| Acenaphthene                   | 5,49 | Pyrene       | 4,3 |
| Defineline oxide               | 1,1 | Phenanthrene  | 8,3 |
| Benzofluorene                  | 1,03 | Indole       | 0,58 |
| Benzantracene                  | 0,94 | Phenanthracene | 6,45 |
| Benzopyrene                    | 0,3 | Carbazole     | 0,58 |
| Fluoranthene                   | 6,93 | Phenols      | 3,94 |
| Chrysene                       | 3,15 | Crezol       | 1,14 |
| Quinoline                      | 0,96 | Xylenols     | 0,84 |
| Pyridine homologues            | 0,15 |

Figure 1. Storage of used wooden sleepers.

Table 1. Hydrocarbons included in composition of coal oil.
sleepers at the age of 7 days showed the presence of the following compounds in them (figure 2): 3-aminophenol; phenol; 4-nitrophenol; 3-nitrophenol; 2-nitrophenol; 4-chlorophenol; 3,5-dimethoxyphenol; 2,4-dimethoxyphenol; pentachlorophenol; 3,4-dichlorophenol.

**Phenols**

| Naming | The content of total phenols (phenol index), average, in water extracts over time: |
|--------|---------------------------------------------------------------------------------|
|        | 6 months | 1 year |
| mg/l   |          |        |
| Exhaust hood | 1,32   | 1,29   |
| Excess of maximum concentration limit, times | 5,3 | 5,2 |

The results of analyzes of water extracts from spent wooden sleepers showed that the release of phenols into the water and oil products from wooden sleepers is interconnected with the surface area of the samples that came in contact with water. The dependence of the concentration of pollution in water extracts at the age of 1 year on the area of the contact surface.

Research has shown that in order to preserve the environment from pollution, it is necessary to insulate reliably wooden sleepers during their storage in temporary storage places [18-20].

Special structures should be used to isolate used wooden sleepers. These special facilities are designed to minimize the ingress of harmful substances into the environment. The bottom of these structures should be special and should prevent harmful substances from entering the soil.

Special concrete can be offered as a material. Concrete is able to be impermeable to aqueous solutions, including those containing impurities. This ability depends on its density.

To assess the ability of concrete to retain pollution in itself, concretes with traditional and new
additives were selected:
1) Concrete without additives brand 300
2) Concrete brand 350 with the addition of superplasticizer C-3
3) Concrete brand 350 with the addition of liquid glass Na$_2$SiO$_3$
4) Concrete of high density with the sol-containing composition “Hardness-M” H$_2$SiO$_4$ + K$_4$[Fe(CN)$_6$] mark 800

The compositions of concrete are presented in table 3.

Table 3. Compositions of concrete used to isolate spent wooden sleepers.

| Number | Cement | Grit | Rubble mine | Water | Addition of masses, % of weight of cement | Type of additive | W/C | Brand of concrete |
|--------|--------|------|-------------|-------|------------------------------------------|------------------|-----|------------------|
| 1      | 400    | 827  | 1073        | 144   | -                                        | -                | 0.36| M300 (B22,5)     |
| 2      | 400    | 890  | 1073        | 120   | 0.6                                      | C-3              | 0.30| M350 (B25)       |
| 3      | 400    | 858  | 1073        | 132   | 2.5                                      | Na$_2$SiO$_3$    | 0.33| M350 (B25)       |
| 4      | 950    | 184  | 1049        | 223   | 0.75                                     | sol              | 0.23| M800 (B60)       |

Concrete was rated for insulating ability. Samples were made of concrete, inside which contained pieces of spent wooden sleepers.

Studies were conducted on the example of water extracts from these samples of concrete. The technique was following:
1) spent wooden sleepers were sawn into identical pieces of 1 × 1 × 8 cm;
2) concrete mix was made (table 4);
3) the concrete mixture was placed in a special form 4 × 4 × 10 cm;
4) the pieces of the sleepers were placed inside compositions No. 1, No. 2, No. 3, No. 4 in the middle (along the longitudinal axis);
5) all samples were hardened for 28 days under normal conditions;
6) the samples were placed in 1.0 liter glass cylinders and filled with distilled water in a volume of 500 ml;
7) analysis of water extracts was done at regular intervals.

Samples were placed in water for a long time. This water was periodically analyzed after 3 days, 7 days, 21 days, 1 month, 4 months, 6 months and 1 year. The analysis was carried out on petroleum products and on the total content of phenols (phenol index). These indicators are most typical for spent old wood sleepers. One sample did not contain used wooden sleepers. It is called the control. The results are presented in table 4.
Concrete with a sol-additive (sample No. 4) showed excellent insulating ability. This ability is a consequence of a decrease in the porosity of concrete and an increase in its density. The porosity of concrete decreases in the presence of an orthosilicic acid sol. This concrete is called high density. The structure of high-density concrete compared with the usual is shown in Figure 3, 4.

![Figure 3](image1.png)  ![Figure 4](image2.png)

Figure 3. Structure of an artificial stone (magnification 10) control.  
Figure 4. Structure of an artificial stone (magnification 10) high density.

Traditional concrete without additives and concrete with traditional additives are not able to isolate used wooden sleepers. These concretes release the components of the coal oil into the environment over time. Only high-density concrete with a sol-containing additive provided sufficient insulation. Experiments show the importance of the selection of material for the temporary insulation of used old wooden sleepers.

The temporary storage of used old wooden sleepers must be protected. This can be done by designing special building structures. High-density concrete is the best material for such structures. It provides reliable insulation.

The bottom of such structures has special requirements. As a material, it is supposed to create special geo-protective ground structures. Cellular soil screen can be used as a material for such structures. The screen is in the form of a plate. The plate is laid on the bottom of special designs. This plate is able to absorb organic compounds and block them inside. Further, these contaminants are

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**Table 4.** The insulating capacity of concrete of various substances.

| Chemical Substance | Concentration in water extracts of petroleum products (numbers) | TLV, mg/l |
|-------------------|---------------------------------------------------------------|-----------|
|                   | 3 days | 7 days | 21 days | 1 month | 4 months | 6 months | 1 year | |
| 1                 | n/f    | n/f    | 0.09    | *        | *        | *        | *       | 0.05  |
|                   |        |        | 0.05    | 0.27     |          |          |         | 0.25  |
| 2 (C-3)           | n/f    | n/f    | n/f    | n/f    | *        | *        |         | 0.05  |
|                   |        |        |        | 0.17   | 0.37     |          |         | 0.25  |
| 3 (Na₂SiO₃)       | n/f    | n/f    | n/f    | n/f    | *        | *        |         | 0.05  |
|                   |        |        |        | 0.11   | 0.32     |          |         | 0.25  |
| 4 (sol)           | n/f    | n/f    | n/f    | n/f    | n/f      | n/f      | n/f     | 0.05  |
|                   |        |        |        |        |          |          |         | 0.25  |
| Control (without used wooden sleepers) | n/f | n/f | n/f | n/f | n/f | n/f | n/f | 0.05 |

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transferred to the structure of the material and do not allow further migration to the environment. This method refers to preserving the natural-man-made transport system.

3. Conclusions
1) Water extracts from spent wooden sleepers showed a negative impact on the surrounding aquatic environment. Contamination concentrations exceed the standards in all samples.
2) The surface area of the sleepers affects the release of phenols into the water and oil products from spent wooden sleepers. The relationship between precipitation and the surface of the sleepers in contact with water was revealed.
3) Different formulations of concrete were analyzed. Concrete without additives and concrete with traditional additives are not able to create the insulating effect of coal oil on the environment. High-density concrete with sol-containing additives can provide adequate insulation. Water extracts from these samples do not contain phenols and petroleum products.
4) Insulation technology has been proposed to minimize the environmental impact of spent wood sleepers. High-density concrete was adopted as a material for the manufacture of special structures.
5) A ground screen has been proposed to block the dirt inside.

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