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Simona Glazova

Analysis of used wooden railway sleeper waste and its decontamination methods

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- **Problem –** hazardous waste, decontamination of such waste on the market is unattractive financially and environmentally. Large amounts of used wooden sleepers can't be decontaminated in short period of time – the need of new efficient decontamination method.
- **Topicality -** solving environmental problems, the main goal of which is the prevention of waste using bioremediation technologies.
- **Work aim –** to analyze existing used wooden railway sleeper decontamination methods.

Main problem – creosote oil

Figure 1 Creosote oil
(https://www.indiamart.com/proddetail/creosote-oil-13133095197.html)

Wooden railway sleepers

- durability – 25-30 years for hardwood and 18-21 years for softwood;
- it is saturated with creosote oil to prevent the disruption from wood eroding;
- cannot be used inside any buildings or places, including parks and gardens, recreational facilities, and especially not on playgrounds;
- about 30 thousands units each year of disposed sleepers are collected in LTU;

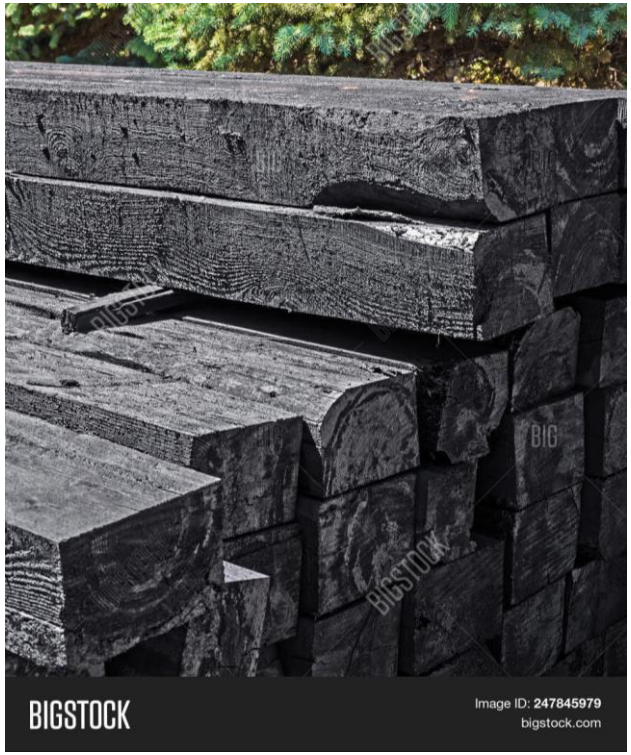

Figure 2. Impregnated wooden railway sleepers (https://www.bigstockphoto.com/image-247845979/stock-photo-set-of-new-creosote-impregnated-wooden-sleepers-are-stacked-on-each-other-against-the-background-of)

Creosote oil

- Creosote oil has antiseptic properties;
- It is difficult to recycle - low solubility in water;
- the most important groups of compounds forming the creosote oil structure are aromatic hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) – 75 – 90%;
- threatens the health of humans and animals leading to increased cancer incidence;
- The main manufacturers are concentrated in China, North America, Europe, India and Japan (20.53%, 15.37%, 17.30%, 23.32%, 13.20%);

Figure 3. View of autoclave for impregnation with the Rüping method *(Wojciechowski et al 2018)*

Decontamination methods

1. **Thermolysis**
2. **Pyrolysis**
3. **Gasification**
4. **Decontamination**
5. **Bioremediation**

Figure 4. Used wooden railway sleeper
(John Keates / Alamy Stock Photo)

Thermolysis/ pyrolysis

- Thermolysis - anaoerobic thermal decomposition of waste in the steel reactor at a temperature up to 490 °C. Decomposition products are char-coal, wood gas, wood vinegas (acetic acid, methanol) and tar.
- Pyrolysis - anaoerobic thermal decomposition of waste at a temperature around 200 – 300 °C. Pyrolysis products always produce solid (char, ash), liquid and non-condensable gases.

Figure 5. Example of thermal decomposition system (Wojciechowski et al 2018)

Gasification

- Gasification is a thermal waste treatment process in which combustible gases such as H_2, CO and CH_4, tar and slag are formed when biomass at high temperatures interacts with air, water vapor or carbon dioxide.
- After cleaning the impurities (carbon particles, ash and tar) from the formed gas, they can be used as fuel in gas turbines, internal combustion engines or industrial equipment

Decontamination

- Removal of hazardous substances while maintaining their structure.
- Decontamination takes place in a vacuum chamber. Studies have shown that low boiling point (218 - 245 °C) PAHs (naphthalene, 1-methylnaphthalene, 2-methylnaphthalene) can be completely removed and higher boiling point (> 245 °C) PAHs (acenaphthalene, acenaphthene) , fluorene, phenanthrene, anthracene, etc.) may be reduced.
- Using this method, up to 70% of PAHs can be removed from sleepers

Bioremediation

The main motor for bioremediation is the stimulation of growth of certain microorganism. These microorganims decontaminate such pollutants like oils, solvents and pesticides for sources of food and energy.

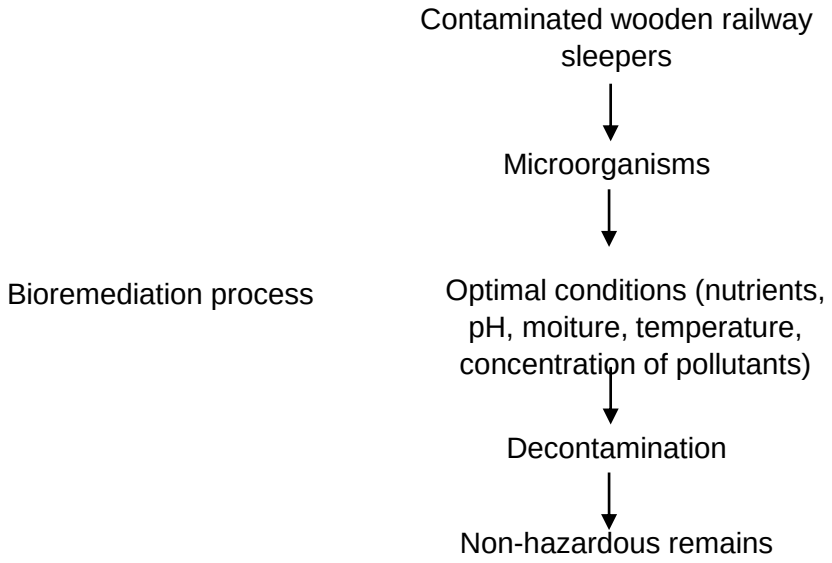

Figure 6. Scheme of bioremediation process

Bioremediation

- Can be done in situ or ex citu. Ex citu bioremediation is a sollution if the conditions are not favorable for microorganisms.
- Bioremediation process can take from several months to even several years to complete.
- High molecular weight compounds are metabolized slowly, because of their structural complexity, low solubility. Mostly these pollutants are biodegradable under aerobic conditions.

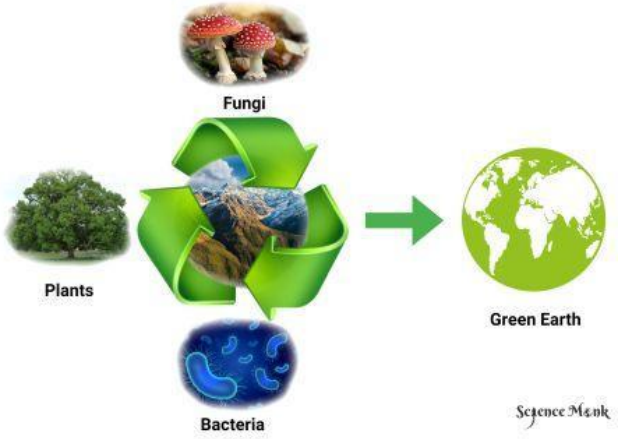

Figure 7. Essence of bioremediation (https://sciencemonk.com/bioremediation/)

Bioremediation

- The amount of C, O_2, pH, temperature, proper concentration of nutrients (such as N, P, K, S, Fe, Ca, Mg, Cl).
- Mainly organic contaminants serve as a providers of carbon – it is needed for new cell growth and energy.
- Majority of microorganisms grow over a narrow pH range of 6–8.
- It has been found that 10^{o}C rise of temperature can double the kinetic rate.
- Water is needed for microbial reproduction and growth, but optimal water presence can’t be higher that 10 – 20 % by mass.

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Simona Glazova

simona.glazova@stud.vgtu.lt

Thanks

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