

## **POLYCHLORINATED BIPHENYLS CONTAMINATION HOTSPOT: A REVIEW OF THE ENVIRONMENTAL POLLUTION AT THE INDUSTRIAL SITE**

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### **Abstract**

The industrial zone of Incel in Banja Luka has been facing severe pollution issues, primarily due to the presence of polychlorinated biphenyls (PCBs) and other harmful contaminants. The contamination is believed to have stemmed from industrial activities, with the release of waste materials and improper disposal practices being the main culprits. PCBs are a class of synthetic organic chemicals that were widely used in various industrial processes such as electrical equipment, plastics, and rubber products. However, their use has been banned due to their potential to cause serious health and environmental problems. The contamination of the Incel industrial zone poses a significant threat to the environment and public health. Exposure to PCBs can lead to various health problems, including skin rashes, liver damage, and reproductive disorders. In addition, the toxic chemicals can accumulate in the food chain, leading to long-term

ecological damage. To address the pollution issue, there needs to be a concerted effort by the authorities and industries operating in the Incel zone. Measures such as stricter regulations, better waste management practices, and increased environmental monitoring can help reduce the release of contaminants and prevent further contamination of the area. Overall, the pollution problem in the Incel industrial zone highlights the importance of sustainable industrial practices and responsible waste management to protect both the environment and human health.

**Key words:** PCB, Incel, Banja Luka, pollution

## INTRODUCTION

Polychlorinated biphenyls (PCBs) are a group of synthetic organic chemicals that were widely used in the past as coolants, lubricants, and insulating materials in electrical equipment. PCBs are highly toxic, persistent, and bioaccumulative, meaning that they can remain in the environment for a long time and accumulate in the food chain. Exposure to PCBs can have severe adverse effects on human health and the environment (Gašić et al., 2010; Ilić et al., 2020; Ilić et al., 2021c).

The pollution issue in the Incel industrial zone in Banja Luka (Republic of Srpska, Bosnia and Herzegovina) is a significant environmental and public health concern (Ilić et al., 2020; Stojanović Bjelić et al., 2022). Incel location (former cellulose factory, now industrial complex) 3 km from the center of Banja Luka – the second-largest city in Bosnia and Herzegovina (Ilić et al., 2020). Results indicate that the soils in the location Incel suffer different levels and other of dangerous and harmful substances and that: polycyclic aromatic hydrocarbon (PAH), Total petroleum hydrocarbons (TPH) and heavy metals. Soil was highly polluted (Ilić et al., 2020; Ilić et al., 2021a; Ilić et al., 2021b; Ilić et al., 2021c; Ilić et al., 2021d). The contamination of the area with PCBs and other harmful contaminants has led to the degradation of the soil, water, and air, posing a severe risk to human health and the environment. PCBs, in particular, are a class of synthetic organic chemicals that are known to cause serious health problems, including skin rashes, liver damage, and reproductive disorders. The sources of pollution in the Incel industrial zone are multifaceted and include industrial activities such as the release of waste materials, improper disposal practices, and lack of proper pollution control measures. Additionally, the industrial zone is located near a residential area, further increasing the risk of exposure to harmful pollutants for local communities (Lammel et al., 2010a; Lammel et al., 2010b;

Lammel et al., 2011; Gašić et al., 2010; Ilić et al., 2020; Ilić et al., 2021a; Ilić et al., 2021b; Ilić et al., 2021c; Ilić et al., 2021d).

The Stockholm Convention on Persistent Organic Pollutants (POPs) is an international treaty that aims to protect human health and the environment from highly toxic and persistent chemicals such as PCBs (Fiedler et al., 2019; Ilić and Maksimović, 2021). The problem of soil contamination with PCBs is directly related to the Stockholm Convention, as soil is a major sink for POPs. Contaminated soil can pose a risk to human health and the environment, as PCBs can enter the food chain and persist for a long time. The Convention provides a framework for addressing the problem of soil contamination with POPs, including PCBs, through measures such as risk assessments, soil remediation, and pollution prevention. By implementing the provisions of the Convention, countries can reduce the risks posed by soil contamination with PCBs and other POPs and protect human health and the environment (Lallas, 2001; Porta & Zumeta, 2002; Fiedler et al., 2019; Ilić and Maksimović, 2021).

When PCBs are released into the environment, they can enter the soil, water, and air, where they can persist for decades (Ododo et al., 2019; Hashmi et al., 2021). The main route of exposure for humans is through the ingestion of contaminated food, such as fish, meat, and dairy products, as PCBs accumulate in the fatty tissues of animals. In addition, PCBs can also enter the body through inhalation and skin contact with contaminated soil and dust. Exposure to PCBs can have several adverse effects on human health, including skin rashes, liver damage, and reproductive disorders. PCBs have been classified as probable human carcinogens by the International Agency for Research on Cancer (IARC), meaning that they can increase the risk of cancer. PCBs can also affect the immune system, leading to increased susceptibility to infections (Dorea, 2006; Srogi, 2008; EFSA et al., 2018). In addition to human health risks, PCBs also pose a threat to the environment. PCBs can accumulate in soil and sediments, where they can affect the growth and development of plants and microorganisms. PCBs can also bioaccumulate in aquatic organisms, such as fish, leading to ecological imbalances and disruptions in food webs (Gašić et al., 2010; Ilić et al., 2020; Ilić et al., 2021c).

## **MATERIAL AND METHODS**

The materials used in this study included data and information obtained from sources such as academic journals, research reports, and online databases. We collected relevant data on the topic of interest to create a comprehensive overview of the subject matter.

The studies included in this review were selected based on the following criteria: (1) studies that reported the concentrations of PCBs and other pollutants in soil and other medium samples collected from industrial zone Incel; (2) studies that described the characteristics of PCBs; and (3) studies that reported the geographical location of the industrial zone.

## **RESULTS AND DISCUSSION**

The presence of PCBs in soil in location Incel is a significant environmental and public health concern. Exposure to PCBs can have severe adverse effects on human health, and they can persist in the environment for a long time, posing a risk to the ecosystem (Dorea, 2006; Srogi, 2008; Gašić et al., 2010; EFSA et al., 2018; Ilić et al., 2020; Ilić et al., 2021c). Therefore, it is crucial to take measures to reduce the exposure to PCBs and prevent their release into the environment. Industrial sites that were in use prior to the introduction of regulations on the use and disposal of hazardous chemicals often pose a significant risk of soil contamination with PCBs and other pollutants. Old industrial sites, such as Incel, contaminated with heavy metals, PAHs and other hazardous materials can pose potential risks to human health and the environment. Heavy metals such as lead, cadmium, and mercury can accumulate in soil, water, and biota, leading to toxic effects on the ecosystem and human health (Ilić et al., 2020; Ilić et al., 2021a; Ilić et al., 2021b; Ilić et al., 2021c; Ilić et al., 2021d). PCBs were widely used in electrical equipment, such as transformers and capacitors, and in other industrial applications, until their production was banned in many countries in the 1970s and 1980s (Gašić et al., 2010; Ilić et al., 2020; Ilić et al., 2021c). The problem of soil contamination with PCBs and other pollutants is particularly acute in older industrial sites that have been abandoned or repurposed without proper clean-up. These sites can release toxic substances into the surrounding environment, including soil and groundwater, which can pose serious risks to human health and the environment. Industrial development in Bosnia and Herzegovina has led to the contamination of many sites with hazardous pollutants, including PCBs. PCBs were widely used in various industrial applications in Bosnia and Herzegovina (Ilić et al., 2020; Ilić et al., 2021c). Contaminated industrial sites in Bosnia and Herzegovina pose a significant risk to public health and the environment (Dorea, 2006; Srogi, 2008; EFSA et al., 2018). Location of the Incel industrial zone in Banja Luka has had a significant impact on the population and the environment of the city. The pollution caused by the release of hazardous substances into the soil and groundwater has raised concerns about the health effects on nearby residents, as well as the long-term environmental impact on the local

ecosystem. Efforts to address the issue are underway, but much work remains to be done to ensure the safety of the local population and the health of the environment.

Previous studies indicate that the level of PCBs on several sampling sites in industrial zone Incel in Banja Luka was as high as 400,000 ng/g (400 mg/kg) of the dry soil sample, which are two orders of magnitude higher than on any other investigated site performed by in the first investigations at the site (Apopšbal 2019). The additional pollution surveys (soil, air etc.) at the site were conducted in 2008 (Lammel et al., 2010a; Lammel et al., 2010b; Lammel et al., 2011; Gašić et al., 2010). Intensive soil testing for the presence of PCBs, PAHs, heavy metals and other pollutants continued in 2019 (Ilić et al., 2020; Ilić et al., 2021a; Ilić et al., 2021b; Ilić et al., 2021c; Ilić et al., 2021d). Total PCBs concentrations ( $\sum$ PCB congeners: PCB28, PCB52, PCB101, PCB118, PCB138, PCB153 and PCB180) varied in range from 0.26 to 6,722 mg/kg in soil, with a median of 31.80 mg/kg (Table 1) (Ilić et al., 2021c). According to the national standards, all the concentrations of  $\sum$ PCB congeners found in this study were significantly higher than the permissible value of 0.02 mg/kg (Rulebook, 2021).

Table 1. Statistical summary of total PCBs and PCBs congeners (PCB28, PCB52, PCB101, PCB118, PCB138, PCB153 and PCB180)

	PCB total	PCB28	PCB52	PCB101	PCB118	PCB138	PCB153	PCB180
Valid	37	37	37	37	37	37	37	37
Mean	495.4	13.59	9.005	33.87	57.34	97.31	148.4	135.8
Median	31.80	0.65	1.52	1.47	1.67	2.77	3.25	2.44
Std. Deviation	1,238	31.12	14.83	83.92	140.5	236.1	375.4	420.8
Coefficient of Variation	249.95	228.91	164.70	247.74	245.09	242.63	252.91	309.78
Variance	1.533e+6	968.4	220.0	7,042	1.975e+4	5.575e+4	1.409e+5	1.771e+5
Skewness	3.952	2.945	2.193	3.677	3.455	3.371	3.554	4.632
Kurtosis	18.14	8.453	4.833	15.08	13.29	12.87	14.44	23.82
Range	6,722	139.8	61.64	434.7	709.3	1,190	1,933	2,385
Minimum	0.26	0.01	0.01	0.01	0.02	0.04	0.03	0.01
Maximum	6722	139.8	61.65	434.7	709.3	1,190	1,933	2,385

The government of Republic of Srpska (entity in Bosnia and Herzegovina) and City of Banja has recognized the need to address the problem of contaminated industrial sites and has taken some steps to address the issue. However, much more needs to be done to adequately address the risks posed by these sites to public health and the environment. International organizations, such as the United Nations Development Programme (UNDP), have also provided support for cleanup efforts in Bosnia and Herzegovina. It is made Project of remediation and recultivation for Incel zone (Project, 2021). The project envisages short-term measures. Short-term preventive measures are designed to immediately prevent contact of local employees, visitors and trespassers moving at the contaminated sites (hotspots) with contaminated soil and/or construction materials.

The pollution issue in the Incel industrial zone in Banja Luka is a complex problem that requires a multifaceted approach. Addressing the problem will require a concerted effort from all stakeholders, including the government, industry, and local communities. Implementing effective regulations, promoting sustainable industrial practices, and adopting better waste management practices will be critical in ensuring the long-term health and well-being of local communities and the environment (Ilić et al., 2020; Project, 2021).

To reduce soil pollution with PCBs)at the industrial zone several general measures can be recommended:

- **Soil Remediation:** One of the most effective ways to reduce soil contamination is through soil remediation, which involves removing the contaminated soil and replacing it with clean soil.
- **Phytoremediation:** Phytoremediation is a process that uses plants to remove pollutants from the soil. This method can be a cost-effective and sustainable way to reduce soil contamination.
- **Containment:** Another option is to contain the contaminated soil by using barriers, liners, or capping the soil with a layer of clean soil or impermeable material.
- **Land Use Restrictions:** The government can implement land use restrictions, which can limit access to contaminated areas and reduce the risk of exposure to harmful pollutants.
- **Improved Waste Management:** To prevent future contamination, improved waste management practices can be implemented, such as proper storage, transportation, and disposal of hazardous waste.

The best option would be Soil remediation, i.e. excavation of contaminated soil and construction materials and thermal treatment in incineration plant or thermal desorption plant abroad and replacing it with clean soil. This process can be expensive, but it is an effective way to reduce the risk of exposure to harmful pollutants.

## CONCLUSIONS

The industrial zone of Incel, located in Banja Luka, Bosnia and Herzegovina, has been identified as a site of significant contamination due to the presence of PCBs and other hazardous substances in the soil. PCBs are known to be persistent organic pollutants that do not break down easily in the environment and can accumulate in the food chain, posing a risk to human health and the ecosystem. They are classified as a probable human carcinogen and have been associated with a range of adverse health effects, including developmental and reproductive disorders, immune system dysfunction, and neurological damage.

The contamination in the Incel industrial zone has been identified as a significant risk to human health and the environment, particularly due to the potential for PCBs and other hazardous substances to migrate from the soil into groundwater and surface water. The site is also a potential source of air pollution, as PCBs can volatilize and become airborne, posing a risk to the respiratory health of nearby communities. Efforts to address the contamination in the Incel industrial zone have been ongoing for several years, with measures including soil remediation, groundwater monitoring, and the removal of contaminated materials from the site. However, progress has been slow due to the complexity of the contamination and the high cost of remediation efforts. The contamination has also led to legal disputes between the authorities and the companies responsible for the pollution, which has further delayed progress.

The pollution issue in the Incel industrial zone has prompted concerns from various stakeholders, including local residents, environmental groups, and the authorities. There have been calls for stricter regulations to prevent the release of harmful contaminants, better waste management practices, and increased environmental monitoring to prevent further contamination of the area.

In response, the authorities have implemented various measures aimed at reducing pollution levels in the industrial zone. These include tighter controls on industrial activities and improved waste management practices. However, there is still much work to be done to address the pollution problem comprehensively.

The contamination of the Incel industrial zone is a stark reminder of the importance of sustainable industrial practices and responsible waste management. It highlights the need for industries to take a more proactive approach to environmental protection and to prioritize the health and well-being of local communities. Moreover, it underscores the importance of effective environmental regulations and enforcement mechanisms to ensure that industries operate in a way that is safe and sustainable for both people and the planet.

Overall, the contamination in the Incel industrial zone is a significant environmental and public health issue that requires urgent attention and long-term solutions to prevent further harm to the ecosystem and human health. The remediation of the site will require a multi-stakeholder approach involving government agencies, industry, and local communities to ensure effective and sustainable solutions are implemented.

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