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Fire Without Smoke

In former coal-mining areas, unseen underground fires can pose a significant danger to people's health. Careful observation of changes in plant cover can offer an important early warning of such threats.

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Recent years have witnessed increasingly frequent reports in the Polish media about fires plaguing waste dumps. Such fires may be caused by humans and their activity (exogenous fires) or by non-anthropogenic phenomena such as self-heating (endogenous fires). Regardless of the cause, burning waste poses an enormous danger to the natural environment, including the health of local residents.

However, fires in waste dumps are nothing new: they have occurred for a long time, and the public is simply unaware of many such incidents. Dumps of coal mining waste, however, are particularly treacherous in this respect – coal waste has a propensity to self-heat, which can initially lead to self-ignition, then to dangerous fires deep within such sites. In fact, this is by no means a rare occurrence.

Right now, there are at least a dozen-odd fires burning inside coal waste dumps in Poland's Upper Silesia region, and some of them have been burning for decades. Such underground fires are not as manifest as their surface counterparts. We should not expect to see any spectacular, raging flames, or even glowing embers. Rather, fires within such dump sites often seem to be completely hidden from view. Sporadically, we may only sense a certain acrid odor or, if the conditions are right, notice a wisp of smoke rising slowly from among cracks hidden in the grass. Ignoring the danger, however, may lead to incidents that pose health hazards. Walking on the surface of

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such dumps means above all inhaling toxic gases, such as carbon monoxide, sulfur oxides, and methane, and in less favorable circumstances may result in burns or, still worse, fatalities. Unfortunately, there have been at least several such incidents.

Scientists from all over the world, working to resolve the problem, have developed numerous methods of identifying and monitoring underground fires in coal mining waste dumps. However, most of them require specialist knowledge and high-tech measurement devices, which makes it very difficult for non-experts to assess the threats. A somewhat simpler solution is offered by analyzing changes in the condition and distribution of vegetation that are caused by underground fires.

Helpful plants

Because of the special structure of the substrate, waste dumps are not covered by typical plant communities. This is undeniably influenced by the characteristics of the coal mining waste itself, including its uneven distribution and differences in grain sizes. In addition, waste dumps do not have constant access to ground-

A view of the burning Szarlota waste dump from the burning Marcel waste dump

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The first signs of the wilting of the annual fleabane (*Erigeron annuus*) on a waste dump in Ruda Śląska

water, so the only water that plants can harness is rainwater, which makes colonization a lot more difficult. Waste dumps are mainly populated by species particularly resistant to various ecological factors, such as temperature, the presence or absence of nutrients in the soil, the presence of various grain sizes, the thickness of the humus horizon, and the degree of soil looseness. Such sites are dominated by species that are commonly found in Poland and able to grow in harsh and changing conditions.

Specific patches of vegetation differ in terms of dominant and accompanying species, depending on such elements as texture, morphology, slope, thermal state, and the anthropogenic supply of organic matter. Seed germination is impossible in places dominated by coarse gravel or cobbles, and so even very loose sod coverage can't form there. Such material quickly becomes desiccated and weathered, due to the considerable porosity of waste and its susceptibility to environmental factors. Given its high thermal conductivity, coal waste heats up very quickly. Such conditions mean the presence of isolated plant species that do not form patches of vegetation that could initiate soil-forming processes.

Coal waste dump fires are very dynamic, which makes it a lot more difficult for plants to grow at such sites. High temperatures cause water depletion, which causes the pore spaces to decrease and squeezes air out of the soil. In this way, soil undergoes very strong compaction, so plant roots are unable to breathe and therefore die. Unlike fires in natural ecosystems, the fires within waste dumps are not visible on the surface until high temperatures damage the root systems of plants. In such situations, fire may destroy the entire vegetation cover within a short period. By the same token, the condition of plants and their distribution on burning waste dumps largely depend on the thermal conditions of the soil. Fires within waste dumps, like in other ecosystems, leave behind a mosaic of habitats that comprises completely burned areas, partially burned areas, and areas not damaged by fire. Completely burned areas are characterized by the complete absence of vegetation cover. Individual plant species start colonizing such sites only after the thermal activity of the ground decreases. Until such time, plants will only cover the areas that are not burning.

Danger

Areas partially covered by vegetation are very important for the identification of fires. Such areas can be classified into ones characterized by a rising or falling soil temperature. In the former case, we are dealing with a fire that is spreading to the areas not characterized by thermal activity. In such areas, the condition of vegetation cover declines substantially – the plants start to wilt, become dry, and gradually die. In the latter case, the reverse is true. When a fire becomes less intensive, it leaves behind burned areas that offer excellent water and air conditions for plant growth. Consequently, plant species start populating such areas rapidly. This is because fire is not just a negative phenomenon and a destructive element, but also one of the natural ecological factors.

Plants growing on burning coal waste dumps react in a characteristic way to rapid changes in the thermal situation of the soil. The presence of large and healthy plants on coal waste dumps indicates the absence of thermal disruptions in the soil profile, whereas plants that are wilting, withering, or dying may indicate elevated ground temperatures or even initial phases of fire. The plants that grow on burning waste dumps are clearly diversified in morphological terms, so even non-experts can observe the emergence of new fires and therefore become aware of the coming danger. Since these burning areas are frequently found within cities and, paradoxically, often even used as leisure areas, raising public awareness of the characteristics of the plants that grow there may prevent many accidents. ■

Further reading:

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