Monitoring the auto-road air and reducing its toxicity

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Abstract. In order to simplify the air purification method and increase its efficiency in our studies conducted on the Vladikavkaz - Rostov highway, the sections between the forest plantations are covered with a layer of zeolite-containing clay - allanite, and crushed corn stumps in 4:1 ratio. In this case, the stumps are pre-soaked in Zamankul mineral water, and toxic substances accumulating on the layer surface are planted: chicory, phacelia, winter camelina and annual clover species. Covering sections of the park zone with natural sources of local origin in the form of allanite clay with plant waste mixture - corn stumps, which have high sorption ability and saturated boron-containing elements of Zamankul mineral water, reduces the highway air toxicity to the maximum permissible concentrations. The analysis on the toxic substances content in the air showed that the method used and its application provide favorable conditions for a normal environmental situation on the highway. It was revealed that due to the placement of plants accumulating toxic substances along the roads in the Vladikavkaz city, their number decreased to safe, maximum permissible concentrations. Thus, the concentration of contamination with lead salts and metals from the control infected option 0.105 μg / m3 decreased to 0.018 μg / m3. The amount of zinc, nickel, manganese also decreased several times. A significant reduction in toxic elements was observed for sulfur dioxide, nitrogen oxides, volatile organic compounds, carbon, ammonia, and methane.

Introduction
The growing danger of the anthropogenic factors’ negative impact on human health and on the biosphere state as a whole has led to the creation of warning systems, monitoring and predicting the state of both individual environmental objects and the entire biosphere [1-6]. Such information from observation and analysis systems of the environment state, primarily the pollution levels’ observation and the effects they cause in the biosphere, is called monitoring, in the system of which there are three levels: biosphere, ecological and sanitary-toxicological. The most widespread is the last level, as a result of which the air purity is studied. Moreover, the pollution level distribution is based on the urbanized area zoning according to the soil conditions in GIS technologies [7,8]. Exceeding the limits of toxic elements violates the air composition, which contain: hydrocarbons, nitrogen oxides, sulfur oxides, lead, cadmium and other heavy metals, ozone and other photochemical elements, acids - mainly sulfuric and nitric [9-11]. Atmospheric pollution and natural air impurities are subjected to complex processes of interaction, leaching, etc. Air is an oxidizing medium in which the chemical and photochemical
pollutants transformations occur. The main reason for such transformations in the urban atmosphere is air pollution with organic substances (mainly oil hydrocarbons) and nitrogen oxides formed during the high-temperature combustion [12, 13].

Road transport significantly pollutes water (oil, oils, solvents) and soil (oil, oil products, non-ferrous metals and rubber as a result of machine parts and tires’ abrasion). Nothing has been growing in the place of oil stains for 20 years, a strip 50-100 m wide on both sides of the road is a degradation zone of soil and vegetation with an excess of heavy metals (10-20 MPC) and a deficiency of nutrients. Exhaust gases and strong vibrations of soils from motor vehicles accelerate the aging process of buildings, lead to the roadside vegetation degradation. The reasons for significant atmospheric emissions are the absence or insufficient effectiveness of the localization systems for gas and dust sources and dust collecting devices, design flaws of production and transport equipment, their technical malfunction and lack of tightness, improper process management, etc. (GOST 32965-2014. Automobile roads general use. Methods of accounting for traffic flow”).

According to Federal Service for Supervision of Natural Resources in the Republic of North Ossetia-Alania, the total amount of pollutants into the air from vehicles was on average more than 7 thousand tons over the past three years, and this figure has been increasing annually. Consequently, the number of emissions in the dynamics increases significantly.

In some places of the republic, high fluctuations of cadmium (5-10 mg / kg dry weight) are noted, which significantly exceeds the maximum permissible concentrations. The atmospheric air pollution monitoring is carried out by the Federal Service for Supervision of Natural Resources in the North Ossetia-Alania and the Hydrometeorological Center at 4 hospitals and 6 mobile observation posts, which note 14 substances polluting the air. According to these services, the average annual pollution index is over 8.

In recent years, there has been a slight change in the nitrogen balance in the atmosphere due to the economic activities of people, manifested by the atmospheric nitrogen inclusion in the complex chemical compounds in the nitrogen fertilizers production. Its release into the atmosphere is reduced due to the soil-forming processes’ violation in large areas. A decrease in the oxygen supply to the atmosphere occurs due to a reduction in the area of forests, steppes, degradation of hayfields and pastures [14-15].

Therefore, plant organisms with a high sorption ability to absorb harmful substances during photosynthesis are necessary to reduce air toxicity.

Monitoring of the atmospheric air state includes the pollution sources’ study, the study of chemical and photochemical transformations of pollutants, the identification of the most harmful to humans and all substances, the study of the pollutants spread with air currents, the selection and analysis of pollutants (Sources: Hygiene standards. GN 2.1.6.3492-17. M. 2018. Appendix: Maximum Permissible Concentrations (MPC) of pollutants in the air of urban and rural settlements; GOST 32965-2014. General-use automobile roads. Methods of accounting for traffic flow”).

One of the most common air pollution sources is road transport. Automobile internal combustion engines pollute the atmosphere with harmful substances emitted from exhaust gases, crankcase gases and fuel fumes. At the same time, 95-99% of harmful emissions are from the exhaust gases, which are an aerosol of a complex composition, depending on the operating mode of the engine.

In total, about 280 components were found in the exhaust gases. The group of toxic substances is carbon monoxide CO, nitrogen oxides NOx, sulfur oxides, mainly dioxide (SO2), cadmium lead and other heavy metals, ozone and other photochemical oxidizing agents, acids,
mainly sulfuric and nitric, a large group of hydrocarbons, including paraffins, olefins, aromatics, and the like. At the same time, the toxic substances concentration varies significantly depending on the machine’s design (On approval of the calculation methods for dispersing emissions of harmful (polluting) substances in the air / Order of the Ministry of Natural Resources and Ecology of the Russian Federation of 06.06.2017 No. 273. M. Ministry of Justice of the Russian Federation, 2017.5.80) [12].

In the well-known works, it is proposed to purify air, where wood sawdust modified with urea, phosphoric or nitric acid is used [15].

However, sawdust has a low sorption capacity, especially when air is infested on roads with carbon monoxide, sulfur dioxide, benzo pyrene, hydrocarbon, lead and cadmium compounds.

Some scientists propose air purification using a mixture of zeolite with ammonia-containing sawdust at 1: 4 mass ratio [16].

In the known solution, wood chips are used, worked out in the process of air purification from ammonia, which reduces the efficiency of the method due to their low sorption ability.

The most effective and rational technique is to protect the atmospheric air, where the forest areas are created along the tracks and use poplar, lilac, and acacia to reduce toxicity [17].

However, the applied air purification methods are quite complicated for its implementation for the following reasons:
- the technology parks’ location is a long process,
- park areas are calculated according to the formula taking into account the number of cars and their emissions,
- the specific pollutants absorption is determined,
- the construction of forestry facilities by wind rose is quite costly and time consuming when laying trees and shrubs.

In order to simplify the method and increase efficiency, our solution to the problem is proposed.

It consists in the fact that between the forest areas, the plots are covered with a layer of zeolite-containing allanite clay and crushed corn stumps in 4: 1 ratio, while the stumps are pre-soaked in Zamankul mineral water, the calculation of reasonable doses was 1 hectare.

Zeolite-containing clay Allanite (of North Ossetian origin) contains (in%): silicon - 52.7; calcium - 32.6%; iron, 6.17; manganese, sulfur, phosphorus, potassium, copper, zinc (within 0.1-0.9%) and other trace elements.

Due to the high calcium content, the reaction of the clay medium is alkaline (pH-9.3), which reduces the soil acidity, which occurs on the site of planted trees.

Zamankul mineral water contains (mg / l) - Ca-2.5; Mg-2.0; Cl-143; SO4-0.68; Na-650; K-21.5; NO3-4.2; NH4-0.04; Zn-5.0; Cu-0.5; Fe-0.1 at pH 8.1.

Many herbs, like small seeds, were sown at the rate of 2 kg per 1 hectare. The total sowing rate of all sown crops was 12 kg / ha.
In the aisle, in autumn (early September), winter camelina and annual clover species (Persian clover, incarnate, Alexandrian) are sown. In early spring (late March - early April) chicory and phacelia are planted. At the same time, camelina and clover are sown with a see-spacing of 45 cm with a seeder, and in the spring, chicory and phacelia are planted at these intervals. At a distance of 6 meters between the trees, poplar and acacia are sown row-by-row with a distance of 45 cm between the rows, and in spring, chicory and phacelia are planted in the row-spacings.

Evenly spaced substrate was leveled, compacted and sown.

**Research results**

In contrast to the well-known technologies, annual types of clover (Persian clover, incarnate, Alexandrian) and camelina are sown in late August - early September, when the traffic is high. And already in the first year, air toxicity is reduced, unlike in a situation with planted trees. In spring, the following plants are sown: perennial chicory and annual phacelia, with hyperaccumulative properties.

Winter saffron (camelinasilvestris Waller) has hairs on its leaves and stems, and therefore sorb more toxic substances from the air (sulfur, lead, zinc, and others).

Chicory (cichoriumintybutus) is a roadside, biennial plant that has high sorption properties due to large aerial organs and a powerful root system.

Phacelia (phacelia) - a family of aquatic leaves, biennial plant, aletophyte culture, improves the composition and structure of the soil. This culture contributes to the accumulation of organic substances, accelerates all biological processes in the soil and acts as its baking powder. It is cultivated on all types of soils, protects other types of plants from the harmful insects’ invasion.

In the decomposition process, the leaves of phacelia secrete nitrogen, which takes part in the development and growth of other plant species sown. This versatile plant has high sorption properties, creating a good atmosphere for the pollinating insects’ flight.

Formed grass between the strips ensures the polluted air purification before the ripening of poplar trees, acacia and lilac bushes.

Covering sections of the park area with Allanite mixed with corn stumps saturated and dissolved in Zamankul mineral water of local origin, allows to reduce the highways’ air toxicity to the maximum permissible concentrations.

Annual clover species: Persian clover (Trifoliumresupinatum), Alexandria (Trifoliumalexandrinum L), and incarnate (Trifoliumincarnatum L) have a high accumulating ability to absorb toxic elements from air and soil, while accumulating biological nitrogen, increasing soil fertility.

Corn stumps - agricultural waste as an organic carrier, contains: lignin - 8%, cellulose - 42% and other environmentally friendly substances. Saturated with mineral substances from the natural source of Zamankul water, corn stumps, within 2-3 hours, are easily crushed and mixed with Allanite. Such a substrate, in a ratio of 4 parts of Allanite and one part of stumps, provides significant air purification from toxic substances.

Softened corn stumps in mineral water, saturated with nitrogen compounds (NO3 and NH4) with a sufficient amount of minerals, enrich the soil layer in a mixture with Allanite nutrients, at the same time positively affect the sown accumulating plants - annual types of clover, camelina, chicory and phacelia.

**Table 1.** Pollutant emissions from the vehicles on the highway Vladikavkaz - Rostov for 2017-2019
From the data in Table 1, it follows that in our embodiment, using natural sources of raw materials: local origin: mineral water and zeolite-containing clay Allanite with additional sowing of grass in the roadside forest belts’ rows, it is possible to significantly reduce air toxic substances.

Using the proposed methods to reduce air toxicity, it was found that toxic elements of air decreased several times: sulfur dioxide, nitrogen oxides, volatile organic substances, carbon monoxide, carbon, ammonia and methane. When using the republic’s natural resources: Zamankul mineral water, Allanite zeolite clay with low alkalinity, soil acidity reduction and more than 50% silicon containing sorption abilities, as well as sowing of hyperaccumulating herbs, air condition along the highway can be significantly improved.

Table 2. The content of heavy metals in the air on the highway Vladikavkaz-Rostov

| Experience Options | Heavy metals, mcg / m3 |
|--------------------|------------------------|
|                    | Lead | Zinc | Nickel | Manganese |
| Forest belts (poplar, acacia) control | 0.105  | 0.305  | 0.0074  | 0.035     |
| Accommodation Allanite | 0.58   | 0.186  | 0.006   | 0.030     |
| 4: 1 Allanite + corn stumps | 0.48  | 0.162  | 0.005  | 0.028     |
| Corn stumps in mineral water Zamankul + Alanite | 0.42 | 0.160 | 0.005 | 0.026    |
| Allane + 3: 1 corn stumps | 0.52 | 0.168 | 0.006 | 0.028    |
| Allane + corn stumps + winter camelina sowing + annual clover species Allane + corn stumps + replanting winter camelina + annual types of clover + chicory + phacelia | 0.18 | 0.156 | 0.005 | 0.024 |
| Allanite + corn stumps + winter camelina sowing + annual clover species | 0.02 | 0.148 | 0.004 | 0.022 |
| Allanite + corn stumps + winter camelina + annual types of clover + chicory + phacelia | 0.02 | 0.148 | 0.004 | 0.022 |
Allanite + corn stumps soaked in mineral water Zamankul + planting grass in the aisles of roadside forest belts

From the data given in table 2, it follows that in Vladikavkaz, planted trees along roads and sowing grass adsorbing heavy metals, as well as the use of Allanite in a mixture with corn stumps dissolved in grain stillage provides a significant reduction in the atmosphere of toxic elements.

Summary

Using natural sources of local origin in the Vladikavkaz city, the toxic elements’ volume decreased to the maximum permissible concentrations (for example, the lead concentration from 0.105 decreased to 0.018). At the same time, the amount of zinc, nickel, manganese decreased several times. A significant decrease in toxic elements is observed for a number of elements: sulfur dioxide, nitrogen oxides, volatile organic compounds, carbon, ammonia, methane, mineral water, zeolite-containing clay Allanite with high sorption properties, containing a significant amount of silicon and calcium. Using the plants - hyperaccumulators of toxic substances, as well as waste from plant origin - corn stumps with simultaneous sowing of herbs, it is possible to significantly clean the air of impurities harmful to humans.

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