Bioenergy Of Technogeneously Polluted Soils In Azerbaijan

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Abstract

The reliability of the functioning of biogeocenoses depends on the vigorous activity of soil organisms that carry out the destruction and reutilization of organomineral and technogenic components of various etiologies entering the soil. Therefore, the study of the bioenergetic characteristics of invertebrates of technogenically polluted gray-brown and gray-brown (chestnut) soils is of certain scientific importance. The studies were carried out on uncontaminated natural cenoses of gray-brown and gray-brown (chestnut) soils, as well as in technogenically polluted biotopes. The conducted studies on uncontaminated gray-brown soils showed that the total amount of energy accumulated in the mesofauna biomass is 2555.71 cal/m^2. The main carriers of energy are: Lumbricidae; Isopoda, Insecta. In the biotopes of cement and gypsum factories polluted with waste, the biomass energy is 1372.67 cal/m^2 and 3592.70 cal/m^2, respectively (an increase in biomass energy is noted due to calcophilic species). The energy accumulated in the biomass of the mesofauna in the biotopes polluted with the wastes of the superphosphate and the organochlorine synthesis factories varies between 1694.69 cal/m^2 and 15873.47 cal/m^2 (an increase in energy is noted due to gastropods - Gastropodae). In uncontaminated gray-brown (chestnut) soil, the energy accumulated in the mesofauna biomass is 11392.40 cal/m^2. The main carriers of energy are: Lumbricidae; Isopoda; Insecta; Gastropoda. In biotopes polluted with aluminum plant waste, the mesofauna biomass energy decreases to 9142.01 cal/m^2. In this case, the main energy accumulators are insects - Insecta (Tenebrionidae and Scarabaeidae).

Key words: invertebrates, energy, abundance, biomass, pollution.

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INTRODUCTION

During the year, a huge number of various substances from the atmosphere, as well as anthropogenic activities in the form of man-made waste, pesticides, and ballast types of fertilizers, enter the soil surface. Since the scale of such inputs is continuously increasing, the problem of soil pollution arises. As a result, the qualitative and quantitative characteristics of the circulation of substances and the transformation of energy between the individual links of the biogeocenoses are violated. The reliability of the functioning of biogeocenosis depends on the vigorous soil activity organisms that carry out the destruction and recycling of organo-mineral and technogenic components of various etiologies entering the soil. The study of the bioenergetic characteristics of invertebrates in technogenically polluted gray-brown and gray-brown (chestnut) soils is of particular scientific importance. The evolution of the biosphere is closely connected with the evolution of the forms of living matter (organisms and biocenoses) and the complication of their biogeochemical functions.

An important role in the evolution of the biosphere is played by the transformation of solar energy by plants and chemical energy by chemosynthetics. The energy entering the soil with bioorganic substances is redistributed over various microstructures and soil components. The equilibrium (stationary) state of biogeocenoses in nature differs due to the optimization of the circulation of substances and energy flows in it, and the main control mechanism for stabilizing the biogeocenotic process is located in the soil [6,7].

From this it becomes clear that when studying biogeocenoses as open systems capable of self-regulation, special attention should be paid to the study of the soil as a dynamic system that determines the reliability and duration of the biogeocenoses functioning. Estimation of the mass of living matter is an important, necessary criterion for the role of living matter. It is necessary to know the species diversity of living organisms, their abundance, biomass, what is their contribution to the energy and geochemical cycle of substances. The issue of anthropogenic fusion is given great importance as an important problem, which is associated with a change in the ecological state of soils [9,10].

It can be suggested that cement dust falling on the soil surface causes fusion of soil particles that worsen the ecological, physicochemical properties and create anaerobic conditions that adversely affect the biological processes and life of the mesofauna. Halophytes and their remains, which form the main plant background of saline (alkaline) soils, are food resources only for limited halophilic species of woodlice and insects inhabiting these cenoses. The introduction of organo-mineral fertilizers into soils during their cultivation and development should not only stabilize their fertility, but also fill in the missing links of the biogeochemical cycle and ensure a positive balance of energy and chemical elements. However, some mineral fertilizers (in the production of superphosphate, potash, and nitrogen fertilizers) contain impurities of heavy metals (Pb, Cd, Hg, Cu), which, getting into the soil and plants through food chains, can transform into the human body and cause serious diseases.

Insects surpassing other groups of invertebrates in their biomass turned out to be the main accumulators of energy accumulated in the total zoomass, which in turn proves that insects have wide adaptive capabilities and abilities to utilize the remains of natural vegetation, i.e., act as phytophages and facultative phyto-saprophages, thereby complementing the saprotrophic activity of Lumbricidae and isopods [1,2].

From this comparison, the waste of the cement factory, compared with the waste of the gypsum factory, had a more negative impact on the qualitative and quantitative composition of invertebrates involved in the transformation of the energy of plant matter in the trophic links of the ecological pyramid of technogenic landscapes. The negative impact of polluting cement production waste on the bio-ecological indicators of gray-brown soils of natural cenoses was also revealed by earlier studies [3,4,11].

Many xenobiotics: phenols, fluorine, chlorine compounds (chlorinated benzofurans, organochlorine compounds are difficult to decompose in the soil and accumulate pollute the environment, causing a violation of the balance between living organisms. Some authors argue that with such pollution there is a potential danger of mutagenic activity in the soil itself [8,12].

Materials and methods:

The objects of research were technogenically polluted gray-brown and gray-brown (chestnut) soils. Natural cenoses of gray-brown and gray-brown (chestnut) soils contaminated with technogenic waste from a cement and gypsum factory, a superphosphate factory, an organochlorine synthesis factory and an aluminum factory were chosen as biotopes for the study. The sampling of soil invertebrates was carried out according to the method generally accepted in soil zoology by Gilyarov M.S. followed by considering their abundance and biomass [5].

The energy of invertebrates accumulated in the biomass was determined on a V-O8MA calorimeter by burning 1 g of dry matter in a colorimetric bomb. The obtained energy indicators for individual invertebrate's groups were used to calculate the total amount of energy accumulated in the dry matter of the recorded representatives mesofauna. In this way, it is possible to comparatively assess the impact of industrial wastes of various etiologies on the energy performance of invertebrates.

Results:

Natural cenoses of gray-brown uncontaminated gray-brown soils with a wormwood-ephemeral community are inhabited by three main groups of invertebrates: lumbricidae (Lumbricidae); isopods (Isopoda) and insects (Insecta) in the total (dry) biomass of 0.4741 g/m^2 which accumulated - 2555.71 cal/m^2. The main part of the energy accumulated in the biomass of insects (Insecta) - 2090.27 cal/m^2 is concentrated in two families: carabides (Carabidae) - 1893.77 cal/m^2 and pollen eaters (Alleculidae) - 196.50 cal/m^2. The least energy is accumulated in the biomass of Lumbricidae (Lumbricidae) - 328.34 kcal/m^2 and Isopods (Isopoda) - 137.10 cal/m^2 (Fig. 1).

Find certain differences in the energy content of invertebrates in natural cenoses of gray-brown soils under saltwort and wormwood-grass-saltwort associations contaminated with waste from cement and gypsum factory. On natural cenoses contaminated with cement factory waste, the amount of energy accumulated in the total zoomass of 0.2925 g/m^2 is relatively small - 1372.87 cal/m^2 and is concentrated in two groups: isopods (Isopoda) - 256.10 cal/m^2, insects (Insecta) – 1116.77 cal/m^2. The energy accumulated in insects is divided into the following families: Ortoptera - 155.16 cal/m2; Hemiptera - 99.60 cal/m^2; Coccinellidae - 117.72 cal/m^2; Curculionidae - 68.84 cal/m^2; Tenebrionidae - 352.41 cal/m^2; Elatridae - 323.04 kcal/m^2 (Fig. 2). In the soil of natural cenoses, the energy accumulated in the total zoomass of 1.136 g/m^2, polluted by the waste of the gypsum factory, is 3592.70 cal/m^2, almost 2.6 times higher than the energy intensity of the total zoomass of the virgin cenoses located in the sphere of influence of the cement factory. The energy of the total biomass is formed mainly by four groups of invertebrates: isopods (Isopoda) - 946.79 cal/m^2; molluscs (Gastropoda) - 617.71 cal/m^2, spiders (Aranei) - 91.41 cal/m^2 and insects (Insecta) - 1936.79 cal/m^2. The energy accumulated in insects is distributed among the following families: Coccinellidae – 141.35 cal/m^2; Tenebrionidae - 1532.62 cal/m^2; Lepidoptera - 262.82 cal/m^2 (fig. 3).

Comparatively comparing the obtained data, one can see how polluted cenoses differ from each other not only in the amount of total energy accumulated in the zoomass, but also in the nature of its distribution among individual groups and families of invertebrate animals. The structure of invertebrates of these cenoses determines both similar and distinctive elements. In both technogenic landscapes, the dominant groups are isopods and insects, in which a significant part of the energy is accumulated. But, if in the biotopes polluted with cement dust the distribution of energy is limited precisely by these two groups of invertebrates and six families of insects, in the biotopes of the gypsum factory contaminated with waste, the transformation of energy is complicated due to the settlement of these biotopes by other representatives of the mesofauna by gastropods, wood lice, although the number of insect families is reduced to three.

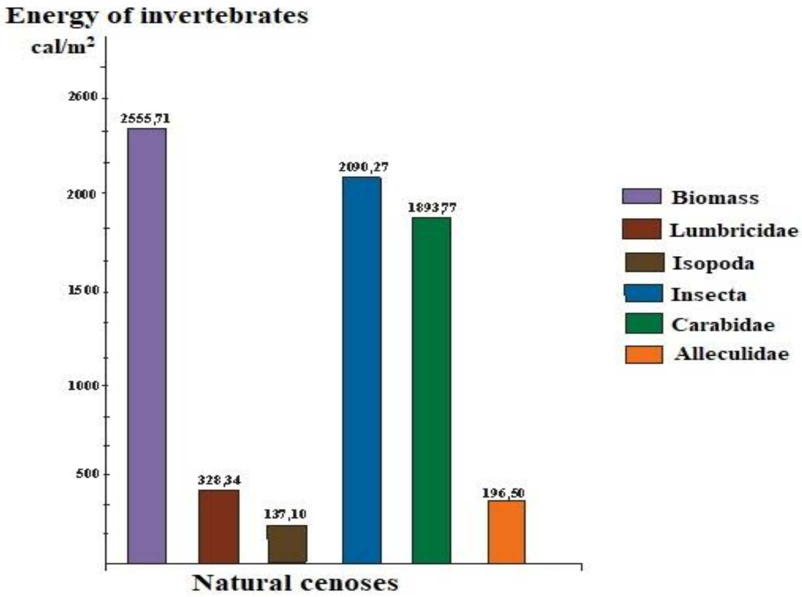

Fig. 1. Energy stored in invertebrates uncontaminated gray-brown soil of natural cenoses

Gypsum factory waste enriched with mineral calcium entering the soil contributes to the neutralization of its alkaline properties, and thus favorably stimulates the biological life of the cenoses. As a result, new calcophilic groups of invertebrates appear in the community: molluscs, isopods, darklings, lepidoptera (caterpillars) form additional links in the food chain in the soil-plant-invertebrate system. Therefore, gypsuming was proposed as an effective method for increasing the bioproductivity and biological activity of solinity soils, because of mineral calcium displaces Na from the soil absorbing complex and neutralizes solinity.

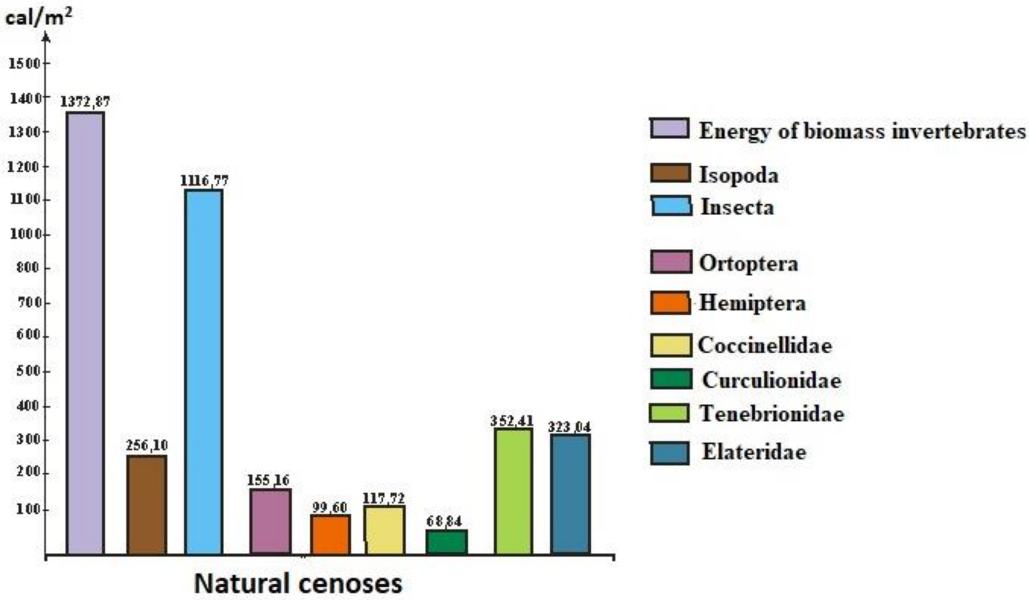

Fig. 2. Energy stored in invertebrates gray-brown soils of natural cenoses polluted with cement waste

Energy analysis of changes in the coenotic balance of invertebrates (separate groups) on the example of gray-brown soils contaminated with waste from a superphosphate plant and an organochlorine synthesis factory: Comparing the results obtained, it was found that in natural cenoses of gray-brown soils contaminated with waste from a superphosphate plant, the energy accumulated in the total biomass - 0.3910 g/m^2 - 1694.69 cal/m^2 is concentrated in two groups of invertebrates - molluscs (Gastropoda) - 1403.70 cal/m^2 and insects (Insecta) - 290.99 cal/m^2. The bulk of the energy accumulated in insects is distributed in the following families: Meloidae - 123.64 cal/m^2; Coccinellidae - 80.90 cal/m^2; Carabidae - 46.95 cal/m^2; Alleculidae - 39.50 cal/m^2. (fig. 3).

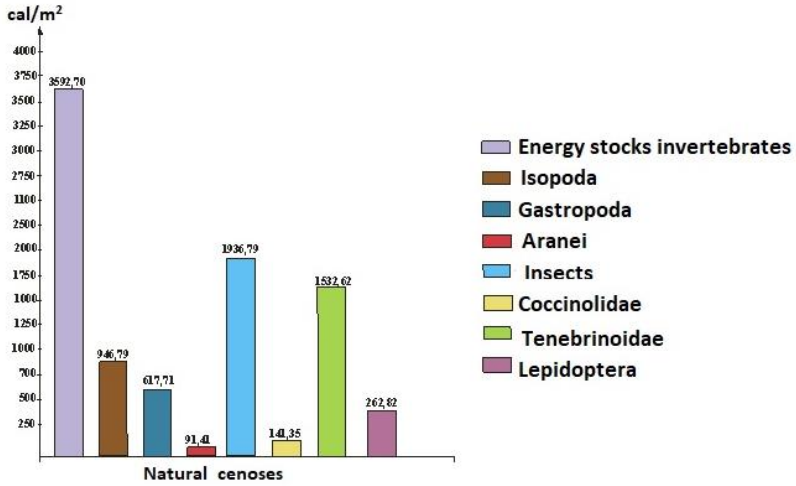

Fig. 3. Energy stored in invertebrates gray-brown soils of natural cenoses polluted with gypsum waste

This cenoses in the soil, the energy accumulated in the total biomass of 3.750 g/m^2 - 15873.47 cal/m^2, polluted by the waste of the organochlorine synthesis plant, is also concentrated in two groups: molluscs (Gastropoda) - 15723.93 cal/m^2 and insects - 149.54 cal/m^2. However, the bulk of energy from insects is concentrated only in two families: Coccinellidae - 87.72 cal/m^2 and Meloidae - 61.62 cal/m^2 (Fig. 4).

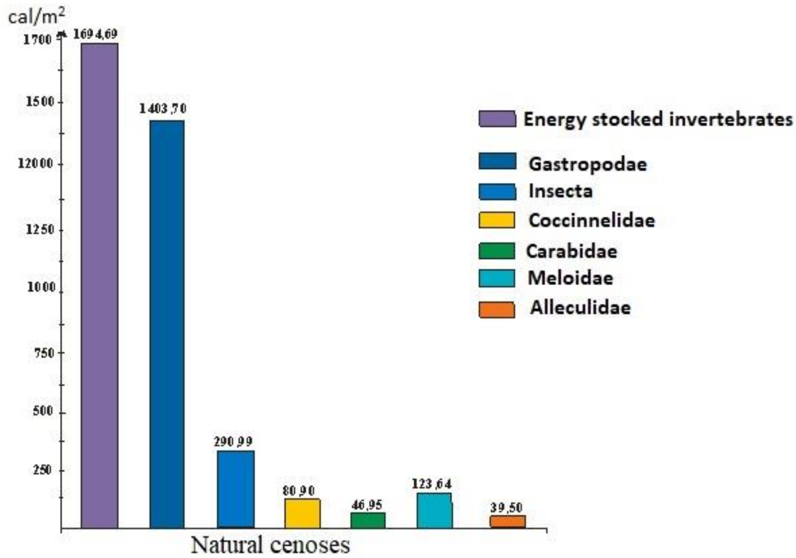

Fig. 4. Energy accumulated in invertebrates of gray-brown soils of natural cenoses contaminated with waste from a superphosphate factory

As can be seen from these data, wastes containing chlorine compounds, compared with wastes from superphosphate production, had a much stronger effect on the life of insects and reduced the number of their families, but at the same time, these pollutants revealed the dominant role of mollusks. It can be assumed that the waste of these enterprises that enter the soil and plant systems, by their toxic effects, significantly reduced the food resources of invertebrates, limiting their distribution and migration in certain biotopes. In this case, mollusks, which turned out to be more resistant to these pollutions, had more pronounced and effective adaptive mechanisms. Possessing powerful digestive enzymes, they process and utilize coarse and lignified plant residues that are low-nutrient for other groups of invertebrates, on polluted cenoses, they perform the main role of phyto-saprophages. Gray-brown (chestnut) soils are significantly superior in their physicochemical properties and humus content to gray-brown soils. Despite their commonality in the formation of dry-steppe conditions, the zoological spectrum of the species composition of invertebrates is quite extensive and diverse. Uncontaminated natural biocenoses with herbaceous-grass-legume vegetation create an abundant food base for the development of many groups of phyto-saprophages. Energy - 11392.40 cal/m^2 accumulated in the total biomass of 2.2088 g/m^2 of invertebrates is represented by four dominant groups: Lumbricidae (Lumbricidae) – 4031.16 cal/m^2; insects (Insecta) – 6966.38 cal/m^2; isopods (Isopoda) - 149.64 cal/m^2 and molluscs (Gastopoda) - 245.22 cal/m^2. A significant amount of energy accumulated in insects is transformed into the following families: Tenebrionidae - 1863.18 cal/m^2; Coccinellidae - 404.96 cal/m^2; Alleculidae - 350.00 cal/m^2; Scarabaeidae - 3573.75 cal/m^2; Carabidae - 521.36 cal/m^2; Cerambucidae - 110.34 cal/m^2; Lepidoptera - 142.79 cal/m^2.

In earthworms, energy is distributed among three species of the common genus: N. caliginosus Sav.f. trppezoides - 2097.72 cal/m^2 and N. jassyensis Mich - 1394.69 cal/m^2 and N. Roseus Sav - 538.75 cal/m^2. actively populating natural biotopes, thereby providing brown (chestnut) soils with dominant energy generation in their population. Among the enterprises, the waste of which significantly affects the ecological state of gray-brown (chestnut) soils, is the Ganja aluminum factory. Studies have shown that silty particles of aluminum sludge, settling on the soil surface, intensively pollute soil and plant systems, and form a compacted hard coating (up to a depth of 0-30 cm), which negatively affects the individual phases of the biological activity of the soil, due to the formation of anaerobic processes. It was found that the main polluting components of aluminum sludge are SiO_2 (74.16%); Al_2O_3 (14.90%); Fe_2O_3 (5.5%); toxic compound of sulfuric anhydride - SO_3 (3.1%); absorbed sodium (51.0%), dominance in the composition of salts - Na_2SO_4; $NaHCO_3$; $CaSO_4$; $Ca(HCO_3)_2$ as well as a pronounced alkaline reaction (pH) - 9.5; 9.7, confirming the alkalinity of these soils. Invertebrates inhabiting natural, technogenically polluted biotopes have also undergone significant changes. Apparently, such a tense ecological situation had a rather strong effect on their qualitative composition, according to which the energy of the zoomass is transformed. The energy accumulated in the total zoomass of 2.0521 g/m^2-9142.01 cal/m^2 is represented here by only one group: insects (Insecta), in which the energy is distributed only between two families: Tenebrionidae – 6255.70 cal/m^2 and Scarabaeidae – 2886.31 cal/m^2 (Fig. 5).

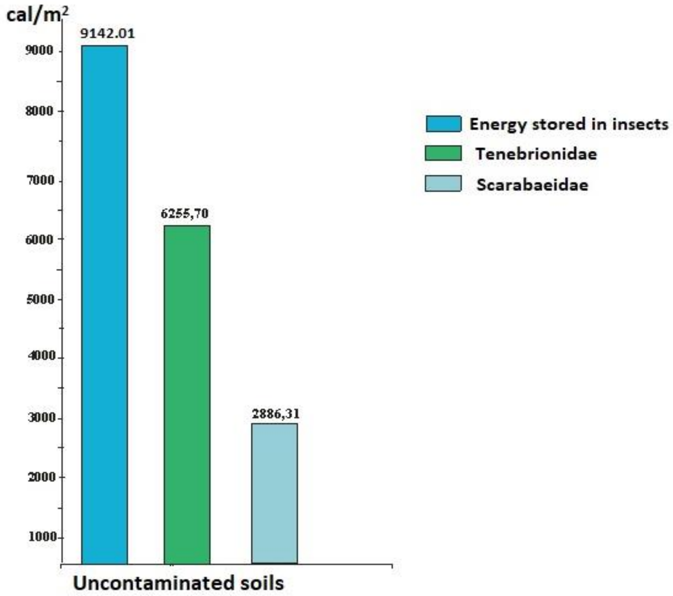

Fig. 5. Energy accumulated in invertebrates of gray-brown (chestnut) soils contaminated with waste from the Ganja aluminum factory

The accumulation of energy in limited groups of invertebrates indicates the formation of individual adaptive mechanisms in various groups (species) of animals. In this case, and in the previously considered gray-brown soils contaminated with waste from chemical enterprises, the dominant groups are invertebrates with hard (chitinous, mineral) body covers and the virtual absence of soft-covered animals. Due to the resistance of insects to the waste of an aluminum factory, the energy of the remains of perennial shrubs (wormwood, burial ground) is processed and transformed into subsequent stages of the biological cycle.

Conclusion:

An energy assessment of the biomass of invertebrates in natural cenoses of gray-brown and gray-brown (chestnut) soils and their technogenically polluted biotopes was carried out. In uncontaminated gray-brown soils, the total amount of energy accumulated in the mesofauna biomass is 2555.71 cal/m^2. The main carriers of energy are: Lumbricida; Isopoda; Insecta (Carabidae, Alleculidae). The total amount of mesofauna biomass energy in technogenically polluted biotopes with cement and gypsum factory wastes is 1372.87 cal/m^2 and 3592.70 cal/m^2 (an increase in energy is noted due to calcophilic species). The energy of accumulation in the biomass of invertebrates in biotopes contaminated with waste from the superphosphate factory and the organochlorine synthesis factory varies between - 1694.63 cal/m^2 and 15873.47 cal/m^2 (an increase in energy is noted due to gastropods - Gastropodae). In uncontaminated gray-brown (chestnut) soil, the energy accumulated in the mesofauna biomass is 11392.40 cal/m^2. The main carriers of energy are: Lambricidae; Isopoda; Insecta; Gastropoda. In biotopes polluted by aluminum plant waste, the mesofauna biomass energy decreases to 9142.01 cal/m^2. In this case, the main energy accumulators are insects - Insecta (Tenebrionidae, Scarabaeidae).

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