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## **ECOLOGICAL STATUS OF LANDSCAPE RESOURCES OF THE KRASNODAR COUNTRY BLACK SEA COAST AND METHODS OF ITS IMPROVEMENT**

Since 1998, the Research Institute for Applied and Experimental Ecology of the Cuban State University has regularly carried out ecological monitoring of the Krasnodar Country Black Sea coast, in order to specify the ecological status of the area, trends of coastal ecosystems' development under a growing anthropogenic influence. The primary task to be implemented in the region is to preserve the unique nature of the coastal area and populations of plants, among which there are numerous protected and rare species, to detect negative processes taking place in different natural environments, in order to prevent their further development and improve the state of the area. Between 1998 and 2001, the Ecological Institute of the Cuban University carried out tests and assessed the ecological state of the Krasnodar Country Black Sea coast according to the following indices:

- the state of the soil cover,
- the state of plants,
- water quality.

### 1. Ecological status of soil cover

The coastal area soils belong to the group of southern chernozem (the Temriuk region and part of the Anapa region), ordinary slightly humus, slightly washed out chernozem (the Anapa region), to typical turf-carbonate and leached turf-carbonate (Novorosyisk and Gelendzhic) and loess soil in combination with brown rock-forest soils (Tuapse and Sochi). According to the analysis made, the soils are characterised by a mixture of light clay soils and moderately and heavily sandy-clay soils. Alkaline reaction is dominant in rock-forest soils, a great variety of reaction from slightly acid to slightly alkaline is observed in ordinary slightly humus, slightly washed out chernozem and alkaline reaction in southern chernozem. As regards the humus content the coastal area soils range from slightly to moderately humus, on average it is 3.8%. Overall, this value is in the range from 0.31% to 10%. The great variation in these values is not only due to different soil, climatic and geological factors but also to anthropogenic impact on coastal eco-systems. To the largest extent were transformed the coastal areas of the Temriuk and Anapa regions. Huge areas were ploughed and utilised for orchards and vineyards. Resulting from the land utilisation for agricultural production, intensive processes of soil cover degradation are taking place, the humus content of soil is decreasing (it is no more than 2.9% in these regions) and the application of fertiliser and chemical plant protection substances leads to the accumulation of pollution in the soil. The fact that these areas are situated in close vicinity to the Black Sea poses a constant risk of its waters contamination resulting from pollutant movements with ground waters and river runoffs.

The use of artificial fertiliser in dosages exceeding the optimum plant needs in the course of many years resulted in substantial quantities of heavy metals and pesticides in the coastal area. The Institute's Toxicology Laboratory determined the content of seven heavy metals in a mobile and general form (zinc, lead, cadmium, cobalt, copper, manganese, nickel). The results of the analyses showed that the maximum permissible concentration (MPC) was exceeded to a lesser or greater extent for all metals.

For zinc, in the Old Macesta region the level was found to be three times in excess of MPC in a mobile form and 2.5 times in excess of MPC in a general form, in Tuapse 1.5 in excess of MPC. A significant content was also observed in the town of Adler and on the shore of the Kyziltashski Limano.

The lead content also exceeds the permissible levels, 2.8 times in a general form and 4.8 times in a mobile form in the Old Macesta region. High concentration of lead in soil was detected near Makopse (over 2 MPC in a general form and 3 MPC in a mobile form). Soils in Novorosiysk, the villages of Lazariyevskoye and Viesielovka on the left shore of the Kyziltashski Limano are characterised by 1 to 2 MPC.

For cadmium maximum permissible levels were exceeded in Novorosiysk and in the upper part of Great Sochi.

The general concentration of manganese was found to be 1.3 times higher than the permissible level on the Taman Peninsula.

Particularly high levels of copper were detected in soils. The general analysis showed that in 20% of samples the permissible levels were exceeded 2.6 times. Generally, these are soils utilised for agricultural production, i.e. vineyards and soils of urbanised areas – health resorts such as Novorosiysk, Gelendzhik, Anapa, Old Macesta (the values were in excess of MPC from 1.2 to 1.5 times).

The maximum permissible levels were exceeded 22 times(!) in the concentration of mobile copper forms (in the region of the Bolshyie Chutora village, in a vineyard), and in 15% of the samples tested the permissible levels were exceeded from 5 to 10 MPC. Overall, 83% of the samples were found to be in excess of the established threshold value. According to the content of the mobile form of copper, the tested soils can be classified as heavily contaminated. The mobile form of heavy metals is accessible to plants which absorb metal salts together with nutrients from the soil. Therefore, the quality of products grown on such soils is low and has a negative impact on health of people consuming such products. However, a high copper concentration was not only found in technologically transformed but also in biogenic landscapes, which can be explained by trans-border movement during which polluting substances move from one natural environment to another and shift between different landscapes cumulating in some of them (of the accumulation type).

For nickel, the permissible concentration was also found to be exceeded in a large number of model samples (50%), however no more than twice.

In order to fully assess the soil quality, the remaining quantities of organic pesticides containing chlorine were determined in accordance with 10 standards: lindane ( $\gamma$ -GHCG) and its  $\alpha$  and  $\beta$ -GHCG isomers, hexachlorobenzene, dieldrin, heptachlor and its heptachloroepoxide metabolite, DDT and its DDD and DDE metabolites. The test results indicated high levels of the total DDT concentration, which was from 3 to 9 MPC in the Gelendzhik region. All samples were taken in orchards where even now the banned pesticides are used, which is confirmed by the high DDE content indicating that the preparation was applied in the soil recently.

Pollution of the coastal soils with hydrocarbons of crude oil origin is of a local character and can be observed in health resorts in the close proximity to motor ways and facilities involved in storage and sale of fuel and grease. The MPC was found to be exceeded 2.6 times in the Lazarevskoye village, the sample was taken in the close proximity to the road.

## 2. The status of plant cover

The plant cover in the ecosystems adjacent to the coast, unique in its original structure thanks to the presence of relict species and an endemic character of flora, is at present a plant assemblage to a large extent affected by human activity. The main factors causing a decrease in areas under plants are tree cuttings, fires, tillage, grazing, construction of health resorts, recreation, establishment of cultivation terraces in order to utilise steep slopes.

Of particular value are 22 steppes and forests where there are sets of rare species and those threatened with extinction of great scientific, practical and aesthetic significance.

- *Agropyretea pinifoliae* formation (the Markoth range);
- *Hedisareta candidi* formation (the Markoth range, Archipo-Osipovka area);
- *Cephalarieta (coriacea et uralensi)* formation (the Anapa area);
- *Asphodelineta (tauricae et luteae)* formation (the Black Sea region from Anapa to Dzhubga);
- *Onosmetea polyphyllae* formation (the Markoth range, Su-Psechu area, Sukko);
- *Thymetea helendhici* formation (the Markoth range, Betta area, Dzhubga);
- *Thymetea markhotensis* formation (the Markoth range);
- *Stipeta pulcherrimae* formation (the Anapa area, Markoth range);
- *Leucojeta aestivi* formation (Tonkij Mys, Loo-Hosta);
- *Leymetea sabulosi* formation (the Anapa area);
- *Eryngieta maritimi* formation (the Anapa area, Sukko, Djubga);
- *Glycyrrhizeta glabrae* formation (the Anapa Lagoon);
- Formations of *Astragalus arnacanthoides* + *Thymus helendzhicus* + *Cephalaria coriacea* (the Markoth range);
- Formations of *Jasminum fruticans* + *Eremurus spectabilis* (Markoth range);
- *Juniereta excelsae* formation (Gelendzhik area);
- *Pineta pallasianae* formation (area between the Wulan river valley and Adler's Gully);
- *Pistacieta mutieae* formation (Abrau, Betta, Gelendzhik);
- A group of forest concentrations with trees *Querceta (pubescentis)* *Juniperosa (oxycedri)* (southern slope of the coastal mountain range from the Sukko river valley to the Niebug river);
- A group of forest concentrations with trees *Querceta (pubescentis)* – *Cornosa* (north-western part of the Caucasus Black Sea coast to the Tuapse river valley);
- A group of forest concentrations with *Fagetum trachystemosum*, *Fagetum matteucciosum* (central mountain range of the southern slope south of the Tuapse river valley);
- A group of forest concentrations with *Fageta fruticosa* – *Colchica* (a southern slope south of the Tuapse);
- Sub-formations of forests with *Carpineto* – *Fageto Buxeta*; *Fraxinus Buxeta*; *Carpineto* – *Buxeta* (in river valleys of the Caucasus Black Sea coast).

The majority of plant formations is not protected, thus degradation processes dominate in their development leading to the simplification of the structure and impoverishment of the species variety, effacement of regional specificity and introduction of advent elements.

It should be stated that contemporary anthropogenic impact on the coastal phytocenoses may lead to their destruction, which in general will considerably affect the functioning of the coastal and adjacent ecosystems, including those urbanized.

### 3. Evaluation of the Black Sea water quality

The sea coast from Anapa to Adler is intensively used by the local population and people from the whole country as a recreation area. Therefore of particular importance is information on the quality of the surface water layer, i.e. 0-10 cm, which is an important natural environment for habitation and ensuring life functions of sea organisms using phytoplankton as the source of energy, and for people (especially children) bathing in this water layer.

The results of the analyses indicated that in all samples taken the content of crude oil derived products exceeds MPC. It ranges from 1.6 MPC (Novorosyisk) to 45 MPC (the Niebug village). Significant pollution levels were observed in the Praskovieevka village (the tourist facility “Leningradiec”), MPC was exceeded 36 times 15 m from the sea shore, on the oil pier in Tuapse MPC was exceeded 26 times in the sea 50 m from the shore, in the tourist facility “Nieftianik” between Arcihpo-Osipovka and Betta (50 km from the shore) - 23.2 times.

It should be emphasised that the contamination of the water surface layer with crude oil is also found in sea areas further from the shore. In the Novorosyisk Bay, 700 km from the sea shore the oil product content was found to be at the level of 5 MPC. As compared with the surface water level, the layer of 10-50 cm is slightly less polluted, however, in general the pollution level at all points is much above MPC (from 2 to 6 times). Large pollution of the sea water by oil-derived products was detected in the village of Agoy at the depth of 2-5 m.

Generally, the Black Sea waters were considered as considerably polluted by oil-derived products.

The results of water tests for heavy metal content showed the excess of the maximum permissible concentration for zinc, cadmium and cobalt separately. The excess of zinc content was noted in Anapa, Gelendzhik, Adler and the highest concentration was observed in Novorosyisk (3 MPC). Cadmium content was found to be close to the MPC and the cobalt content exceeded MPC 2.5 times in the Sochi region (the northern pier). As for other metals the maximum permissible concentration was not exceeded. The water was also tested for the presence of trace quantities of pesticides as they exhibit such dangerous features as durability in the natural environment, capability to cumulate in live organisms in the food tract (accumulation). Resulting from tests, no heptochlorine was found and the quantities of hexachlorobenzene, GHCG and DDT are much lower than MPC. Determination of the sanitary status showed that Coli levels were exceeded in all samples, which indicates contamination by fecal matter. In the majority of samples low indices of water autopurification were detected. The exception in this respect are waters near Anapa and the beach in the Gelendzhik area where the autopurification indices are 1 and 1.27 respectively. Sea water pollution by household sewage and fecal matter poses a great epidemiological hazard as the contaminated areas are in close proximity to seaside resorts.

In addition, it should be noted that the concentrations of water micro-organisms tested indicate the existing capacity of autopurification of near-shore enclaves.

The state of the Black Sea recreation areas is affected by serious crises:

- chemical and biological pollution of air, water and soil is continuing;
- forest areas are diminishing;
- floods are increasingly frequent in mountain rivers;
- the processes of slope slide and beach strip wash-down are intensifying.

The main source of air pollution is emission of exhaust gases (90%). In a holiday period the car traffic increases hundreds of times due to, among other things, transit.

As regards agricultural production in the Black Sea region, it is vineyard and orchard growing because of specific climatic and geographic characteristics of health resort areas. Although the aforementioned agricultural sectors do not use soil damaging technologies, poisonous chemicals have been applied for many years, leading to the contamination of all unique components of the natural environment.

Therefore, particular attention should be focused on reducing pesticide levels in orchards and vineyards, applying complex forms of chemicals, utilising rational fertilisation technology, lowering fertiliser dosages to the minimum level.

A particularly important problem for the Black Sea coast is solid waste produced by various service companies, catering facilities, health resorts, sanatoria and the housing sector. The dumping sites were established and are operated not complying with the environmental standards. During the rainfall the pollutants leak to the soil, they are washed down along the slopes and finally they flow to the sea.

The health resort complex, while being the main economic sector of the Black Sea areas, has at the same time a negative impact on the environment. This is first of all due to the specific use of natural resources, i.e. the management of particularly valuable areas. The functioning of health resorts leads to an increased demand for water supply, to additional burden of sewage removal and treatment systems, to the generation of solid municipal waste. In this context of particular validity is the problem of the coastal natural ecosystem transformation due to which the probability of extinction of rare and protected plant and animal species is high. Given present rate of the area management, it may lead to the full degradation of natural landscapes.

In order to avoid such development of the area, it is indispensable to take a broad approach to the analysis of the situation on the coast, to develop and adopt ecological programmes aimed not only at eliminating ecological effects of the irrational use of the unique coastal nature but also at preventing the processes unfavourable to the health resort development.

Within recent years local authorities have been paying more attention to ecological problems of the areas situated on the Black Sea coast. The proof is ecological policy adopted by the Gelendzhik administration, formulated in the “Comprehensive Programme for the Gelendzhik Town-Health Resort for 2001-2005”.

The main trends of ecological policy adopted by the Gelendzhik administration are as follows:

- introduction of a comprehensive management scheme for the coastal area;
- rational spatial planning, taking into account the landscape topographic features;
- limiting the development of potentially dangerous types of production and business operations, the versatile use of resources;
- preservation and development of bio-diversity of protected areas, in particular all valuable ecosystems, nature monuments and sites of historical value;
- elimination of anthropogenic pollution of the environment from industrial, agricultural and municipal sources.

On examination of the above mentioned rules, it should be stated that increasing attractiveness of the health resort should not be done by urbanising new natural areas, transforming natural landscapes, which leads to diminished bio-diversity and degradation of the transformed eco-systems. An attentive attitude is necessary to such a unique natural landscape of the coastal health resort area. In order to preserve it, it is advisable:

- to systematically collect essential information on the state of the natural environment and based on such information to analyse the area development tendencies;
- to expand the territories that have the status of particularly protected areas;
- for the local community to participate in discussions on the area development plan and in a decision making process;
- to assess impact of each newly constructed building on the environment in accordance with the developed standards and rules for particularly protected natural and recreational areas.