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Monograph

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Concentration of Heavy Metals in Some Types of Soils of Georgia and Their Influence to Qualitative Parameters of Agricultural Crops: new public management: monograph / [edited by **Dubovická Lenka**, PhD (Economic Sciences), University of Central Europe Skalica, Slovakia, **Olga Rudenko**, Doctor of Science in Public Administration, Professor, Chernihiv National University of Technology, Ukraine]. – Published by Academic Society of Michal Baludansky, Slovakia, 2019 – 89 p. – (educational-scientific series: “Public management and administration”; issue 12). Printed by UK Technical University of Košice, Slovakia; Printing 300 psc.

The given Monographic Work “Concentration of Heavy Metals in Some Types of Soils of Georgia and Their Influence to Qualitative Parameters of Agricultural Crops: new public management” demonstrates multiyear scientific research results, which reflect influence of chemical pollutants (heavy metals) omitted by auto-transportation means in densely populated areas of central Sarpi-Poti-Senaki highway Sarpi-Kobuleti Section, on physical-chemical qualities of red soils and household land plots with agricultural crops (Tangerine, Potato, Green onion, Tomato, Autumn corn, Pkhali) in these locations and on ecological quality of them. The Monographic Work also demonstrates concentration issues of general and movable forms of heavy metals in basic types of soils (Chernozem, Meadow-Brown, Carbonate Brown) of Eastern Georgia and their separation issues in soil profile for the purpose of evaluation of ecological conditions of these soils and crops cultivated on the (autumn corn).According to received results it is identified, that plants pollution with heavy metals depend on load of highway and conditions of road way. Soil pollution with Plumbum and Cadmium with omitted gasses from vehicles is increased (above MPC) at 50 meters distance from highway, normal growth and development processes of plants is ruined near at roads and qualitative parameters of products produced from them. Hence, while cultivating agricultural crops their distance from highways and variety of crops must be examined. Soils and plants pollution with heavy metals because of gasses omitted from vehicles is decreased at 20 meters distance from highway. Enhanced background of heavy metals is typical for well-humus soils with heavy granulometric composition and low concentration is typical for low-humus consistency soils. The separation peculiarities of heavy metals in soil profile indicate at maximal amount of movable forms concentration of these elements in arable layer. Based on experimental research results, scientific recommendations are elaborated for owners of household land plots in western and eastern Georgia for the purpose of ecologically pure agricultural crops.

The present monographic work is focused on students with specialties of agriculture (agro-chemistry, soil science), nature studies (chemistry, biology, ecology) as well as professors-lecturers working in mentioned fields and scientists employed in research institutions.

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Contents

Introduction

Problem Actuality

Protection of environment and agrobio-diversity is one of the most actual problems of nowadays. It has gone far beyond the boundaries of a certain country and became a subject of interest of broad international societies. It is a global problem, it does not have any natural or state boundaries and it is a problem of densely populated and industrial as well as less-populated areas. Environmental pollution is a human disease which is caused by multiple anthropological activities on environment. The polluted environment is still against a human and it affects human health. Among other environmental polluters, chemical polluters play special role which first of all are heavy metals, pesticides, specific chemical substances and elements, aromatic and poly-aromatic hydrocarbons, plastics, inorganic pollutants, etc.

Ecological conditions of agricultural crops and therefore nutritious products produced from them greatly depend on quality and type of atmosphere, soil and water pollution. One of the sources of environmental pollution is transportation (in particular, auto-transportation, railway, air, etc.). Among them automobile transportation is one of the most active pollutants especially the vehicles with diesel motors which pollute the air with aromatic and circle hydrocarbons and aldehydes. The main consisting components of vehicle emissions are Carbon Monoxide, Nitrogen Oxides, Benzpyrene, Plumbum. The excessive concentration of such substances as aluminum, cobalt, copper, iron, magnesium, plumbum, zinc, cadmium and others is produced in surface layer near at soil during wearing out tires. Cadmium and plumbum are strong roadside environmental pollutant agents. They pollute soil and air from road highways at quiet a long distance. Big fraction of dust particles are especially active which pollute soil at both sides of roadway, from 5 to 100 m distance. Small particles, which consist of plumbum, are transported at far distance via airflow, which depends on meteorological conditions, and wind direction.

Research Goals

The objective of experimental research was to study influence of basic chemical pollutants, emitted from vehicles, at agricultural crops in central auto-highway of Western Georgia - Sarpi-Poti-Senaki, Sarpi-Kobuleti section; As well as, determination of general and acid soluble forms of heavy metals in basic types of soils in Eastern Georgia and studying separation of their movable forms in soil profile, in order to identify movable fund accumulation rate of these metals and quality of it as well as to evaluate ecological conditions of those soils.

Research Objectives

According to research goals the objectives of carried work are:

1. Studying the concentration of plumbum and cadmium in agricultural land plot soils and crops being cultivated at those soils in territories of central auto-highway Sarpi-Poti-Senaki, Sarpi-Kobuleti section (Gonio, Urekhi, Makhinjauri);
2. Determination of pollution quality with plumbum and cadmium of products produced from the above-stated crops;
3. Determination of heavy metals concentration in some types of soils of Eastern Georgia, as well as identification of their separation peculiarities in soil profile;
4. Determination of concentration of heavy metals movable forms and analysis towards Maximum Permissible Concentrations (MPC), on the example of soils of eastern Georgia, for evaluation of their ecological conditions;
5. The influence of fertilizers on concentration of fluorine and heavy metals in soil and plant (winter wheat grain).

Research Subject

Research subject was basic soils under intensive usage in western and eastern Georgia, in particular, Adjara red soils and Chernozem, field brown, carbonate brown soils of eastern Georgia; And from agricultural crops – potato, green onion, tomato, tangerine, corn, Pkhali, winter wheat and products produced from them – boiled potato, tomato-paste, tangerine juice, corn flour, boiled Pkhali.

Sources

The given work is based on Decree N297/N of the Minister of Labour, Health and Social Protection of Georgia “On approval of standards of environmental qualitative condition”; Law N490 of Republic of Georgia “On Soil Protection”; Besides, by-laws of Georgia and other normative acts in the mentioned field, state standards about methods of determination qualitative parameters in soils, researches of scientists acting in various periods in Georgia and abroad in the field of soils; Internet materials are used in the given work as well. Experimental data and literature materials obtained by the authors and their leadership were broadly used during representing the above-mentioned issues.

Research Results

The concentration of plumbum and cadmium in agricultural land plot soils and crops being cultivated at those soils in territories of central auto-highway Sarpi-Poti-Senaki, Sarpi-Kobuleti section (Gonio, Urekhi, Makhinjauri) is studied. The pollution quality with plumbum and cadmium of products received from the mentioned crops is determined.

In the given monographic work, there is shown in a modern way the background concentration of general and movable forms of heavy metals in intensive agricultural usage areas of Eastern Georgia which have special importance in their monitoring system as on it depends evaluation accuracy of soil pollution quality. The influence of mineral fertilizers taken in soils on concentration of movable forms of heavy metals is identified, as well as regulations of separation of movable forms of heavy metals in soil profile are shown.

Experiment Schedule and Methods

The alongside territories of central auto-highway Sarpi-Poti-Senaki, Sarpi-Kobuleti section are villages: Gonio, Urekhi, Makhinjauri. The mentioned areas are characterized by densely settlements, agricultural land plots are at 3-4 meters distance from roadways. There are cultivated annual vegetables and perennial orchard crops. The samples of experimental soil were taken from surface at 10, 20, 40 cm depth.

The samples of experimental soils were taken from selected objects at 5, 20 and 50 m distance from highway in Western Georgia. The experiments were carried repeatedly for two times. The samples taken from soils (Chernozem, Field-Brown and Carbonate Brown) under intensive agricultural usage in Eastern Georgia were analyzed. To this end, soil samples taken from industrial objects and highways distanced from intensive traffic has been analyzed where chemical means (samples were taken totally at 200 points at 0-20cm depth) were not used. Besides, several full cuts have been made from which samples were taken according to genetic horizons to study vertical separation of heavy metals and general and movable forms of fluorine and heavy metals were determined. Heavy metals concentration was determined via plasma atomic emission spectral analysis. pH in water and KCl suspension, $CaCO_3$%; Humus %, physical clay %, general nitrogen, phosphorus, Potassium - %, hydrolyzed nitrogen, movable phosphorus and Potassium - mg/100g, absorbed bases and their sum - mg/equivalent/per 100g soil were determined in soil samples.

In western Georgia alongside central highway the studying of toxic substances concentration (Pb, Cd) in agricultural crops took place via atomic-absorption method: potato, green onion, tomato, tangerine, corn, Phkhali. After defining concentration of toxicants in plants from research objects, it was necessary to identify existence of toxicants in the products produced from the mentioned plants. To this end concentrations of Cd and Pb were determined in products (potato boiled, tomato-pasta, tangerine juice, corn flour, Pkhali boiled) of plant samples taken from all three objects at various distances.

Soil and plant analysis were carried through using universally recognized and broadly approved classic and modern methods.

Material-technical basis for carrying researches was

Batumi Shota Rustaveli State University Agrarian and Membrane Technologies Institute;

N (N)LP Georgian Agrarian University; Tea, Subtropical Crops and Tea Production Institute, Soil and Grocery Diagnostic Center “Anaseuli”.

Chapter I. Review of Literary Sources

I.1 Physical-geographical description of research territory

In social development process natural conditions play a great role. The main components of it are: climate, surface waters, relief, useful natural resources, soils, flora and fauna. In scientific-technical revolution process, the importance of natural conditions is not decreased and it will not decrease in the future as well. Hence, special attention is paid to description of local geographical and climatic-soil conditions.

Adjara Autonomous Republic is located in south-west part of Georgia. From the north it is surrounded by Adjara-Guria and from the south - Shavsheti and from the east - Arsiani ranges and from the west - the Black Sea and from the south – Turkey. The areas is 2900 sq. m (4,3% of total territories of Georgia), population - about 337 thousand, population density - 130 person. Administrative center of Autonomous Republic - is Batumi City. In the territories of Autonomous Republic there are 342 populated areas, including: 2 cities - Batumi and Kobuleti; 5 boroughs - Chakvi, Ochkhamuri, Keda, Shuakhevi, Khulo, village - 333. The main part of Adjara territories are occupied by mountains, foothills and deep valleys.

Geographical location of Adjara is comfortable. It is considered to be very interesting districts in the aspect of diversity and complex natural-climatic conditions. Here at several kilometers length there is diverse climate, soil, plants and other elements of nature. Adjara is called Geographical Museum of alive nature without exaggeration.

Among natural resources of Adjara Autonomous Republic the forest flora with its multifunctional purposes has main role and it plays significant role in creation of precondition for sustainable socio-economic development of the region. Such a great importance of forests is stipulated by complex orthographic structure of Adjara highlands (more than 83% of slopes is more than 21° and more inclination), high demographic density (140 persons per 1 sq. km) and high precipitation conditions, with the risk of violating natural stability of mountainous eco-systems and therefore necessity of soil-protection, water-maintaining and water-regulating functions efficacy by floral co-associations.

One of the most important issues of the given work is to provide monitoring of biodiversity of flora and its ecological functions, types of forests, revealing peculiarities of natural landscape transformation and development in desired direction in the conditions of complex, highly changeable geographical background of mountainous Adjara in time and space.

Relief

Adjara is diverse region in geomorphological aspect. In the relief of it there is synthesis of high mountains, deep valleys, hills, plains and other landscapes. Complex structure of relief, high quality of separation and sharp inclination of slopes limits high-quality lands and agricultural activities of a human. 13,6 % of the territories is occupied by plains, 9,3% is occupied by hills and 77,1 % - mountains and Foothills. There are five geomorphological units in Adjara according to relief forms and other signs: Adjara-Guria, Shavsheti and Arsiani ranges, Adjara structural basin and coastline plain alongside The Black Sea.

Autonomous Republic is surrounded by south slope of Adjara-Guria Range from the north at latitudal direction. This zone is more or less useful from population. In agricultural aspect, the territories at 500-1300 m's height from sea level are comparatively well used. Here resides 72 percent of Adjara population. The upper boarder of on settlement achieves 1520 m.

Adjara boarders with Shavsheti range North Slope in the south. The highest point is mountain Kheva (at 2810 m's from sea level). Matchakhela, Merisi and Mareti valleys are in the territories of the mentioned geomorphological unit, where 9,5percent of Adjara population resides. The upper boundary of constant renovation achieves up to 1580 m.

Adjara is surrounded by Arsiani Range at extreme east part on a meridian. Skhalta, Rikheti and partly Mareti Valleys in the territories of it. It occupies 18,6 percent of Adjara territories, here is highest point of Adjara mountains - Khandilaghi mountain (2,992 m). This zone of settlement is well used for agricultural purposes.

Hereby is Adjara main mountainous-climatic resort Beshumi and Batumi-Akhaltsikhe highway of republican importance at Arsiani Range which crosses Goderdzi pass (2025 m). In the mentioned zone the upper boundary of constant settlement is spread at 1500 m from the sea level. Here lives 3,2 % of total population.

Adjara structural basin starts from upper part of village Dandalo (Keda Region) and spreads at tributary of river Skhaltistskhali. This section is less populated. Here is borough Shuakhevi and several villages where only 1,2 % of total population resides.

Adjara Black Sea Coastline plain area can be divided into hilly and plain sub-regions according to the nature of relief. Hilly sub-regions is spread at 100-350 m height from the sea level. It occupies 9,3 % of Adjara total area, where resides 21,9 percent of Adjara total population. Mainly the free area of Adjara where population can be settled is plain area sub-regions. Here are cities: Batumi, Kobuleti and big rural settlements. It occupies 6,1% of total area and 57,2% of population resides.

Adjara plain area starts from river Choloki reaches and continues to river Kintrishi (in the south). It consists of morphologically different parts. The extreme west part of the plain area includes beach, which is met with various sizes stones and sands. The height is from 0,5 to 5 m from the sea level and average height is at some places up to 15-60 meters.

Adjara coastline lowland plain areas are the lowest parts of intermountain plain areas of Georgia inclined to the Black Sea, they are not much distributed from the west to the east, it is between 200-300 meters to 5-7 km's to the extreme south. Alongside the river tributaries the plain areas are broadened, such plain areas are: Kakhaberi, Kobuleti-Choloki and Chakvi plain areas.

Kakhaberi plain areas was the sea bay for the beginning of the fourth period. The land was growing and Alluvial plain area was created by accumulation of waste material from river Tchorokhi and other small rivers. It has triangle form, the bottom of it is edged to the Black Sea, and the top of it is in Village Erge, it is surrounded by plain areas of Meskheti Range south-west and Ponto Range north-east branches. Kakhaberi plain area is almost spread to Makhinjauri Cape and in the south up to Gonio Cape, the length of it is 18 km, width about 12 km from Tchorokhi tributary to Village Erge. The plain area has wavy surface, slightly inclined to the Black Sea, the height is 0-12 m from the sea level. It is divided into two parts: sea coastline beach and plain area itself.

Chakvi plain area is located almost at central part of Adjara coastline alongside by river Chakvistskhali. The width is averagely 3, 5-4 km, breadth alongside river Chakvistskhali valley - is 6-7 km's. It is alluvial plain area and it has triangle form, the bottom of which is towards The Black Sea, the top of it is at Village Khala, Chakvi plain area genetically is quiet similar to Kakhaberi plain area.

Kobuleti plain-lowland is located at northern part of Adjara Coastline, between river Choloki lower reach and Tsikhisdziri hills. It is lied on 17,5 km's length from the north to the south and at 14-15 km's length at river Choloki parallel from the sea coastline. This plain area is part of Kolkheti plain area (almost up to river Kintrishi). Certain parts of the plain area is known by various names, in particular: Choloki plain area - alongside river Choloki, Kobuleti or Kintrishi plain area - at lower flow of river Atchkhva and Kintrishi. Kobuleti plain area is much more open to the east, it is slightly inclined to the sea. It raises at 0-20 m's from the sea level. Here are morphologically two basic parts: sea coastline beach with sand hills and plain lowlands.

The hilly zone is spread from the left coastline hills to the village Sarpi with straight line at 54 km's length, this zone occupies 425 sq. km's which takes 40% of western Adjara. Hilly foothill zone which orthographically is represented by Adjara-Guria (Meskheti) south Range at northern-western and Ponto Range northern eastern branches, it is structure by volcanogenic rocks. Sarpi-Gonio hilly region is represented with much more sharp forms, which is in the extrem southern-western part of Adjara hilly zone. It is created by the plain areas of Ponto Range Northern-eastern branches. Ponto Range branches is in the black sea in the forms of Sarpi and Gonio Capes.

Batumi-Tsikhisdziri hilly territories occupy great part of Adjara hilly zone. Orthographic basis of it is created by Chakvi range and partly Kobuleti Range branches, which are represented in the face of Erge, Akhalsheni, Salibauri, Peria, Urekhi, Makhinjauri, Green Cape, Chakvi and Tsikhisdziri uplands.

The complexity of Adjara relief makes negative influence at socio-economic development of the region. It is especially felt at special organization of settlement, mostly - in mountainous Adjara. The complexity of relief to its part finds expressions in the space of populated settlements and it equals to 771,4 sq. km, so 26,6 % of general area (17,3% in mountainous Adjara), when this indicator is 34,6% throughout the country.

The inclination of slope and high quality of separation limits usage of lands for producing agricultural products. In Adjara 0,05 hectare arable land per each person (and 0,14 hectare around the country) and 0,12 hectares of processed land.

Water Resources

Mineral waters are often met in Adjara which are distinguished by high treatment substances. Radio-active mineral-healing waters in Keda, Shuakhevi and Khulo regions deserve attention as well, in particular: in Merisi, Kokotauri, Uchamba, Khikhadziri and others. From sulfuric waters Makhindjauri waters must be noted, at the basis of which Sanatorium is working. Waters consisting sulfur are met in Kobuleti and Chakhati as well.

Adjara is pretty much rich with hydrographic network. The majority of rivers belong to The Black Sea Basin and three of them (rivers Kvabliana, Dzindzikhi and Bushemi) belong to the Caspian Sea Basin. The largest rivers are Tchorokhi, Adjaristskhali, Kintrishim Chakvistskhali. They have special industrial importance as high hydro-potential resources distinguish them. Special channels are made on them, mechanized irrigation systems are organized, and the rivers have industrial and every-day importance.

The lakes are met in plain and mountainous areas in Adjara but they are characterized by small areas and depths. All the lakes are characterized with fresh waters. Marshlands mostly are in plain areas. The region is rich in inside underground waters, which are at 2-3 m's depth in plain areas. In recent years the ground waters of large amount was discovered in Kakhaberi plain area. With the help of the discovered waters it is planned to provide Batumi with drinking water in the future. Underground waters are of a large amount in Adjara Mountains and local population uses them for drinking purposes.

Climatic Conditions

Adjara climate is characterized with peculiar character and diversity, starting from humid subtropical and ending with mountainous alpine climate. The peculiarities of Adjara climate are stipulated by mountainous relief, general atmospheric circulation, influence of the Black Sea, Paleographic past and other factors as well.

The disposition and height of mountains supports regular change of it according to climate and mountain heights. The mountains border Adjara from all three sides. In the west, the territory is opened to the Black Sea. The mountains stop flown humid air masses and supports atmospheric precipitation. This explains the fact that the majority of precipitation (3300-3800 mm per year) come to Adjara in particular in Chakvi and Mtirala mountain areas compared to other regions of the Black Sea Basin and for this reason, this place is often called "Pole of precipitation".

Adjara Climate is characterized with the following types:

1. Humid subtropical with warm winter and long hot summer, which is distributed at coastline plain and hilly areas. Average annual consistency of precipitation 2500-3000 mms.
2. In the midst of Adjara there is subtropical climate close to Mediterranean climate, along with river Adjaristskhali and its tributaries, at Meriistskhali below line gorges. Average annual consistency of precipitation is 1300 mm.
3. Humid climate with cool summer and moderately warm winter, which is spread at upper zone of mountainous line of coastline. Average annual consistency of precipitation is between 2200-2500 mm.
4. Moderately humid climate - with moderately warm winter and hot summer. It is spread in the middle zone of Adjara mountains. Average annual consistency of precipitation is 1075 mm.
5. Humid climate with comparatively cold winter and cool summer which is spread in upper zone of middle Adjara. Average annual consistency of precipitation is 1321 mm (Khulo).
6. Humid climate - with cold winter and short cool summer, which is spread in sub-alpine and alpine zones of mountainous Adjara. Average annual consistency of precipitation is in the limits of 1500-1800 mm.

Humid subtropics of the Black Sea Coastline is located between $41^\circ 30^I$ and $43°21^I$ of the northern latitude, on this latitude average annual temperature is almost unchangeable and it equals to $14,3^\circ$C. The sea which becomes warmer slowly in summer and becomes colder in winter, importantly averages out annual temperature in coastline. Annual amplitude of temperature from sea starts rising, it increases in summer and decreases - in winter, precipitation is decreased and confidentiality of climate is increased.

Average annual air temperature is: for Chakvi - $14,0^\circ$C, for Sokhumi - $14,9^\circ$C, for Gagra -$15,2^\circ$C. Average minimal temperature of the coldest month in Batumi achieves $6,5^\circ$C, in Chakvi - $6,0^\circ$C , in Ozurgeti and Anaseuli - $4,5^\circ$C , in Sokhumi $6,2^\circ$C -, in Poti - $5,8^\circ$C. The type of annual movement of temperature is similar at the whole Black Sea Coastline. The parameters of the coldest months - January and February are close to each other. The temperature increases in summer quiet slowly. Vegetative period of subtropical crops starts up to $+10^\circ$C, in solid average day-night temperature conditions. Such temperature in the Black Sea Coastline comes only for the end of March and in more continental area - for the end of second Decade of March. Stable temperature up to $+10^\circ$C disappears for the end of November. The total of active temperatures during vegetation period equals to 4000°C, and active up to $+10^\circ$C temperatures' minimal total, which can provide harvest of subtropical crops, is about in the limits of 3500°C.

In order to characterize the Black Sea coastline and Adjara inside climate (total precipitation, average air temperature, total of active temperatures of air, comparative humidity of air) the data in Table 1 is given according to average annual records of Batumi, Kobuleti, Chakvi, Keda, Shuakhevi, Khulo and Goderdzi pass Meteorological Station. As the table shows, the hottest months are July-August ($19,4^\circ$C - $22,6^\circ$C), according to data from all seven meteorological stations and the coldest months are January ($0,9^\circ$C - $6,7^\circ$C). According to average annual air temperature, the higher parameters are shown in Batumi ($14,4^\circ$C), than - in Chakvi, Kobuleti, Keda, Shuakhevi, Khulo and Goderdzi pass, hence: $14,1^\circ$C;

$13,4^{\circ}C$; $12,7^{\circ}C$; $11,0^{\circ}C$ and $10,4^{\circ}C$. Chakvi is distinguished with the highest average annual amounts of precipitation - 2788 mm, than Batumi - 2589 mm, Kobuleti - 2514 mm and finally Keda - 1652 mm.

Adjara climate is characterized by high correlative humidity of air the annual average parameter of which in coastline (Chakvi, Batumi, Kobuleti) is 78-84%.

As a rule, the direction of winds in Adjara are subject to a general regularity: in Summer and generally the wind blows in warm period - from the sea to the land and in cold period - from the land to the sea, therefore it has monsoon character.

Hence, analysis of basic consisting elements of Adjara climate approves that air temperature, correlative humidity, total of active temperatures, amount of precipitation and the separation nature of it, from the sea coastline to the sub-alpines are fully satisfying for cultivating perennial and annual crops, and for normal growth and development of perennial and annual grasses, plants types and species spread in valley in sub-alpines.

Table 1 Average Monthly Data of Air Temperature in Adjara

Months / Meteorological station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Kobuleti Total of precipitation, mm	248	222	166	162	153	173	221	331	290	280	269	245	2514
Average air temperature, ^0C	4.8	5.8	7.6	10.9	15.4	19.5	22.4	22.6	19.5	15.4	10.7	6.7	13.4
Absolute minimum, ^0C	-16	-15	-9	-4	-1	6	10	10	4	0	-8	-10	-16
Absolute maximum, ^0C	9.8	10.3	12.5	15.6	19.7	23.5	26.0	26.6	24.1	20.9	16.3	12.3	18.1
Correlative humidity of air, %	80	80	79	80	82	80	80	82	84	84	82	80	81
Chakvi Total of precipitation, mm	281	240	207	120	111	170	192	251	333	291	297	215	2788
Average air temperature, ^0C	6.2	6.5	8.3	11.5	15.7	19.6	22.2	22.6	19.7	16.1	12.0	8.4	14.1
Absolute minimum, ^0C	-9	-9	-7	-3	1	7	4	10	6	1	-3	-7	-9
Absolute maximum, ^0C	10.7	11.1	13.1	16.4	20.3	23.8	25.8	26.4	23.9	21.1	16.9	13.2	18.6
Correlative humidity of air, %	74	76	78	78	81	79	80	81	81	80	78	73	78
Batumi Total of precipitation, mm	265	216	168	117	87	155	173	244	319	292	289	264	2589
Average air temperature, ^0C	6.7	6.7	8.2	11.3	15.9	20.2	22.9	23.1	20.1	16.2	12.1	9.0	14.4
Absolute minimum, ^0C	-9	-9	-7	-1	3	10	13	14	7	3	-6	-6	-9
Absolute maximum, ^0C	11.2	11.4	13.2	15.3	20.2	23.8	26.8	26.8	24.8	20.9	16.4	12.7	18.6
Correlative humidity of air, %	78	78	80	80	82	80	81	82	84	84	81	76	80

I.2 Brief Description of Soils in Research Zones. Red Soils of Western Georgia

Almost all types of soils are met in the territories of Georgia, starting from on one hand subtropical zone red soils of western Georgia ended by mountainous-meadow soils of highlands and on the other hand ended by dry meadows and dessert-meadows, Chernozem chestnut-coloured and reddish brown soils - from its south, Chernozem soils of mountains-meadows. Such diversity of soils is increased via intense erosion processes as a result of irrigation, cultivating and fertilizing, etc. as a consequence with various degrees of their cultivation. We will stop by brief description of such soil types which are widely spread in Georgia and on which we have carried out examinations.

Adjara red soils

The basic soil types of subtropical zone of Georgia are red soils, yellow soils and subtropical podzolic soils. Red soils are widely spread in hilly foothill line of western Georgia subtropical zone, in particular in Adjara and Guria (from 80 to 200 m height) it is less spread in Samegrelo (Tsalendjikha, Chkhorotskhu, Zugdidi) and Imereti regions (Samtredia, Tskhaltubo) and in Abkhazia (Ochamchire, Gali) they have fragmental and spot like distribution.

Great variety of consisting parts of joint complex of natural conditions cause special diversity of soil cover of Adjara. As for vertical zoning Adjara soils are represented with the following basic types: Alluvial soils are mostly spread in sea coastline and terraces of rivers as well as silty soils of marshland, peaty, at some places bleached – silty and subtropical bleached soils. Silty soils of marshland are typical for Kobuleti and Kakhaberi plain areas and peaty soils of marchland is spread in Kobuleti plain area. Flood plains of rivers there is widely spread clay-sandy and alluvial mostly carbonate soils developed at rocks. Almost at whole coastline there are alluvial soils which are caused by insignificant distribution of carbonate waters in the mentioned territories. Humus concentration is alluvial soils rarely exceeds 2,5%, nitrogen concentration is between 0,15 – 0,2%, according to mechanical consistency light and average clay, rarely sandy and clay substances according to structure large-grained in upper layers and with no structure in lower layers.

At plain areas of Adjara Coastline alluvial soils with no carbonate, alluvial-marshy, bleached-marshy and peaty-marshy soils. In hilly zone of Adjara coastline and in foothill and slopes red assoils are spread mostly, which are distributed at 400-600 meters height form the sea level. In the mentioned zone the main place takes volcanogenic rocks, andesite and basalts. During quiet a long period these rocks were suffering from chemical decomposition in the conditions of subtropical climate. According to comparison of great amount of precipitation, ground waters, in the conditions of deep location and hilly relief, weathering bark suffers from surface washing out or deep washing out. Intensity of chemical weathering causes impoverishment of rocks with silica soils and foundation and enriching products with aluminium and iron oxide hydrates. The most widely spread soil-producing rocks of humid subtropics red soils are: andesite, basalts, Porphyritic tuffs and third precipitated layers clays and sandy-clays.

In humid subtropical zone of western Georgia there are widely spread weathering skin of basic volcanic rocks (basalts, tuff, andesites) and so called “zebroid” clay layers. The main qualities of red soils are high concentration of aluminium hydroxide. The soils in which $SiO_2/Al_2O_3 = 2$ and more and laterites - soils, where $SiO_2/Al_2O_3 < 2$ can be called Red soils. High concentration of one and half oxides cause high micro-regularity of red soils which importantly improves their water-physical qualities.

The volume weight of the mentioned soils is changed from 0,9 and upper horizons up to 1,1 m at lower horizons; specific weight from 2,4 to 2,7. Soil pores is high – 70-75% and it decreases in depth. At bleached red soils pore is lower by 7-20%. Besides the above-stated, red soils are characterized by maximal concentration of hygroscopic water, sound water-permeability, aeration, water moisture capacity, firm structure.

The concentration of “Physical Clay” in red soils achieves up to 90%. Silt fraction concentration is 20-40% (sometimes 50% and more) and concentration of clay – 25-70%. The amount of fraction with less than one micron is about 50%. Hygroscopic water in red soils is more almost by two and half times rather than in laterites, which mainly is determined by their mechanical consistency and great amount of “Physical Clay”. Though, in the soils of both types there is noted regular decrease of hygroscopic water. Red soils are characterized by higher field water moisture capacity rather than subtropical laterites, in red soils at 0-20 cm depth this parameter is 90% and in tropic soils 44-45%.

Typical red soils are distinguished with deep profile the accumulation-alluvial horizon thickness of which is between 20-50 cm and according to the depth it transfers into weathering skin which achieves 7-10 meters in Chakvi-Tsikhisdziri areas. The bleaching processes in red soils is combined with the turf process as a result of which at upper horizon humus is accumulated. The main source of accumulation humus in red soils is “Kolkheti Type” forests under which they have been formed. Ferns grow much in subtropical forest area and forest fields.

High existence of bases High saturation with bases and existence of aluminum together with hydrogen causes strong oxide reaction: pH in water suspension in upper layer it is 4,7 and it grows downwards up to 5-3; pH in KCl suspension is 4,0-4,6. Changeable (6,8-7,0 mg. equivalent / per 100 g soil) and hydrolysis (10,0-12,3 mg. equivalent per/100 g soil) acidity values are characterized by high rates, which mostly is caused by aluminum.

Silt fraction of red soils which mostly is composed by kaolinite group minerals (Kaolinite, Galuasite, Hetitis, Gibsitis) and one and sesquioxides group cause their poor cationic changing capacity, which is 10-12 mg. equivalent per/100 g soil. 15-40% of changeable cationic take Calcium and Magnesium, the major part (60-75%) takes aluminum and hydrogen. Basic nature of red soils colloids cause strong absorption capacity (10-15 mg. equivalent per / 100g soil) of anions. In the conditions of high concentration of colloids, red soils are characterized by low capacity from 8 to 20 mg. equivalent / per 100 g soil.

In recent years it was identified, those humus substances actively participate in physiological and bio-chemical processes. The red soils generally are distinguished by high humus concentration but it should be highlighted that its amount significantly depends on soil cultivation and erosion activity. In bleached red soils humus is less and it is sharply decreases in soil profile. Nitrogen concentration in correlation with humus and often in upper horizon achieves 0,3-0,4%. Hence, humus achieves 7% at 0-10cm in upper layer of red soil, nitrogen concentration is more and it decreases according to the depth.

Nitrogen concentration achieves 5-6% in humus of red soils. Despite this fact, because of poverty of bases and high acidity, of red soils and bleached soils, microbiological processes are restricted in them and mineralization of organic nitrogen takes place quiet slow. High efficacy of nitrogen fertilizers at productivity of agricultural crops in subtropical zone is explained by the above-stated circumstances. In the conditions of soils rich with humus, humus is the source of nitrogen and mineral nutritious, herewith, it give some physical-chemical qualities to the soil, it influences at water and air mode, etc.

In Adjara-Guria hilly and foothill regions there are five soil sub-regions. Kobuleti-Sarpi sub-region is one of them, which includes narrow line which to its part is represented by deep weathering skin of volcanic rocks and homogenous red soils are developed on it at which there are citrus plants cultivated (at 50-150 m heights from the sea level). In 2, 3, 4 Tables there are given agro-chemical parameters of red soils in various vegetation periods of citrus plants (Tangerine, Washington-Navel): in early spring, at the end of second vegetation and during harvest. The reaction of soil samples in early spring is acid. The soils of garden are much more acidic at 150m height from the sea level. The acidity is increased together with increasing soil layer depth especially in 20-40-th cm layer, in particular: in soils of garden at 150 m height form the sea level, pH KCl suspension it is decreased by 0,4 units and in soils of garden at 50 m height it is decreased by 0,1 units.

Exchange acidity is increased at 20-40 layer while moving to the depth of soil layer. The soils of Washington-Navel garden at 50 m height form the sea level is characterized by the lowest parameters of exchange acidity. Soils of gardens at 150 m height from the sea level are characterized by high concentration of hydrolytic acidity. This parameter increases at 20-40 layer while moving to the depth of soil layer and it achieves maximum point. The importance of hydrolytic acidity is lowest in soils of Washington-Navel garden at 50 m height form the sea level and it decreases while moving to the soil layer depth.

The absorption capacity increases by 1,95% at 20-40 cm layer while moving to the depth at 50 m height from sea level in soils of tangerine gardens and in 40-60 cm layer it is decreased by 4,7 %. At the same height this parameter is decreased by 5,98% in soils of Washington-Navel garden. The absorption capacity is increased by 8 times at 20-40 cm of soil layer in gardens at150 m height from sea level and in 60 cm layer it decreased unimportantly by 0,22%.

The quality of bases level of saturation with bases is increased by 8,24% while moving to the depth in soils of citrus gardens at 150 m height from sea level. This parameter is decreased at 20-40 cm depth while moving to the depth by 2,6 times in soils of Washington-Navel garden at 50 m height from sea level and it is increased by 2,2% in 20-40 cm layer in soils of tangerine garden at 50 m height from sea level, as for 40-60 layer it is decreased by 2 times (Table 2).

After the second vegetation period pH is low in KCl suspension in samples of research soils – in soils of garden at 150 meters height from sea level with 0,2-0,45 units, herewith, while moving to the soil layer depth importance of pH is increased unimportantly with 0,1 %. And pH is decreased with 0,2 % in soils of Washington navel gardens at 50 meters height and in soils of tangerine garden it does not change.

Soils of gardens at 150 meters height from sea level are characterized by high parameter of exchange acidity. The soils of Washington-navel garden at 50 meters height are characterized by the lowest importance. The importance of exchange acidity is increased while moving to the depth in soils of gardens at 50 meters height from sea level with 0,4-0,6%.

Soils of gardens at 150 meters height from sea level are characterized with the highest parameter of hydrolytic acidity. Herewith, this parameter decreases while moving to the depth of soil layer. Soils of Washington-Navel gardens at 50 meters height from sea level are characterized with the lowest parameter of hydrolytic acidity and it increases unimportantly while moving to the depth - with 0, 8%. The absorption capacity is high in soils of gardens at 150 meters height from sea level. The capacity increases while moving to the depth with 2 %. Herewith, Washington-Navel gardens are characterized with lower parameters of absorption capacity. The quality of saturation of bases level of saturation with bases is increased with 3,7% in soils of gardens at 150 meters height from sea level, and it is decreased in soils at 50 meters height from sea level (Table 3).

In harvest period pH in KC1 suspension of research gardens is lowest in soils of tangerine gardens, especially in sols of tangerine garden at 150 meters height from sea level (pH 3,9-3,4) with 0,5 unit. Exchange acidity is high in soils of tangerine garden at 50 meters from sea level (1,48 mg. equivalent per / 100 g soil). Hydrolytic acidity is high in soils of gardens at 150 meters height from sea level (14, 53-14, 69 mg. equivalent per / 100g soil).

The parameter of saturation quality of bases level of saturation with bases is high in soils of gardens at 50 meters height from sea level: in soils of tangerine garden by 4,34%, in soils of Washington-Navel garden - by 1,15% (Table 4). The absorption capacity during vegetation periods in soils of gardens at 50 meters from sea level is increased by about 1,2-3%. In soils of gardens at 150 meters height from sea level, this parameter first is increased by 8-11% and then it is decreased by 5-8%.

Water consistency in soils of gardens at 150 meters height from sea level in early spring is: in soils of tangerine gardens – 2-2,46% and in soils of Washington-Navel gardens 1,58-2,57%. The water consistency increases while moving to the depth of soil layer in all types of soils. Tangerine garden at 50 meters height from sea level is provided with humus at average level in 0-20, 20-40 cm layers and Washington-Navel gardens at 150 meters height from sea level with 0-20 cm layer. Humus level is low in 20-40 cm and 40-60 cm layers in soils of the same gardens. Humus concentration is even more decreased while moving to the depth of soils: in soils of tangerine garden at 50 meters height – with 1,02%, in soils of Washington-Navel garden with - 1,82%; In soils of tangerine and Washington-navel gardens at 150 meters height from sea level with 3,1%. Therefore there is low carbon and nitrogen concentrations: 2,8-2,2% and 0,24-0,19%.

Amount of exchange aluminum is importantly increased while moving to the depth, especially at 20-40 cm layer: with 0,2% - in soils of tangerine garden at 50 meters height from sea level and with 0,42% - in soils of Washington-Navel garden. Concentration of calcium is decreased with 0,5-1,14-7% while moving to depth. Soils of experimental land plots are less filled with magnesium. In all the variants concentration of magnesium is low. It is increased while moving to the soil depth: in Tangerine garden – with 1,1%, in Washington-Navel garden – with 2,15%.

Concentration of phosphorus is very low in soils of Washington-Navel garden at 50 meters height from sea level soil of Tangerine garden cultivated at the same height is averagely provided with phosphorus. In the very depth phosphorus concentration is more decreased: in soils of Tangerine garden at 50 meters height it is decreased by 7,22 %, in soils of Washington-Navel garden by 1,98%. Decrease is intensive at 150 meters height form sea level in 20-40 cm: in soils of Tangerine garden - with 43,25%, in soils of Washington-Navel garden - with 39,05%. Amount of Potassium in soils of tangerine garden at 50 meters height from sea level is very low, especially - in soils of Washington-Navel garden.

After second vegetation water concentration in research soils is lowest in soils of tangerine garden at 50 meters height from sea level. Water consistency increases in depth: under tangerine it is increased by 0,78%, under Washington-Navel - by 0,47%. While moving to the soil depth concentration of aluminum is increased in red soils of tangerine garden - by 0,435%, in red soils of Washington-Navel - by 0,52%.

Amount of calcium is more in soils of gardens at 50 m height from sea level in the mentioned period. Herewith its concentration is decreased in the depth of soil. Amount of magnesium is lower to all the other variants. While moving to the depth concentration of it in soil is decreased. For the end of second vegetation amount of phosphorus is high to all the other variants in research soils. Especially in soils of gardens at 150 meters height, where concentration of phosphorus is twice high. While moving in the depth soil it is by decreased 7-13,8-17,64% at 150 m height from sea level. The same regularity was fixed for concentration of Potassium.

In the harvest period water amount is high – 0,47-0,23% in research soils. Amount of aluminum is more by 0,8-0,6% % in soils of Tangerine Garden at 50 meters height from the sea level. Consistency of Calcium is high as well. Low concentration of magnesium is maintained in soil samples being discussed. Twice more concentration of phosphorus is noted in soils of Tangerine garden at 150 m height from sea level, compared to soils of gardens at 50 m height from sea level.

Multiple observations and wide industrial practices approves that creation of high agro-technical background in red soils, plantations and gardens, providing them with fertilizers according to agricultural rules, improvement of varietal composition of crops, reasonable usage of soils and protection of them, are one of the main conditions for enhancing crops' productivity.

According to the above-stated with the help of leaf diagnostics the forms and dosages of mineral fertilizers to be used in soils of research objects were identified, in particular, from nitrogen fertilizers: Ammonium Saltpeter 35%, Sodium Nitrate 16%, Ammonium Sulfate 21%, Urea 46%; from phosphorus fertilizers: Thomas slag 27,8%, phosphate flour 25%; from potassium fertilizers: Pottasium Chloride 59,9%, Pottasium Salt 40%; from magnesium fertilizers: ammoshenite (MgO-10%, N-8%); from organic fertilizers -manure with dosage 1 per one root 25-30 kg (Table 5).

Table 2

Agro-chemical Parameters of Soils of Citrus Gardens before Starting Vegetation (Early Spring)

Sample	Soil layer depth, sm	pH in KCl suspension	м Milligram equivalent per 100 g of soil			Level of Saturation of bases, %
			Exchange acidity	hydrolytic acidity,	Absorption capacity	
Tangerine garden at 50 m height from the sea level	0-20	4,0±0,041	1,21±0,016	10,41±0,012	17,02±0,02	62,04±0,04
	20-40	3,9±0,041	1,51±0,01	10,55±0,012	18,97±0,012	64,26±0,04
	40-60	4,1±0,041	0,86±0,02	9,65±0,014	14,27±0,014	59,66±0,045
Tangerine garden at 150 m height from the sea level	0-20	4,1±0,041	0,51±0,02	10,52±0,012	16,9±0,02	61,63±0,04
	20-40	3,7±0,047	4,7±0,041	13,49±0,004	33,54±0,004	71,32±0,039
	40-60	3,8±0,045	4,65±0,041	12,64±0,004	33,76±0,004	72,75±0,037
Washington-Navel garden at 50 m height from the sea level	0-20	4,2±0,039	0,75±0,016	8,25±0,022	13,28±0,016	61,68±0,04
	20-40	4,1±0,041	1,034±0,014	7,39±0,025	12,05±0,018	61,2±0,04
	40-60	4,4±0,037	0,35±0,025	5,19±0,029	7,3±0,025	58,45±0,045
Washington-Navel garden at 150 m height from the sea level	0-20	4,1±0,041	0,51±0,02	10,52±0,012	16,9±0,02	61,63±0,04
	20-40	3,7±0,047	4,7±0,041	13,5±0,004	33,54±0,004	71,3±0,039
	40-60	3,8±0,045	4,7±0,041	12,5±0,004	33,76±0,004	72,87±0,037

Table 3

Agro-chemical Parameters of Soils of Citrus Gardens during Second Vegetation (August)

Sample	Soil layer depth, sm	pH in KCl suspension	M **Milligram equivalent per 100 g of soil**			Level of Saturation of bases, %
			Exchange acidity	hydrolytic acidity,	Absorption capacity	
Tangerine garden at 50 m height from the sea level	0-20	4,0±0,041	1,02±0,016	12,02±0,012	19,74±0,012	62,15±0,012
	20-40	4,0±0,041	1,42±0,012	11,95±0,012	17,54±0,016	60,7±0,012
Tangerine garden at 150 m height from the sea level	0-20	3,8±0,047	1,68±0,01	14,36±0,008	28,3±0,008	66,34±0,008
	20-40	3,9±0,045	2,66±0,008	12,8±0,008	29,9±0,004	70,02±0,004
Washington-Navel garden at 50 m height from the sea level	0-20	4,2±0,039	0,45±0,02	8,18±0,02	13,28±0,02	58,77±0,02
	20-40	4,0±0,041	1,06±0,016	8,94±0,02	11,66±0,02	42,81±0,016
Washington-Navel garden at 150 m height from the sea level	0-20	3,8±0,047	1,68±0,01	14,37±0,008	28,3±0,008	66,32±0,008
	20-40	3,9±0,045	2,67±0,008	12,81±0,008	29,9±0,004	70,02±0,004

Table 4

Agro-chemical Parameters of Soils of Citrus Gardens during Harvest (November, December)

Sample	Soil layer depth, sm	pH in KCl suspension	M Milligram equivalent per 100 g of soil			Level of Saturation of bases, %
			Exchange acidity	hydrolytic acidity,	Absorption capacity	
Tangerine garden at 50 m height from the sea level	0-20	3,9±0,041	1,48±0,012	12,63±0,016	21,25±0,016	62,72±0,012
Tangerine garden at 150 m height from the sea level	0-20	3,4±0,082	0,63±0,02	14,53±0,014	20,38±0,02	58,38±0,05
Washington-Navel garden at 50 m height from the sea level	0-20	4,0±0,037	0,77±0,018	8,56±0,025	14,43±0,025	62,77±0,012
Washington-Navel garden at 150 m height from the sea level	0-20	4,0±0,037	0,82±0,016	14,69±0,014	23,59±0,012	61,62±0,016

Table 5

Dosages of mineral fertilizers in grams per 1 root of tree

Height from the sea level	Nitrogen fertilizers, g	F Phosphorous fertilizers, g	Potassium fertilizers, g	M Magnesium fertilizers, g
Tangerine garden at 50 m height from the sea level	360	175-218,9	261-390	131,25-157,5
Tangerine garden at 150 m height from the sea level	360	30-50	39-65	131,25-157,5
Washington-Navel garden at 50 m height from the sea level	450	263-315	261-390	131,25-157,5
Washington-Navel garden at 150 m height from the sea level	360	30-50	39-65	131,25-157,5

I.3 Basic Types of Soils of Eastern Georgia

Carbonate Brown soils of Bazaleti Plateau

Brown soils are distributed in mountainous-forest zone of eastern Georgia (generally Transcaucasia). This type of soil was noted by professor S.Zakharov in Mtskheta areas at Mountain Didgori slope which he called brown forest soil. Great works have been carried for studying the above-stated soils by I.Gerasimov, M.Sabashvili, I.Anjaparidze, M.Talakhadze and others. The mentioned scientists have identified the distribution rules of such soils, classified basic sub-types of them and gave the brief description of them as well. According to I.Anjaparidze, brown soils are divided into 3 sub-types: leached, typical and carbonate soils, which have multiple basic qualities, but they still differ from each other with some properties which do not go further type scope.

Carbonate brown soils mostly are distributed in lower foothill line of typical brown soils. This sub-type is characterised by high consistency of Calcium Carbonates in alluvial-carbonate horizon and high concentration of carbonate from the surface. Profile is well differentiated at genetic horizons. Humus horizon is brown, dark brown and sometimes blackish colours. Sometimes light brown is met as well the thickness of which equals to 20-30 cm. Illuvial-carbonate horizon often has light colour because of high concentration of carbonates and is very colourful with lime “crystal” and “fibrils”.

Carbonate brown soils occupy quiet great territories in Eastern Georgia. Often this sub-type is in complex distribution together with typical brown soil and sometimes, they can be hardly differentiated from them because of similarity of morphological signs. Carbonate brown soils with such complex distribution together with typical brown soils are met in slopes of Tsiv-Gombori range – in the area of villages: Ikhalto, Ruispiri, Vazisubani, Akhalsheni, Khirsi and other as well as in Shida Kartli Plateau – at south slopes of it – in villages: Bazaleti, Kobiantkari, Tchintcharaantkari, Sakramulo, Mtchadijvari, Dzalisi and others; and ion the areas of villages: Ruisi, Khurvaleti, Eredvi, Kavtiskhevi and others. The mentioned soils are distributed at from 5000 to 1000-1300 meters height above sea level.

Carbonate brown soils are well developed in loess type clays. One of the characterizing qualities of the mentioned soils is heavy mechanical consistency and high quality of argillization. According to the consistency of <0,01mm particles, carbonate brown soils of Bazaleti Plateau are clay soils. The amount of Lime slimy fraction is within important limits. Maximal accumulation of it noted in the middle part of profile. Despite of heavy mechanical consistency, in most cases firm and well-expressed structure of those soils are noted which is caused by high concentration of humus in them.

Agrochemical analysis data of carbonate brown soils indicate at high quality of saturation of bases level of high saturation with bases of the mentioned soils (Table 6). The sum of absorbed bases is high and in 0-10 cm layer, it is 50 milligram equivalent per 100 gram soil. Percentage concentration of Ca equals to 80-82% of absorbed cations. The great amount of absorbed Calcium and lack of sodium ions are the basis for water-physical qualities of carbonate brown soils. Humus concentration in upper layer of soil is 3,3%, total nitrogen – 0,22%, phosphorus – 0,16% and Potassium – 1,2%. In lower profile, their concentration is decreasing. Concentration of hydrolytic nitrogen is average, movable phosphorus - is very low and it does not exceed 1,6 mg/per 100 g soil. For the purpose of increasing productivity of research soil great importance has mineral and organic fertilizers on due taking of which it depends high harvest of agricultural crops.

Field Brown Soils

Field brown soils of eastern Georgia are studied by multiple scientists: M.Sabashvili, G.Talakhadze, D.Gedevanishvili, G.Tarasashvili, V.Lataria, and E.Nakaidze, and others. As for S.Zakharov he was he first who described soils in Mtskheta surroundings and classified them as brown soils. V.Fridland was the first scientist who have called them field brown soils and classified them as separate genetic type. G.Talakhadze discusses field brown soils as next step after brown soils evolution. According to him by destroying coniferous plants the underground water has raised up partly which has supported the process of field-developing and brown soil was placed at brown soil development stage.

The general areas of field brown soils of eastern Georgia equals to 130400 hectares and it is 1,9% of the territories of our country. Great masses of such soils are met in foothills of Bolnisi and Kvemo and Shida Kartli plain areas – Mukhrani, Ruisi, Skra, Gori, Saguramo, Dighomi, areas as well as alongside the both banks of river Liakhvi, bank plain areas of river Kura, in Kakheti – Akhmeta, Kondoli, Gurjkaani and other areas. The mentioned soils are developed at carbonate rocks of fourth period sediments loess rocks type. Field Brown Soils are classified into two sub-types: Typical and Field Brown soils.

Field brown soils of eastern Georgia are characterized by brown color poorly differentiated genetic profile and the ability of collecting lime concretions in illuvial-accumulation horizon. These soils according to their mechanical consistency are heavy clay. The fraction of physical clay is between 75-88% according to the profile. Silty fraction is represented with important amount, which achieves 50%. Field brown soils are characterized by firm aggregates, which indicates to high firmness of its micro-aggregates, so it is difficult to treat such soils and the ploughed soil is often non-homogenous, clod, rough and has low quality.

For morphological and agro-chemical description of field brown soils, soil holes were done at research areas (Villare Kareli and Natakhtari). Agro-chemical parameters were determined in soil samples taken according to horizons. The results are specified under Table 7. As it is vivid from table data, it is necessary to apply fertilizers and especially phosphorus fertilizers in the mentioned soils for producing vegetable crops, cereals and sugarbeets.

Chernozems of plain area of Eastern Georgia

The very first reports about Chernozems of plain areas of Georgia as genetic type belongs to V.Dokuchaev. S.Zakharov played great role in studying soils of Georgia and specifically steppe zones who was the first who has classified Chernozems at Chernozems of hilly and plain areas. G.Talakhadze has dedicated special monographic work to these soils, in which there are thoroughly described all the properties of Chernozems of Georgia. These soils basically are represented at Iori Plateau at 500-750 m height and in the form of small masses they are met at Kvemo Kartli plain area as well.

According to bio-ecological conditions, there are classified Ordinary and Southern Chernozems. The main areas of them are used for agricultural crops cultivation and for this reason, they are different from initial – virgin lands according to their chemical and physical-mechanical parameters. According to the morphological signs the both sub-types are close to each other. Natural Chernozems are distinguished by heavy mechanical consistency, they belong to average clay mostly. The main peculiar characteristics of the mentioned soils are high general porousness which achieves 50-65% at upper layer and in the depth is reduced. The parameters of specific and volume weight of Chernozems of plain area are not high but they increase in the depth.

In A-arable horizon of natural Chernozems of eastern Georgia, humus concentration mostly is between 4-5,2%. According to the researches of M.Sabashvili, G.Talakhadze and others, humus concentrations equals to 8% in virgin lands in the zone (Shiraki and others) of distribution of such sub-type.

In humus horizons of ordinary Chernozems the sum of absorbed bases equals to 45-55 mg /equivalent, correlation - Ca:Mg – in the limits of 5:1. For the purpose of providing agro-chemical description of Chernozems in Kvemo Kedi, soil hole was made at research plot (170 cm) and morphological description of it was provided. Agro-chemical analysis were made in soil samples taken according to Horizons. The results are given under Table 8. From the table we see that Humus concentration is in the limits of 4,7-2,4% in research soil layer 0-40 cm. The nitrogen concentration is reduced in the depth. Despite the fact that concentration of phosphorus is quiet high (0,135%) concentration of movable phosphorus is very law and it does not exceed 1,3 mg per 100 g soil. Research soil is averagely filled with exchange Potassium. As we can see, from agro-chemical parameters of soil hole, it is necessary to take fertilizers and especially phosphorus fertilizers in the mentioned soils to gain high production of cereal crops.

Table 6

Agro-chemical Parameters of Carbonate Brown Soil Holes in Village Bazaleti (Dusheti Region)

The depth of soil samples, cm	pH in water suspension	$CaCO_3$ %	Humus %	Nitrogen		Phosphorus		Potassium		Absorbed bases, mg equiavlent / per 100 g		
				General %	Hydrolytic mg/100g	General %	movable mg/100g	Exchange %	movable mg/100g	Ca^{2+}	Mg^{2+}	Total Ca+Mg
0-10	7,8	6,4	3,3	0,22	4,9	0,16	1,6	1,2	33,1	42,0	8,0	50
10-20	7,8	9,2	2,2	0,20	4,5	0,15	1,1	1,0	29,0	41,0	6,0	47
25-35	7,8	11,2	2,1	0,13	2,4	0,12	0,9	0,85	29,7	38,0	7,0	45
45-55	8,0	12,4	1,07	0,11	1,7	0,11	0,4	0,58	15,0	34,0	6,0	40
90-100	8,2	28,0	-	-	-	-	-	0,5	2,0	31,0	5,0	36

Table 7

Agro-chemical parameters of field brown soil holes (Village Kareli)

The depth of soil samples, cm	pH in water suspension	$CaCO_3$ %	Humus %	General types, %			Movable types, mg/100g			Sum of absorbed bases, mg equiavlent / per 100 g
				N	P	K	N	P_2O_5	K_2O	
0-10	7,7	11,0	3,3	0,18	0,12	1,9	8,5	1,6	38,5	53,0
10-20	7,6	11,5	3,1	0,16	0,10	1,8	8,0	1,2	34,7	52,5
30-40	8,0	12,9	2,1	0,14	0,10	1,5	7,0	0,9	30,0	50,0
50-60	8,0	15,7	0,9	0,09	0,08	1,1	4,0	-	18,0	48,5
70-80	8,2	18,8	0,5	0,06	0,08	0,6	2,2	-	9,6	47,0
110-120	8,2	21,5	-	-	-	-	-	-	-	44,0
130-140	8,3	22,4	-	-	-	-	-	-	-	40,5
150-160	8,3	25,5	-	-	-	-	-	-	-	38,0

Table 8

Agro-chemical Parameters of Chernozems Hole in Village Zemo Kedi

The depth of soil samples cm	Hu-mus %	pH in water suspen-sion	Nitrogen		Phosphorus		Potassium	
			Gene-ral %	Hydro-lytic mg/100g	Gene-ral %	Movable mg/100g	Excha nge %	movable mg/100g
0-10	4,7	7,9	0,19	8,2	0,13	1,3	1,1	41,0
25-35	3,7	7,9	0,16	7,3	0,12	1,0	1,0	40,5
40-50	2,4	8,1	0,11	6,0	0,11	0,9	0,6	32,6
52-62	1,8	8,3	0,10	4,1	0,09	0,8	0,5	16,8
70-80	0,6	8,5	0,07	1,1	0,06	0,6	0,5	11,4
110-120	0,4	8,5	0,06	-	0,01	-	0,5	10,8
140-150	0,3	8,5	0,04	-	-	-	0,2	10,5

Carbonate Brown Soils of Southern Georgia

The soil cover of southern Georgia has been initially studied B.Klopotovsky who has classified mountainous-field, forest fulvous and forest brown soils as well as the zones of Chernozems and chestnut soil zones. The author gives their general description and discusses them in the aspect of suitability for viticulture. Academicians M.Sabashvili has elaborated soil maps of Akhaltsikhe, Adigeni and Aspindza administrative regions according to materials by B.Klopotovsky. General description of soils in Akhaltsikhe basin areas forest-steppe and mountain-forest areas is given in monographic work of M.Sabashvili “Soils of Georgia”. M.Shevardnadze has carried important researches regarding to studying soil of Meskheti and Adjara. Thorough studying of Meskheti soil was started since 1966 by R.Petriashvili. Brown soils of southern Georgia are located at below part of mountainous-forest zone at 1200-1500 m height from sea level, where they occupy transitive place between forest fulvous and steppe (chestnut) soils.

From Akhaltsikhe structural basin brown soils leached, typical and carbonate sub-types are classified. Carbonate brown soils are widely spread, which are formed at carbonate layers of andesite-basalts, loess clay areas and carbonate clay areas. The mechanical consistency of the soils above in the whole profile is heavy clay, herewith, argillization process is vividly expressed in the middle part of the profile, where Silt fraction achieves 42%.

Table 10 demonstrates agro-chemical analysis results carried in samples taken from horizons of carbonate brown soil holes at research plot (Sviri). Humus concentration is between 3,3-2,0% in 0-40 cm layer research soil. General phosphorus is 0,15%, movable phosphorus – 1,5 mg per 100 g soil. Concentration of exchange potassium is average. Because of low concentration of movable phosphorus applying phosphorus fertilizers in the mentioned soils is highly effective.

Table 9

Agro-chemical Parameters of Ponitchala Carbonate Brown Soil

The depth of soil samples, cm	pH in water suspension	$CaCO_3$ %	Humus %	Nitrogen		Phosphorus		Potassium		Sum of absorbed bases, mg equivalent / per 100 g		
				General %	Hydrolytic mg/100g	General %	movable mg/100g	Exchange %	movable mg/100g	Ca^{2+}	Mg^{2+}	Sum Ca+Mg
0-20	7,5	6,0	3,0	0,20	6,2	0,18	2,2	0,83	33,3	29,8	7,1	36,9
20-40	7,3	7,0	2,2	0,15	5,1	0,17	1,2	0,72	30,5	31,1	8,2	39,3

Table 10

Agro-chemical parameters of Carbonate Brown Soil of Village Sviri (Akhaltsikhe Region)

The depth of soil samples, cm	Hu-mus %	pH in water suspen-sion	Nitrogen		Phosphorus		Potassium	
			Gene-ral %	Hydro-lytic mg/100g	Gene-ral %	Mova-ble mg/100g	Excha nge %	movable mg/100g
0-10	3,3	7,8	0,22	6,4	0,15	1,5	1,0	30,0
30-40	2,0	7,8	0,18	4,5	0,09	0,8	0,9	25,5
50-60	0,95	8,1	0,09	3,5	0,10	-	0,9	12,5
65-75	0,6	8,2	0,07	2,0	0,10	-	0,5	7,0
85-95	-	8,3	-	-	-	-	-	-
106-150	-	8,3	-	-	-	-	-	-

I.4 Environmental Pollutants

Environmental pollution of our immediate habitats is called Catastrophe of XXI century. Nowadays environmental and nature protection problems is so actual that it is far beyond the problems of one certain country and became the subject of special attention of wide circles of society. Environmental pollution is a human disease, which is caused by anthropogenic activities. Polluted environment is still against a human and affects human health. This is a global issue - it has no natural or state boundaries and it is spread is densely populated and less-populate areas. Environmental pollution is the result of technological progress. Human activities have ruined natural separation of elements in geographical shell of the earth, which caused geo-chemical anomalies and deep changes in biosphere. This latter has regional and global character as well. On one hand rocks consisting heavy metals came at the surface of the earth, pollution of alongside territories; and on the other hand – their distribution in environment with various ways; third which is considered as the most dangerous circumstance, participation of metals in biogenic migration process.

Migration of heavy metals takes place in the form of biotic (turning in food chains), abiotic (wind erosion, water circulation, etc.) and anthropogenic (applying fertilizers, pesticides, dyes, antiseptic preparations). With all the above-stated factors heavy metals happen in tropic network of eco-system in any eco-system and they participate in atomic biogenic migration processes.

At present, heavy metals take one of the first places in Biosphere Pollutant Agents' Registry. Many of them have genetic activity qualities together with toxic activity, which jeopardises gene pool of living organisms including humans.

Strict selection process of toxic admixtures is on in populations including for the benefits of resistant forms of heavy metals. This process is accompanied by elimination of great amount of individuals. Resistant forms created as a result of spontaneous mutation process somehow hinder this process, as they include changed material in the face of mobilization reserve. As a result of realization of changed material populations genetic adaptation takes place as a reply to the increased toxic and mutagenic background. The preference is given to such forms, which are characterized by high intensity of reproduction and speedy change of generations. Populations having small and long-term living circle experience difficulties in getting rid of and adapting to such conditions

In recent years the scales of processing mineral resources is importantly increased, which leaded us to increase of loss of various elements (including heavy metals). From 77 metals of Periodic Table, 52 participate in environmental pollution, among them 20 metals are toxic and significantly jeopardize living organisms (Table 11).

Table 11

Environmental Pollution with Heavy Metals (Thousands of tons per year)

Pollution Sources	**Toxic Metals**				
	Ca	**Cu**	**Ni**	**Pb**	**Zn**
Non-ferrous Metallurgy	5,31	21, 1	9, 6	77, 3	116, 2
Black Metallurgy	0, 07	5,9	1, 2	50, 3	35, 2
Burning Garbage and Waste	1, 4	5, 3	3, 4	8, 9	37, 0
Total anthropogenic	7, 3	47, 3	47, 4	449, 2	314, 4

Industrial enterprises annually emit millions of tons of heavy metals annually, which create the following row according to intensity of emitting in environment: Ca, Cu, Ni, Pb and Zn. Since 1980 up to present, more amount of plumbum was emitted in atmosphere by enterprises and auto-transportation means rather than during the whole length of the history. All recent natural pollution sources takes second place compared to human activities (anthropogenic factor). Only industrial and agricultural enterprises daily emit million tons of toxic substances – pesticides, polychloride-oxines, as well as separate elements – Mercury, Cadmium, Plumbum, Fluorine, Sulphur, etc. During last 100 years more than 1,5 millions of Arsenic, 1,0 million tons of Nickel, 900 thousand tons of Cobalt, 600 thousand tons of Zinc and 125 thousand tons of Mercury were emitted in environment.

12 billion tons of fuel consisting carbon – gas, oil, black coal and the products received from them are used annually on the earth, as a result of which about 360 tons of toxic pollutants are sedimented per 1 km. the modern metallurgy factory emits 100 000 tons of dust, 30 000 ton CO_2, 8000 ton of SO_2-, 3000 ton NO_2, 1000 ton H_2S, 50 ton HCN, 40 ton HCl, 3000 ton of mud and 800000 ton of slag in the environment for producing each one million ton of steel. Metallurgic industrial complexes annually emit 150 000 ton Cu, 120 000 ton Zn, 90 000 ton Pb, 12 000 ton Ni, 1,5 ton Mo, 800 ton Co, 30 ton Hg on the surface of the earth .

It is well-known that according to the specific weight, all the metals are divided into two groups: light the specific weight of which does not exceed 5 g/cm^3 and other, heavy (the rest ones). Heavy metals are: Cr, Zn, Sn, Mg, Fe, Ni, Cu, Hg, Pb, Ag, W, Pt, Bi, Ag, Au, etc.

Soil pollution with various metals has got various sources:

1. Mountainous-mining industrial wastes;
2. Industrial Emissions;
3. Fuel products;
4. Car Emission airs;
5. Means of agricultural chemization.

From the mentioned sources millions tons of metals happen on the surface of the earth, the majority of which is accumulated at upper horizons of soils. For instance, more than 250 000 tons of Plumbum happen on surface of soils annually together with emitted airs and it is considered to be the main source of polluting soils with Plumbum.

Separation of heavy metals on the soil surface is determined by various factors: it depends on pollution factor, meteorological and landscape peculiarities of the region and geo-chemical factors as well. Pollution source defines quality and amount of emitted product. The emission quality of pollutant depends on emission height. The maximal pollution zone is spread at 5-40 m distance and the duration of it depends on mass of pollutant and chemical-physical qualities of it. The heavier are particles, the faster they are sediment. The wind speed makes influence at separation of pollutants also: the faster is the speed the more active is dissolution of emission through air masses and the less is pollution at area unit.

In addition to meteorological factors the separation nature of heavy metals depends on relief. Metals are participated in biological circulation, they are transmitted with food chains and cause a number of negative consequences. In particular, heavy metals from soil first of all happen in plant and than through food chains – in living organisms and they make toxic influence at plants, animals and humans. From toxic elements initially must be distinguished Mercury, which is especially dangerous in the form of strongly toxic admixture – Methyl-Mercury. This latter is produced in the nature in anaerobic conditions from inorganic Mercury, with the participation of organic substances. This takes place at the bottom of water basins, where industrial waste is thrown away.

Mercury admixtures including toxic Methyl-Mercury are moving through food chains and at the end they happen in human body. In case they exceed maximal permissible concentration (MPC) they cause kidney, liver and brain injuries as well as psychic disorders and human death. In Minamata city in Japan was recorded cases of human poisoning with Mercury and the nervous disease caused by Methyl-Mercury was called was given the name of the city “Minamata”. In Japan approximately 300 000 people experienced mercury poisoning. The Plumbum is transferred through food chains as well; it is accumulated in plants, animals and human bodies.

A human pollutes atmospheric air with his agricultural activities which to its part, negatively turns to a human. Among environmental pollution sources first place takes useful minerals, they are: coal, oil and gas. The emissions through burning the stated products pollute atmosphere and they make negative influence at human body. Atmospheric pollutants make active physical and chemical influence at human bodies. Radioactive substances, thermal pollution (increase of temperature), noise and low-frequency vibrations make negative influences on human bodies. The dissoluble hydrocarbons, detergents, plastic materials, pesticides and other synthetic substances, as well as nitrogen and sulphur wastes, heavy metals, fluorine mixtures, solid impurities, organic substances make chemical influence.

According to origin atmospheric air pollutants are divided into natural and artificial (anthropogenic) admixtures. Natural admixtures are met in atmosphere as a result of vulcanic activity, soil and mountainous rocks weathering, forest fires and burning meteorites. Anthropogenic admixtures are produced, first of all, during fuel burning process – inside combustion motors, at thermal power stations, heating systems and as a result of industrial and everyday waste burning and nuclear explosion processes, etc. The total mass of world industrial emission in atmosphere per one year equals to approximately 600 mega tons.

During last century 1,35 megatons Si, 1,5 megatons As, more than 1 megatons Ni, 0,6 megatons Zn were emitted in atmosphere. Among admixtures happening in atmosphere there are gas, solid and soluble admixtures according to their consistency. Herewith 90% takes gas substances. Gas substances are Carbon Oxide, Suphur Dioxide, Nitrogen Oxides, Hydrocarbons. Solid admixtures take only 10%. They are: dust, heavy metals, minerals, organic admixtures, radioactive substances. Among gas and solid admixtures the mass of soluble admixtures (for instance H_2SO_4) is very low.

Carbon monoxide (CO) is the most distributed gas in atmosphere. The basic mass of it is produced as a result of heat burning and the main source of it is inside combustion motor. In USA cars emit 120 megatons of Carbon Monoxide annually. Maximal amount of it is produced through motor heating process. Among atmospheric pollutants the second place takes Sulphur Dioxide (SO_2) according to mass size. Mainly it is produced as a result of coal burning. According to statistics 145 megatons of Sulphur Dioxide is emitted in atmosphere annually. At the same time, 70% of it is produced as a result of burning coal and the rest 16% - from soluble heating (mostly fuel oil – low quality fuel oil). Decomposition of SO_2 in atmosphere happens through influence of ultraviolet radiation, which produces Sulphur Anhydride (SO_3). Sulphur acid (H_2SO_4) is produced as a result of recent reactions in polluted humid atmosphere. Hydrogen sulfide (H_2S), is also met in atmosphere, which is produced as a result of vital activities of micro organisms in soil and sea environment.

Nitrogen Oxide (NO) and Dioxide (NO_2) are produced in inside combustion motors as a result of burning diesel and petrol. Nitrogen oxide stays in atmosphere during 3 days and nights. As a result of reaction to water steam, it is transformed into Nitric Acid and other nitrates which return to the soil with sediments. Nitrogen Dioxide is dissolved with influence of ultraviolet radiation and it is transformed in NO. It is dissolved during high temperatures (more than 600°C). The basic natural source of producing hydrocarbon is – plants, anthropogenic – auto-transportation. Carbon and nitrogen oxides belong to hydrocarbons. Solid particles or aerosols happen in atmosphere as a result of natural and anthropogenic processes, which have different forms. The main pollution source is the industry connected to obtaining and using construction materials, in particular – sawing rocks sandpits, producing cement, etc. The non-ferrous metallurgy emits great amount of solid particles which consist of Zinc, Copper, Plumbum and Aluminum.

Progress of auto-transportation and aviation has essentially increased the part of emitted gasses in atmosphere. In industrial city with average population 30-70 % takes auto-transportation in the general mass of emissions. As for USA here 40 5 takes auto-transportation among pollutants, among them are – cargo and passenger vehicles, locomotive and air transportation. From means of transportation the main role in atmospheric pollution plays vehicles working on petrol. Their specific share equals 75% in USA and 5% emission from Planes.

The main pollutants of atmosphere are Carbon Oxide (CO_2), hydrocarbons and Nitrogen Oxides (NO, NO_2). The huge emission of hydrocarbons and carbon oxides in atmosphere take place while braking cars and free driving of them and Nitrogen Oxides during high speeds. Generally cars pollute atmosphere greatly while braking and while starting to drive. Diesel motors are much more economic and they emit comparatively small amount of some substances, but diesel motor emits great amount of unburned Carbon, for this reason, they much more pollute environment and they have much more negative effects at human health.

Airplane emissions less affect at city air, it mostly makes negative influence at air only in the Airport area. It is identified that 42% of fuel is spent for taking airplane in and out to the landing strip. The non-used and emitted amount of fuel is higher rather than emitted during the whole flight. Airplanes and spacecrafts pollute atmosphere with Nitrogen acid and Sulphur Acid, as well as with particles of Aluminum Oxide. They negatively affect at Ozone layer and at global air temperature.

Chlorine-fluorine-methanes, Freon-11, Freon-12 are gas, which are formed while evaporating those aerosols preparations which are used for dyeing hair. The mentioned gasses are spread and they exist for a long time in troposphere. Freons induce and increase greenhouse effect. According to calculations, for 2030 year general amount of Ozone will be decreased with 18% as a result of influence of Freons and in the lower stratosphere - with 40%. As a result of all the above-stated, global above-ground temperature has increased by 12-21°C. Noise refers to harmful atmospheric pollutants, it has irritating influence on a human. Its influence depends on intensity of it, at spectral consistency of it and action duration.

Surely it is impossible to cancel technical progress and return back civilization and therefore, we need to find ways for harmonic coexistence with nature, provide correct operation of means of transportation and “placing” human waste correctly. To achieve the mentioned goal it is necessary to carry great and complex works, including it is necessary to study nature of influences of anthropogenic toxicants on various species of plants.

Environmental pollution is one of the biggest problems of economically well-developed countries of the world, during evaluation of general volume of damages of which it is necessary to foresee consistency dynamics of heavy metals. Such heavy metals as Plumbum, Cadmium, Zink, Copper, Titanium is especially dangerous for human health, and their accumulation in human body with generous amount may cause serious diseases of blood vessels, digestion systems and respiratory system as well.

I.5 Pollution of agricultural products with heavy metals and their photo-toxicity influence at human and animals' health

Heavy metals belong to ultra micro-elements, which are distinguished by high toxicity and sometimes radioactivity. While they are in a plant with small amount they can stimulate processes of growth and synthesis, which is caused not because of biological necessity of the mentioned elements but action of micro-dosages of toxic substances and by stimulation of organism intoxication. Hence, taking some micro-elements in soil is very problematic as there is small interval between their optimal non-malignant concentration and toxic concentrations and so, they often exceed dangerous threshold of humans and animals health and cause acute intoxication.

It is necessary to mention that a number of elements in this group – Copper, Zinc, Cobalt, Manganese, Iron, Molybdenum, etc. are basic consisting parts of ferments and they participate in vital processes of plant organisms. Small concentrations of the mentioned elements are used as fertilizers for agricultural crops and in animals for their mineral feed. They are called heavy metals when they are obtained with high concentrations in ecosystem. Heavy metals are inseparable parts of biosphere and they are necessary and they are necessary with small amounts for plants at supreme step animals and humans. Herewith, not only the overexposure of heavy metals but all macro- and micro-elements may be the reason for intoxication and death of living organisms, their high concentration in soil dissolution totally terminates growth of plants roots system and causes their drying up.

While suing high norms of mineral and organic fertilizers, composts made from city garbage, silt taken from river and water basin and other residuals used for fertilizing of crops, such heavy metals as Zn, Mn, Se, Cu, Cd, Cr, Pb, Ni, Hg and other are accumulated in agricultural products. From the mentioned list the most toxic ones are Hg, As, Cd, Pb. The mixtures of the mentioned metals are quiet sustainable and they maintain their toxic nature dor a long period.

Despite fertilizers, during strong pollution of atmosphere with heavy metals their big and heavy particles are sedimented near at pollution source – they move at small distance, happen in soil and they are assimilated to plants roots system. The part of it happens at the very surface of plants leaf and it is assimilated without roots. At the distance from the pollution place, concentration of heavy metals in plant is regularly decreasing.

Pollution of atmosphere, soil and waters with heavy metals is alarming in the aspect that in the future they cause not only decrease of productivity of agricultural crops but ruining naturally created phytocenosis and organogenesis processes, as well as deterioration of hygienic quality of products as in ash of polluted plant the concentrations of heavy metals and radio-nuclides are increased. Therefore, polluted production having high nutritious value can be dangerous for human health in case if the concentrations of Ra, Po, Sr, Co, Ni, Hg, Cd, Pb and others in production ashes exceed maximal permissible concentration (PMC). The additional factor is that even without revealing pathological changes and symptoms of toxicity, agricultural crops may contain such amount of heavy, radioactive and toxic admixtures, which is dangerous for human and animals' health.

It is known that when there is increased amount of heavy metals in soil the process of nitrification is hindered, and decrease of molecular Nitrogen fixation by legume grasses. "Acid rains" in the polluted areas with heavy metals increase the area of their movement, which creates risk for surplus accumulation of it in plant. The absorption quality of heavy metals by various plants from polluted soil is not homogenous. The vegetable crops have got the highest accumulation ability of these elements and technical and cereal crops lowest. Dicotyledonous plants have got the better ability of absorption of heavy metals rather than monocotyledon plants.

Absorption of heavy metals by a plant depends on concentration of soluble forms of them and the concentration of soil itself. There is close mutual connection between general concentration of heavy metals in soil (Pb, Zn, Cd) and amount of them in plant. For instance while increasing Plumbum general concentration from 21 to 411 mg/kg, concentration of it was increased in Corn from 0,1 to 2,0 mg/kg. Roots accumulate Plumbum much more intensively compared to corn. By increasing general amounts of Zinc in corn from 47 to 707 mg/kg this metal accumulation capacities has been increased from 25 to 82 mg/kg. Corn has got the less capacity for cadmium absorption from soil compared to beet. During increasing it in soil from 1 to 7 mg/kg concentration in root crops of sugar beet is increased from 0,3 to 1,4 mg/kg. Accumulation of Cadmium in beet depends on Zinc concentration ins oil which hinders Cadmium accumulation in beet roots. When Zinc background concentration is 47 mg/kg, maximal concentration of Cadmium achieves 7 mg/kg. While increasing Zinc concentration in soil to 700 mg/kg Cadmium Concentration in root crops of sugar beet is decreased to 3 mg/kg.

In order to prevent all the above-stated facts it is necessary to study not only concentration of heavy metals, but all the negative influences caused by them in the aspect of environmental pollution. It is worth attention that joint action of several heavy metals Cd, Pb, Zn is less toxic rather, than their action separately which can be explained by ion antagonism of the mentioned metals and by reduction of their absorption capacity. For instance there is antagonism between Zinc and Cadmium, Calcium and Cadmium, Magnesium and Zinc, Calcium and Zinc. This quality must be used for reduction of absorption capacity heavy metals plant roots at some polluted soils.

Heavy metals belong to protoplasmatic poison, the toxicity of which increases along with increase of atomic masses. Strongly phyto-toxic elements are those elements, which make negative influence at plant when they are for 1 mg/l in solution. Such elements are: Ag^{+}, Be^{2+}, Hg^{2+}, Sn^{4+}, Pb^{2+}, Ni^{2+}, Cu^{2+}, Co^{2+} and CrO_4^{2-}. Moderately toxic are elements which make inhibitory influence in the conditions of from 1 to 100 mg/l Concentration. These groups include Arsenates, Borates, Chlorates, Permanganates, Molybdates, Selenates as well as As^{3+}, Se^{4+}, Al^{3+}, Ba^{2+}, Cd^{2+}, Cr^{3+}, Fe^{2+}, Mn^{2+}, Zn^{2+} etc. Less toxic are elements which rarely have negative results when their concentration exceeds 1800 mg/l. such elements are: Cl^{-}, Br^{-}, I^{-}, Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, Rb^{+}, Sr^{2+}, Li^{+}, NO_3^{-}, SO_4^{2-} etc.

Toxicity of heavy metals is expressed in a different ways. For instance, Cu and Hg provide inhibition of ferments activity during toxic concentration. These metals form complex admixtures together with organic compounds which have the ability to enter cell membrane. Cd, Pb, Ni, Hg, Be and Ag provide inhibition and damage of ferments – Phosphatase, Catalasa, Oxidasa, Ribonucleasa, which is the main expression of toxic activity of the mentioned metals. Cd, Au, Fe and Cu cause piercing of cell membrane and promote passive absorption of other heavy metals. Al, Fe, Ba have got the ability to produce precipitates by interaction with PO_4^{2-} ions and Chelates complexes by interaction with metabolites by which they hinder their further participation in metabolism.

Some heavy metals hinder absorption of its own analogs by a plant. For instance, Calcium is changed by Strontium, Zinc by Cadmium, by which it is seriously hindered process of development and growth of a plant. Soil factors make influence at phytotoxicity of metals: soil area reaction – pH, changeability of cations, consistency of organic substances, etc. acid is in area conditions for instance pH during 5,5 parameter, phytotoxicity of heavy metals is increased and when pH parameter is increased it is decreased. Toxicity of heavy metals is decreased in soil when organic substances concentration is increased. Agro-technological measures make non-homogenous influence at movement and transformation of heavy metals in soil – taking fertilizers and liming, as well as conditions of servicing plants and environmental conditions – lighting, temperature, humidity. So, it is really difficult to identify phytotoxicity of various metals in soil. From heavy metals Ni, Cd, Zn, Ga are less absorbed by plants rather than Pb, Cr, Hg.

Plumbum is the most dangerous element. It oppresses the plant even when it is represented with low concentration. Concentration of Plumbum in clean soils equals to 2-3 mg/kg in dry mass of a plant. Concentration of it in food must not exceed 10 mg/kg, when in dry mass of plant samples taken near at Highway in Germany Concentration of Plumbum is 7000 mg/kg. Concentration of Plumbum in out leaves of cabbage is somehow high rather than inside leaves. The same is present in roots at the below part of rootlet Plumbum concentration is high. At certain concentration of Plumbum plants can regulate enter of heavy metals at above-ground areas but in high concentration conditions (200 mg/kg and more) they do not have enough capacity. Though, accumulation of heavy metals in plant seeds is a constant and minimal (0,02-0,004%), when it is high in roots and stems and therefore it is 1,2-21 %.

Many researchers consider that root system has an ability to hinder transition of toxic metals ions from roots to phytosynthetic organs of a plant. This should be the reason for low phytotoxicity of Plumbum. Normal concentration of Plumbum in plant is 0,1mg/kg. Normal concentration of it is 0,1-5,0 mg/kg. Oats die when plumbum concentration in soil is 500 mg/kg. Rye is oppressed at non-treated sod-podzolic soil when the concentration of it is 125-250 mg/kg and at treated soils 1000 mg/kg. At Chernozems, fluorine and humus soils when concentration of it is 2000 – 3000 mg/kg.

Plumbum makes influence at every living organism, causes changes in nervous system, blood and tissues, and actively makes effect at protein synthesis, energetic balance of a cell and its genetic apparatus. Organic and inorganic compounds of Plumbum mostly happen in human organism via respiratory system, with small amount from gastrointestinal system and skin. This element is basically accumulated in kidneys, hair, central nervous system and other areas as well. Maximal Permissible Concentration of Plumbum in human blood is 0,5mg/kg. High concentration of it causes the reactions after which haemoglobin is produced. In this case a human suffers from hypoxia and fatigue.

The Scientists has discovered that high concentration of Plumbum in blood and aorta tissues mostly have patients diseased with heart diseases. Plumbum makes influence at central nervous system, in children great amount of inorganic plumbum can lead to mental disorders. Organic admixtures of Plumbum-Tetraethil- and Tetramethyl-lead causes insomnia, nightmares, convulsion and peripheral neurosis. The basic symptoms of Plumbum intoxication by a human is creation of Plumbum layer around the gums, the consistency of basophilic erythrocytes is increased in blood, which supports localization of carcinogenic cells in human organism. Undesirable changes happen in nervous and cardio-vascular system, gastro-intestinal inflammatory processes are deteriorated which to its part causes endocrinological changes.

Cadmium is in the list of the most dangerous pollutants as it has got the great ability to accumulate in human organism. The dissolution period of it continues for more than 20-32 years. Normal concentration of this element in dry mass of a plant is 0,05-0,2 mg/kg, generally it is between the limits of 0,2-0,8 mg/kg, in some plants it achieves 80 mg/kg and even more, which causes decrease of harvest by 25%. Such vegetables as spinach and salad can have 100 mg/kg Cadmium and herewith they may show no signs of intoxication. Highly polluted plants may consist of more than 400 mg/kg of Cadmium.

Different from other elements Cadmium can be accumulated in generative organs with comparatively great amount. In a seed consistency of it is increased up to 0,2-4 mg/kg, in haulm - 0,1-12 mg/kg. During pollution at non-treated sod-podzolic soil start while taking Cadmium with 10 mg/kg at treated soil more than 50-100 mg/kg. While increasing concentration of rye in nutrient solution which contained 0,5-100 mg/l Cadmium, it was identified that while adding Cadmium to the solution ears are not produced any more and 100 mg/kg of it was lateral dosage during which plants died at the age of two months. When Cadmium concentration in soil is 10 %, green mass of a plant was decreased by 50%.

High phytotoxicity of Cadmium is caused by similarity to Zinc of its chemical qualities, so Cadmium may change Zinc in many bio-chemical processes, which will ruin the activity of such ferments as anhydrases, phosphatase and other dehydrases connected to respiratory and other physiological process as well as functions of protheasa and peptidase which participate in protein and nucleic acidic exchanges. As chemical analogue, Cadmium may change Zinc in enzyme system which is necessary for glucose phosphorylation. Changing Zinc with Cadmium in plant organism leads us to revealing signs of lacking Zinc, oppressing the plants and sometimes to death of a plant. Cadmium is easily absorbed by plant unlike to Plumbum and it is not accumulated in root system for a plant, but it is distributed above-ground organisms of it.

According to sensitivity to Cadmium we can classify plants with the following growing order: tomato < oat < salad < field grasses < carrot < radish <beans < peas < spinach. Cadmium happens in human and animal’s organism from the water and food, it is regularly accumulated and time after time transmits to the blood. Basically it is accumulated in kidney and inside secretion ways. It is omitted from human organism with gastro-intestinal tract in USA it was identified that human takes 23-150 mg/kg Cadmium during 24 hours. According to FAO Maximal permissible concentration of a substance equals to 70 mg/kg.

Cadmium Compounds are very toxic. Their high concentration in food causes increase of artery pressure and left wall of heart, accumulation of fats at artery walls, kidney damages and pathological omission of proteins. Cadmium compounds make influence at respiratory system and gastro-intestinal tract. The early symptoms of Cadmium intoxication are creation of yellowish Cadmium layer around gums and tooth, headache, dizziness, losing appetite, pain in stomach, nausea, sense of vomiting, loosing weight, high amount of proteins in urine, a human suffers from pains in pelvis, waist and vertebral area, which is caused by changes in bone tissue.

Pollution sources of biosphere with Mercury compounds are industrial facilities, mineral fertilizers, industrial and agricultural waste and mercury consisting fungicides, which pollute soil, water and air with mercury and then they are involved in plants' food chain. Normal Concentration of Mercury in plant 0,005-0,01 mg/kg. It is between 0,01-0, 2 mg/kg in most of plants. 95 % of it is accumulated in roots and the rest stems and leaves. Maximal permissible concentration of Mercury is 0,1 mg/kg in UK in plants' material, in Denmark - 0,005 mg/kg, in Austria and Ireland - 0,03 mg/kg, in Belgium – 0 mg/kg. In plant, food products produced under sanitation norms must not exceed 2,5 mg/kg.

Transition of Mercury from polluted soil to plant is especially grown compared to the research clean plots: the concentration of toxic substance is increased almost by two times in carrot root vegetable and three times in spinach leaves. Toxicity of Mercury depends on the forms of its compounds. Organic-mineral compounds of it is especially toxic – Methyl-, Dimethyl- and Ethyl-Mercury. Mercury ions and its metal form is less toxic. In vegetation samples by taking 25-37 kg Hg per 1 ha, the harvest of wheat, rye, clover grass have not been decreased. When it is with 50 mg/kg concentration in soil the growing process of plant is reduced, when it is with 1000 mg/kg concentration in soil - the plant is intoxicated and drying out when it happens in blood the mercury joins protein molecule and complexes of less-sustainable metaloproteids are formed which cause dysfunction of central nervous system. Hard intoxication with Mercury causes kidney failure and human death in 5-6 days. During light intoxication the ruined functions will be restores after 2-3 weeks.

The main symptom of Hg intoxication in a human is headache, edema, bleeding from gums and tooth and layer of Mercury Sulfide in gums. Besides, stomatitis is formed, edema of lymph and sialaden, unpleasant taste in mouth, insomnia. First symptoms of Hg intoxication increased fatigue, weakness, dizziness "Mercury Neurosis", herewith, body shimmering, "Mercury stroke". The shimmering starts from hands and then continues to eyelids, tongue, during acute intoxication feet and finally mental excitement is present – "Mercury erethism".

Arsenic expresses toxicity when the concentration of it exceeds 50 mg/kg in soil. Herewith the more is concentration of sesquialteral oxides in soil, the more arsenic is absorbed by plants.

In case the amount of arsenic in soil is with great concentration, there is a small chance of plants' intoxication as they have the ability of removing this element from above-ground organs. The risk of plants' intoxication exists only at light soils while absorbing great amount of this element.

Phytotoxicity of Copper is twice higher rather than Zinc. The reason for toxicity of this element can be revealed at light soils, in the conditions of low concentration of organic substances and reaction of acid area. In cases of Copper intoxication the plants do not give optimal product and during acute intoxication - they have sharp expresses symptoms. Copper pass from soil to a plant very weakly. 12 times increase of this element in soil can lead to 2 times increase of in seeds, tubers and leaves. Long-term usage of pig manure polluted with copper in ranchlands, the agricultural lands are so polluted that feeding sheeps with this grass negatively affects their growth-and development processes. Maximal Permissible Concentration of Cupper for cattle is 15-30 mg/kg and for pigs 250 mg/kg. The concentration of it in foods from cattle-breeding waste equals to 250 mg/kg which increase its concentration in manure.

Taking Strontium soil causes its accumulation in plant thousandth percentage - from a hundredth part. While taking phosphorus-plaster in soil as ameliorator a plant absorbs Strontium more intensively rather than calcium and this way concentration of it in a plant rapidly increases. For instance Strontium concentration in peas has increased by 4 times and calcium only by 1,44 times. The same happens in oat - 4,7 times and 1,3 times. Strontium is characterized by very low phytotoxicity, which can be explained by small correlative atomic mass (38). Despite this fact while systematically-taking foods polluted with Strontium, humans and animals are diseased by "Urov Disease", which is expressed in curvature of bones, breaking them, creation of formations and losing movement ability. This is caused by changing calcium by Strontium in bone tissue which by high capacity of movement cannot be in bone tissue and it causes bone fragility.

Toxic influence at plant in acid soil and anaerobic conditions can be expressed Mn^{2+} and Fe^{2+} ions. Manganese phytotoxicity is high to 5,5 when pH is low. When pH is high to 5,7 phytotoxicity is decreased as it is transformed from Mn^{2+} to Fe^{2+}. The Symptoms of Mn intoxication was identified at many plants, especially in the areas where soil is strongly acid. For instance, 20 mg/kg Manganese concentration can be the cause of diseasing the apple plant root system with necrosis. High concentration of this element can oppress the potato (when it is 700 mg/kg Mn^{2+} in its tassel). Cabbage is the most sensitive towards high concentration of Manganese, red clover and sugar beets have average sensitivity towards it. Manganese makes influence at basal ganglion of cerebral brain; it causes instable walking, disorder of mimics and reminds symptoms of Parkinson's disease.

Nickel is essential for feeding the plant with small amounts. Phytotoxicity of it is revealed when it is 50 mg/kg in acid soils. This element is easily absorbed and for this reason, it can be more in plant than in soil. 80-100 mg/kg of Nickel is discovered in rye and in potato tassel 17,5 mg/kg.

Zinc and Cobalt makes negative influence on plants, humans and animals. Phytotoxicity of Zync is revealed only when its concentration is increased in soil up to 400-700 mg/kg - at low absorption capacity soils and when it is 2000 mg/kg at soils having high absorption capacity. The toxicity signs is visible when Zn and Co is 300-500 mg/kg in tissue. Zinc concentration in poor parts of plant with chlorophyll equals to 7-27 mg/kg in dry substance and in parts rich in chlorophyll it is40 – 95 mg/kg. In cereals-wheat crops concentration of it is low rather than in legumes.

Correct selection and reasonable usage of norms, terms and tools of mineral and organic fertilizers gives possibility to maintain soil fertility at necessary level, to have good harvest and to avoid soil and food products pollution with toxic elements and compounds, when their concentration does not exceed Maximal Permissible Concentration (PMC) norms.

Absorption of heavy metals by plants depends on their biological peculiarities first of all at changing capacity of cations. Absorption of heavy metals takes place with metabolic and non-metabolic ways between tham correlation is changed according to soil properties. For instance, in absorption process of Pb, Cd, Cu, Li passive changing is present and in absorption processes Zn and Mn is present with active and passive ways. Passive absorption of heavy metals can be explained by ruining cell membrane structure during high concentration of them inc ell which supports happening of more heavy metals in plant through diffusion. Besides roots, a plant can assimilation heavy metals without them as well - with the help of leaves on which they happen from atmosphere together with dust. In recent years information was published abroad about the fact that feeding birds and animals with nutrition products consisting of toxic substances causes degradation of their genotype.

After heavy metals enter plant, a plant itself has three protecting barrier at boarders of soil-root, root – stem, stem – reproductive organs. The biggest amount of heavy metals is accumulated in roots, where chelation process is on while ions of heavy metals enter plant by formation of organic complexes. For this reason consistency of their movable parts decreased and with this action the first barrier limits transmission of them in shoots. To its part even in shoots it is limited transmission of heavy metals in reproductive organs, where they are found by the smallest mount. Metal-Thionin has the regulation function of these metals' concentration in cell. Metal-Thionin is low-molecular weight protein rich in sulfur which unifies Pb, Cd, Hg, Zn, Cu, Ag. This explains the fact that for instance while increasing amount of Mercury by 100 times (to 10 mg/kg) in soil, the plant can absorb it with small amount and moves even smaller amount of it in above ground areas.

In order to prevent pollution of plant products, the basic part of polluters are transformed into less movable and hardly absorptive forms. For this reason, soils polluted with heavy metals are fed by lime, fluorine and other organic fertilizers. Application of mineral and organic fertilizers reduces toxicity of heavy metals. For instance, application of nitrogen fertilizers removes toxicity of Pb, As, Cu in plant. And application of phosphorus fertilizers removes toxicity of Cd, Pb, Cu, Ni, Zn.

Wild plants are more stable towards heavy metals compared to cultural crops. Hence, after several harvest of them in polluted areas their concentration can be importantly reduced in in cultural crops to be harvested in the future. Mangolds, Carrots and Potatoes are more stable toward heavy metals from cultural crops. At highly polluted soils, in these crops concentration of heavy metals is more by 7-21 times rather than in ecologically safe products. Therefore, these crops can be used for cleansing polluted soils with heavy metals.

The role of transpiration is quiet high in reducing toxic influence of heavy metals in plant. A plant evaporates not only Cl, Na, K in atmosphere together with water but Hg, Zn, Pb as well. This process can be considered as one of the ways of removing toxic substances by a plant together with water. Increasing Ni concentration in a plant is resulted into reduction of Ca and Mg in plant leaves. Increasing Mg concentration in solution can prevent toxic activity of Ni. This was the method how the negative activities of one element were improved by increasing second element concentration in a substrate. The influence of fertilizers at environmental pollution is quiet insignificant compared to entrepreneurial and agricultural industry and negative sides of their activities are present only when they are misapplied. For recultivation of chemically polluted soils in industrial zones it is necessary to carry the whole set of measures, starting from chemical transformation of difficult soluble compounds of toxic substances and enriching soils with organic substances and ended with agro-technological, melioration and other kinds of activities.

I.6 Legislative Acts of Georgian Government about Sanitary Protection of Soils. Evaluation of Chemical Pollution Quality of Soil

The risk of soil pollution is determined by potential negative influence level on environment (water, air) nutritious products and directly or indirectly on a human as well as activity of soil and self-cleaning processes. Soil research results are foreseen in the following cases: for determination and forecasting of risk quality in populated areas for residential conditions and health of population, for elaboration of rehabilitation re-cultivation measures, prophylactics of infectious and non-infectious diseases, regional planning, technical resolutions for protection and rehabilitation of water-catchment areas, in the frames of nature protection complex programs for consequential solution of issues, evaluation of rehabilitation and hygienic – ecological measures efficacy and sanitation controlling of facilities which have direct or indirect influence on surrounding conditions.

Applying joint methodical approach will support creation of assumed data while evaluating soil pollution quality. Evaluation of soil pollution risk in populated areas are by determined the following:

a) Epidemic aspect;

b) Its role as secondary source of above-ground layer of atmospheric air and during direct communication with a human;

Chemical pollution of soil – is changing chemical consistency of soil, caused by direct and indirect influence of land-usage factors (industrial, agricultural, communal), which causes quality decrease and creation of potential risk for population health. Buffering capacity of soil – is soil capacity to maintain its chemical conditions to unchanged levels during influence of chemical substances flow on it.

Background concentration (pollution) - consistency of chemical substances in territories of soil, which have no technogenic effects or have it but with minimal amount. Priority component of soil pollution - is substance or biological agent, which primarily is under control.

Maximal permissible concentration of chemical substances in soil (MPC) - is complex consistency of parameters of chemical substances in soil, which is not dangerous for a human. The used criterion for grounding these parameters, reflect possible ways for activities of pollutant on contact environment at biological activity and self-cleaning processes of soil. Grounding MPC of chemical substances in soil is based on 4 main parameters, which are set experimentally:

a) Trans-locational – transmission of substances from soil to plant;

b) Water-emigrational – transmission of substances from soil to ground waters and springs;

c) Air-emigrational – transmission of substances from soil to atmospheric air;

d) general-sanitary parameters – implies influence of pollutant at self-cleaning capacity of soil and biological activity of it.

Herewith, each step is evaluated quantitatively by grounding permissible level of substances and each parameter of toxicity. From set norms of concentration the lowest one – is balanced one and it is accepted as MPC.

The basic criterion for hygienic evaluation of soil pollution by chemical substances is MPC and OPC of chemical substances in soil:

MPC – is Maximal Permissible Concentration of pollutants;

OPC – is Orientation Permissible Concentration of substance.

Evaluation of soil pollution risk quality with chemical substances takes place according to certain substances foreseeing the following regularity.

a) Pollution risk is high, if actual consistency of soil pollutant component is much higher to MPC which can be expressed in coefficient K_0=C/MPC (C - is a concentration of pollutant component); so the more exceeds K_0 to one (K_0>1) the higher pollution risk is;

b) The more is controlling substance risk class its sustainability, solubility in water, movement capacity in soil and depth of polluted layer, the higher is Pollution risk;

c) Pollution risk is high in case, if soil buffer capacity is reduced, which depend on mechanical consistency, concentration of organic substances and soil acidity. The lower humus concentration, pH and lighter its mechanical consistency, the more dangerous is soil pollution with chemical substances;

d) During soil pollution with one substance of inorganic nature the quality of it is evaluated according to 12 Table, foreseeing risk class of pollutant component, maximal permissible concentration (**$K_{max.}$**) of its MPC and element consistency according to one from.

Table 12

Criterion for Soil Pollution Quality Evaluation with Inorganic Substances

Concentration in soil, mg/kg	**Soil Pollution Category**		
Substance Risk Class	***1 Class***	***2 Class***	***3 Class***
> **$K_{max.}$**	Very Strong	Very Strong	Strong
From MPC – to **$K_{maximal}$**	Very Strong	Strong	Average
From background importance - to MPC	Weak	Weak	Weak

Table 13

Polluting Sources of Environment with Heavy Metals

Pollution Source	Black and non-ferrous metallurgy				Instrumental engineering			Mechanical engineering				Chemical industry		Auto-transportation
	A	B	C	D	E	F	G	B	C	D	E	L	M	N
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Chromium	W	W	W				W	W	W	W				
Vanadium	O	O	O		O	O		O	W	O	O			
Zinc	O	O	O	O		O	O	O	O	O	O	W	O	O
Nickel	O				W		W	W	W	W	W			
Copper	W	O		O	W	W	O	W	W	W	W	W		O
Plumbum	W	O	O	O	O	W	O	O	W	O	O		W	O
Cobalt	O						W							
Arsenic														
Molybdenum	O	O					W	W	O					
Cadmium	O	O	O			O							O	O
Selenium														
Mercury				O	W					W	O	O		
Tin	W	O	W		O	O		O	W	W	W		O	
Stibiy		O	O			W						W		
Silver						W						W		
Bismuth						W	W	W	W				W	

Note: **"O"** – obligatory control;

"W" – facultatory control;

Industry: **A** – Alloyed metal factory;

B – Non-ferrous metals factory;

C – Alloyed metals factory;

D – secondary Non-ferrous metals processing;

E – Producing acumulators;

F – Producing radiators;

G – electric-technical production;

H– Certain mechanical engineering;

I – Manufacturing household goods;

J – Heavy machine building;

K – Light machine building;

L – Manufacturing plastic material;

M – Manufacturing lacquer- paints;

N – Network of Auto-roads and petrol stations.

The pollution risk with any toxicants must be evaluated foreseeing soil buffer capacity as it influences on movement of chemical elements and determines their influence at absorption capacity of plants and contact environment factors. The less buffer qualities has a soil the higher is risk of chemical pollution. Hence, when K_0 has the same importance there is higher pollution risk in soils having acid pH, less humus and light mechanical concentration. For example if the K_0 importance of Sod-Podzolic clayey, Sod-Podzolic sandy and Chernozem soils is equal, these soils will have the following row according to risk growth: 1<2<3.

Table 14

MPC of Inorganic Chemical Substances in Soil and Permissible Levels of Their Concentrations according to Malignancy Levels

Title of Substances	**MPC of Soil Substances foreseeing background, mg/kg**	**Malignancy Parameters Levels (K_1- K_4) and maximal – ($K_{max.}$), mg/ kg**				**Risk class**
		Trans-locational (K_1)	**Migrational**		**General Sanitary (K_4)**	
			Water (K_2)	**Air (K_2)**		
Cu	3	3,5	72	–	3	2
Cr	6	666	6	6	6	2
Ni	4	6,7	14	–	4	2
Zn	23	23	200	–	37	1
Co	5	25	1000	–	5	2
F	10	10	10	–	25	1
Sb	4,5	4,5	4,5	–	50	2
Mn	1500	3500	15000	–	1500	2
V	150	170	350	–	150	3
Pb	32	35	260	–	32	1
As	2	2	15	–	10	1
Hg	2,1	2,1	33,3	2,5	5	1

Table 15

List of Pollution Sources and Chemical Elements, which are Accumulated in the Influence Zones of These Sources

Type Industry	Industrial Facilities	Chemical elements	
		Priority	Secondary
Non-Ferrous Metallurgy	Production of non-ferrous metals from directly source and concentrations	Pb, Zn, Cu, Ag	Sn, Bi, As, Cd, Sb, Hg, Se
	Secondary procession of non-ferrous metals	Pb, Zn, Sn, Cu	Hg
	Production of firm and calcitrant non-ferrous metals	W	Mo
	Production of Titanium	Ag, Zn, Pb,B, Cu	Ti, Mn, Mo, Sn, V
Black Metallurgy	Production of alloyed metals	Co, Mo, Bi, W, Zn	Pb, Cd, Cr, Zn
	Production of irons	Pb, Ag, As, Tl	Zn, W, Co, V
Machine Building and Metals' Processing Industry	Factory of thermal processing of metals (without foundry)	Pb, Zn	Ni, Cr, Hg, Sn, Cu
	Production of accumulators, tools for electro-technique and electronic industry	Pb, Ni, Cd	Sb, Pb, Zn, Bi
Chemical Industry	Production of super-phosphate fertilizers	Sr, Zn, F, Ba	Cu, Cr, As, Y
	Production of plastic materials	Sulfur compounds	Cu, Zn, Ag
Building materials industry	Production of cements (accumulation of proper elements may happen during using wastes from metallurgy manufacturing processes)	Ba	Hg, Zn, Sr
Polygraph industry	Font factory and typography		Pb, Zn, Sn
Firm everyday waste used as fertilizers in big cities		Pb, Cd, Sn, Cu, Ag, Sb, Zn	Hg
Sediments from used waters in sewage system		Pb, Cd, V, Ni, Sn, Cr, Cu, Zn	Hg, Ag
Polluted irrigation waters		Pb, Zn	Cu

Table 16

Estimated Permissible Concentrations of Heavy Metals in Soils with various Physical-chemical Qualities (General Concentration, mg/kg)

Name of Substances	Soil Group	Orientation Permissible Concentration Foreseeing Background	Aggregate conditions of substances in soils	Risk Class	Peculiarities of influencing human organism
Ni	a) sandy and sand b) Acid (clay and claye) pH KCI<5,5 c) almost neutral and neutral (clay and claye) pH KCI<5,5	20 40 80	Solid: In the face of salts, in sorbed form, in the consistency of minerals.	**2**	Less toxic for mammals and humans, inhibitor of oxidase. It is characterized by mutagenic activity
Cu	a) sandy and sand b) Acid (clay and claye) pH KCI<5,5 c) almost neutral and neutral (clay and claye) pH KCI<5,5	33 66 132	Solid: In the face of salts, Organo-mineral compounds in sorbed form, in the consistency of minerals	**2**	Increases capacity of cell absorption, inhibitor of glutathione reductasa, it ruins metabolism and reacts with –SH , $–NH_2$ and –COOH groups
Zn	a) sandy and sand b) Acid (clay and claye) pH KCI<5,5 c) almost neutral and neutral (clay and claye) pH KCI<5,5	55 110 220	Solid: In the face of salts, Organo-mineral compounds in sorbed form,in the consistency of minerals	**1**	Lack or excess causes development deviations.
As	a) sandy and sand b) Acid (clay and claye) pH KCI<5,5 c) almost neutral and neutral (clay and claye) pH KCI<5,5	2 5 10	Solid: In the face of salts, Organo-mineral compounds in sorbed form, in the consistency of minerals	**1**	Toxic substances, it causes inhibition of various ferments, it makes negative influence on metabolism. It is characterized by potential cancerogenic activity
Cd	a) sandy and sand b) Acid (clay and claye) pH KCI<5,5 c) almost neutral and neutral (clay and claye) pH KCI<5,5	0,5 1,0 2,0	Solid: In the face of salts, Organo-mineral compounds in a sorbed form, in the consistency of minerals	**1**	Strongly toxic substance, it blocks ferments of sulfate - hydrating groups, Ruins changeability of iron and calcium, ruins Deoxyribonucleic acid synthesis
Pb	a) sandy and sand b) Acid (clay and claye) pH KCI<5,5 c) almost neutral and neutral (clay and claye) pH KCI<5,5	32 65 130	Solid: In the face of salts, Organo-mineral compounds in a sorbed form, in the consistency of minerals	**1**	It is characterized by multiple negative activities, it blocks SH groups of protein, it inhibits ferments, causes intoxication

Table 17

Land Plots Classification according to Agricultural Usage and Requirements towards Soil Pollution Levels

Category	Application	Requirement
1	Households, vegetable gardens, coastline territories, children's' and treatment institutions	High
2	Agricultural land plots, recreation zones.	Increased
3	Forests, big agricultural facilities, buildings of industrial zone of city	Average

Evaluation of soil pollution risk for agricultural plants cultivation mostly is carried according to trans-locational parameter of malignancy. It represents one of the most significant parameters in soil for identification of chemical substances MPC. It is caused by the following reasons:

a) Averagely 70 % of chemical substances happen in human organism from plant nutritious products;

b) Trans-location level determines level of toxicants accumulation and makes influence at product quality.

The difference between chemical substances MPC gives the possibility to issue recommendations about practical application of soils of polluted territories and the basic data in differentiation to polluted soils risk quality to be evaluated (Table 18).

Table 18

Principal Ealuation Scheme of Agricultural Soils with Polluted by Chemical Substances

Pollution Category	Pollution Parameter	Potential Application	Measures to be carried
1. Permissible	Concentration of substances exceed background level but is less than MPC in soil	Used without limitations for any crops	Decrease of influence level of pollution source. Carrying measures for reduction of entrance capacity of toxicants in plants (fertilizing with lime, using organic fertilizers)
2.Averagely Dangerous	Concentration of chemical substances exceed MPC according to limitative, general –hygienic, water-migrational and air-migrational parameters but is lower to permissible concentration according to the trans-locational parameter	Used for any crops by the conditions if there is control at agricultural product quality	Measures similar to the I-st category
3. Dangerous	Concentration of substances exceed MPC according to malignancy limitative trans-locational parameter	Used for technical crops not for agricultural crops	1) Despite the measures necessary for the I-st category, necessary controlling toxicants concentration in plants, nutritious products and animal's products; 2) In case of necessity during plant nutritious products harvest it is recommended to mix them with nutritious products harvested at clean soils. 3) Limitations in using great mass of animals food
4. Highly Dangerous	Concentration of substances exceed MPC according to all malignancy parameters	Used for technical crops, it is permissible in forest protection line	Measures for reduction pollution level and restricting toxicants in soil. Controlling toxicants concentration in working area of agricultural workers and in local spring waters.

Chapter II. Experimental Part

II.1 Study of Territories alongside Central Highway of Western Georgia (Sarpi-Kobuleti section)

Gonio section of research area is 2 km, the road is very crowded, the road cover is made of asphalt; 1 km of road is alongside coastline, where there is no population and there are only touristic buildings and constructions, and at 1 km’s length at both sides there are located agricultural land plots (Fig. 1- 7).

Fig.1

Fig. 2

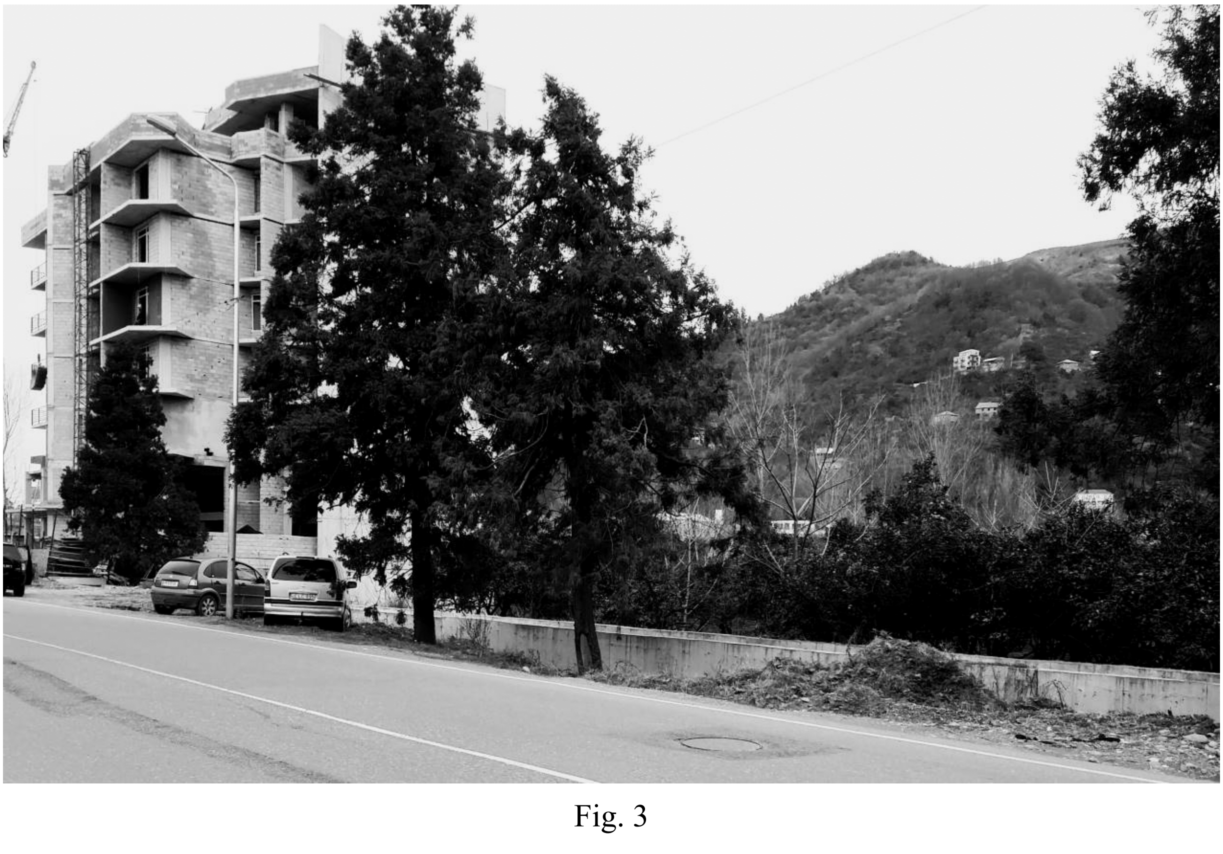

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Urekhi Section of Research facility is 1 km, the road is very crowded, the road cover has very bad quality (refurbishment works are on), agricultural lands are located at both sides of a road (Fig. 8-11).

Fig. 8

Fig.9

Fig. 10

Fig. 11

Makhinjauri Section of Research facility is 1 km, the road is very crowded, the road cover is made of asphalt; 1 km of road is alongside coastline, where the right part of a road is populated and there are located agricultural land plots (Fig. 12-14).

Fig. 12

Fig. 13

Fig. 14

The Road Structure of Central Highway Sarpi-Poti-Senaki, Sarpi-Kobuleti Section (Gonio, Urekhi, Makhinjauri) is shown in Table 19.

Table 19

Road Structure of Central Highway Sarpi-Poti-Senaki, Sarpi-Kobuleti Section (Gonio, Urekhi, Makhinjauri)

Road section	Distance, km	Road Load	Road Coverage	Sea Coastline, km	Populated area, km
Gonio	2	Strong	Good	1	1
Urekhi	1	Strong	Bad	-	1
Makhinjauri	1	Strong	Good	1	1

Various types of vehicles spend various amount of fuel. Light vehicles which spends 8 litres of fuel per 100 km omits 2,4 gr. Plumbum. Vehicles which use 16 litres of fuel per 100 km omits 4,8 gr. Plumbum. Big trailers which use 25 litres of fuel per 100 km emit 7,5gr. Plumbum and extra-big trailers which use 35 litres of fuel per 100 km omits 10,5 gr. Plumbum. During 24 hours 10320 units of vehicles drive at highway. While 1 litres of fuel is used 200-400 gr. Plumbum is omitted in the air. The fuel used per 100 km by the above-stated vehicles is averagely 16 litres and the amount of omitted Plumbum is 5 gr. Per 24 hours (Fig. 15-21).

Fig. 15

Fig. 16

Fig. 17

Fig. 18

Fig. 19

Fig. 20

Fig. 21

The types and intensity of vehicles at central highway is shown in Table 20.

Table 20

Intensity of Vehicles at Central Highway

Object	Type of Transportation,	Recording		Average	%
		Morning	Evening		
Gonio	Light	80	100	90	60
	Truck	50	70	60	40
Sum				150	100
Urekhi	Light	90	90	90	69,23
	Truck	40	40	40	30,77
Sum				130	100
Makhinjauri	Light	100	100	100	66,67
	Truck	50	50	50	33,33
Sum				150	100

From chemical qualities of soil we have studied soil area reaction, humus, concentrations of Cadmium and Plumbum at 5, 20 and 50 meters length from highway (Tables 21, 22, 23).

In soil area reaction the consistency of nutritious elements is changed: in acid soils the solubility of iron, aluminium and manganese compounds is increased and these elements are absorbed by plants with toxic amount which causes plant development defects.

In samples at 5 meters far from highway pH is decreased somehow in the depth and it is 4,25 from to 4,53 - in Gonio; in Urekhi - from 4,34 to 3,94, in Makhinjauri - from 5,3 to 4,6. Hence, the soils we have carried research on are weakly acid.

As it is known one of the main parameters of soil productivity is soil humus, the high concentration of which promotes suitable conditions for growth-development and feeding of plants. In soil samples we have carried research on, the humus concentration is average and it is decreased in the depth: in Gonio - from 4,8-4 to 3-3,7%; in Urekhi - from 4,6-4 to 2-3,4%; in Makhinjauri - from 4,8-4 to 5-4,1%.

Cadmium and Plumbum concentrations in soils were studied in the mentioned territories. The concentration of Cadmium is from 22 mg/kg to 23, its concentration is increased according to the depth and almost in all three zones is similar; concentration of Plumbum is high in all three zones and maximal concentration of Plumbum is in Makhinjauri in 5 meters distance from highway – 160-162,6mg/kg (Table 21).

Table 21

Chemical qualities of Soils at 5 Meters Distance from highway

Research Object	Soil Type	Soil Layer Depth, cm	pH in KCI Juice	Humus, %	Cd, mg/kg	Pb, mg/kg
Gonio	Red Soil	10	4,53	4,8	22,1	132
		20	4,44	4,3	22,6	132,2
		40	4,25	3,7	22,7	132,4
Urekhi	Red Soil	10	4, 34	4,6	22,2	142
		20	4,24	4,2	22,5	142,5
		40	3,94	3,4	22,8	143
Makhinjauri	Red Soil	10	5,3	4,8	22, 7	160
		20	4,8	4,5	22,8	162
		40	4,6	4,1	23	162,6

In soil samples at 20 meters distance from highway pH is decreased in the depth somehow: in Gonio – from 4,56 to 4,24; in Urekhi - from 4,37 to 3,95; in Makhinjauri from 5,6 to 4,7. Hence soils in these territories are weakly acid.

In samples of examined soils humus concentration is average and it is decreased it he depth: in Gonio – from 4,8-4 to 3-3,7%; in Urekhi from 4,6-4 to 2-3,4%; in Makhinjauri from 4,8-4 to 5-4,1%. Hence, humus concentration in territories at 5 and 20 meters distance from highway is almost similar.

Concentration of Cadmium at 20 meters distance from Highway is from 22,5 mg/kg to 22,8 mg / kg, it is increased according to the depth and almost in all three zones it has the same amount; concentration of Plumbum in all three zones is high, but maximal concentration is fixed in Makhunjauri at 20 meters distance from highway 163-163,6 mg/kg (Table 22).

In soil samples at 50 meters distance for highway pH in the depth is decreased: in Gonio – from 4,7 to 4,3; in Urekhi - from 4,6 to 4,1; in Makhinjauri - from 5,7 to 4,6. Hence soils in these territories are weakly acid.

In samples of examined soils humus concentration is average and it is decreased it he depth: in Gonio – from - 4,78-4,54 to 3,67%; in Urekhi - from 4,56-4,32 to 3,45%; in Green Cape - from 4,84-4,53 to 4,16%. Hence, humus concentration in territories at 5 and 20 meters distance from highway is almost similar. Hence, humus concentration is similar like in territories far from 5 and 20 meters distance from the highway.

Table 22

Chemical qualities of Soils at 20 Meters Distance from highway

Research Object	Soil Type	Soil Layer Depth, cm	pH in KCI Juice	Humus, %	Cd, mg/kg	Pb, mg/kg
Gonio	Red Soil	10	4,56	4,82	22,5	134
		20	4,45	4,36	22,7	134,5
		40	4,24	3,77	22,8	134, 8
Urekhi	Red Soil	10	4, 37	4,64	22,4	143
		20	4,24	4,28	22,5	143, 3
		40	3,95	3,44	22,6	143,5
Makhinjauri	Red Soil	10	5,6	4,84	23	163
		20	4,9	4,53	23,3	163,4
		40	4,7	4,18	23,4	163,6

Cadmium concentration was decreased at 50 meters distance from highway and it is from 21 mg/kg to 21,7 mg/kg, its concentration in the depth is not changed and in all three zones is similar; in all three zones Plumbum concentration is quiet high, but it is lower than in soil samples taken from 5 and 20 meters distance from highway and it is between 115 mg/kg to 141,5 mg/kg (Table 23).

Therefore, by studying soil qualities and heavy metals (Cd, Pb) concentration in them we have identified that in the territories at 5, 20 and 50 meters distance from the highway soil pH and humus concentration is almost similar. As for Cadmium and Plumbum concentrations here we see the following: Cd concentration in all three locations and at 5, 20 and 50 meters distance from the highway is almost similar; Pb concentration at 5 and 20 meters distance from the highway is almost similar and at 50 meters distance it decreases.

Table 23

Chemical qualities of Soils at 50 Meters Distance from highway

Research Object	Soil Type	Soil Layer Depth, cm	pH in KCI Juice	Humus, %	Cd, mg/kg	Pb, mg/kg
Gonio	Red Soil	10	4,7	4,78	21	115
		20	4,5	4,33	21,3	115,3
		40	4,3	3,67	21,5	115,5
Urekhi	Red Soil	10	4, 6	4,56	21,4	120
		20	4,26	4,32	21,5	121
		40	4,1	3,45	21,6	121,5
Makhinjauri	Red Soil	10	5, 7	4,84	21,5	140
		20	4,74	4,53	21,6	141
		40	4,66	4,16	21,7	141,5

II.2 Studying Concentration of Toxicants (Cd, Pb) in Crops in Central Highway Territories. Determination of Crops Quality at Research objects

After analysis of soil qualities and determination of Cadmium and Plumbum in these soils, we have studied concentrations of toxicants in plants at all three zones and at various distances from the highway (5, 20 and 50 meters).

As 24, 25, 26 Tables show, concentration of toxicants - Cd, Pb in crops in Gonio research territories at various distances from the highway (5, 20 and 50 meters) is various and their concentration are decreased far from highway.

Cadmium concentration in potato from 5 and 20 meters distance from the highway is decreased - by 33,3% and at 20 and 50 meters distances - by 50 %;

In tomato from 5 and 20 meters distance from the highway is decreased - by 50% and at 20 and 50 meters distances - by 13,3%;

In tangerine fruit from 5 and 20 meters distance from the highway concentration is not changed and at 20 and 50 meters distances - by 28,6 %;

In corn seed from 5 and 20 meters distance from the highway is decreased - by 6,5 % and at 20 and 50 meters distances - by 33,3%;

In Pkhali from 5 and 20 meters distance from the highway is decreased - by 60% and at 20 and 50 meters distances - by 81,81 %.

Plumbum Concentration in potato from 5 and 20 meters distance from the highway is decreased - by 40 % and at 20 and 50 meters distances - by 60%;

In tomato from 5 and 20 meters distance from the highway is decreased - by 8,33% and at 20 and 50 meters distances - by 9,1 %;

In tangerine fruit from 5 and 20 meters distance from the highway is decreased - by 33,3% and at 20 and 50 meters distances - by 50 %;

In corn seed from 5 and 20 meters distance from the highway is decreased - by 4,4% and at 20 and 50 meters distances - by 84,8%;

In Pkhali from 5 and 20 meters distance from the highway is decreased - by 14 % and at 20 and 50 meters distances - by 69,8 %.

Table 24

Studying Concentration of Toxicants (Cd, Pb) in Crops in Gonio Research object at 5 Meters Distance from Highway

Plants	Cd, mg/kg	Pb, mg/kg
Potato	0,006	0,05
Green onion	Trace	Trace
Tomato	0,0015	0,012
Tangerine fruit	0,0014	0,003
Corn (seed)	0,0016	0,09
Pkhali	0,005	0,05

Table 25

Studying Concentration of Toxicants (Cd, Pb) in Crops in Gonio Research object at 20 Meters Distance from Highway

Plants	Cd, mg/kg	Pb, mg/kg
Potato	0,004	0,03
Green onion	Trace	Trace
Tomato	0,0013	0,011
Tangerine fruit	0,0014	0,002
Corn (seed)	0,0015	0,086
Pkhali	0,002	0,043

Table 26

Studying Concentration of Toxicants (Cd, Pb) in Crops in Gonio Research object at 50 Meters Distance from Highway

Plants	Cd, mg/kg	Pb, mg/kg
Potato	0,002	0,012
Green onion	Not fixed	Not fixed
Tomato	0,001	0,01
Tangerine fruit	0,001	0,001
Corn (seed)	0,001	0,013
Pkhali	0,0011	0,013

As 27, 28, 29 Tables show, concentration of toxicants - Cd, Pb in crops in Urekhi research territories at various distances from the highway (5, 20 and 50 meters) is various and their concentration are decreased far from highway.

Cadmium concentration in potato from 5 and 20 meters distance from the highway is decreased by 3,125 % and at 20 and 50 meters distances - by 9,7%;

In tomato from 5 and 20 meters distance from the highway is decreased by 11,11% and at 20 and 50 meters distances - by 11,1%;

In tangerine fruit from 5 and 20 meters distance from the highway is decreased by 11,76% and at 20 and 50 meters distances - by 20 %;

In corn seed from 5 and 20 meters distance from the highway is decreased by 17,64 % and at 20 and 50 meters distances - by 7,14%;

In Pkhali from 5 and 20 meters distance from the highway is decreased by 3,7% and at 20 and 50 meters distances - by 11,54 %.

Plumbum Concentration in potato from 5 and 20 meters distance from the highway is decreased by 3,7 % and at 20 and 50 meters distances by 9,6 %.

In tomato from 5 and 20 meters distance from the highway is decreased by 13,3% and at 20 and 50 meters distances by 15,38 %.

In tangerine fruit from 5 and 20 meters distance from the highway is decreased by 12,5 % and at 20 and 50 meters distances by 11,43 %.

In corn seed from 5 and 20 meters distance from the highway is decreased by 2,2% and at 20 and 50 meters distances by 7,6 %.

In Pkhali from 5 and 20 meters distance from the highway is decreased by 5,36% and at 20 and 50 meters distances by 11,3 %.

Table 27

Studying Concentration of Toxicants (Cd, Pb) in Crops in Urekhi Research object at 5 Meters Distance from Highway

Plants	Cd, mg/kg	Pb, mg/kg
Potato	0,0064	0,054
Green onion	Trace	Trace
Tomato	0,0018	0,015
Tangerine fruit	0,0017	0,004
Corn (seed)	0,0017	0,094
Pkhali	0,0054	0,056

Table 28

Studying Concentration of Toxicants (Cd, Pb) in Crops in Urekhi Research Facilities at 20 Meters Distance from Highway

Plants	Cd, mg/kg	Pb, mg/kg
Potato	0,0062	0,052
Green onion	Trace	Trace
Tomato	0,0016	0,013
Tangerine fruit	0,0015	0,0035
Corn (seed)	0,0014	0,092
Pkhali	0,0052	0,053

Table 29

Studying Concentration of Toxicants (Cd, Pb) in Crops in Urekhi Research object at 50 Meters Distance from Highway

Plants	Cd, mg/kg	Pb, mg/kg
Potato	0,0056	0,047
Green onion	Not fixed	Not fixed
Tomato	0,0011	0,011
Tangerine fruit	0,0012	0,0031
Corn (seed)	0,0013	0,085
Pkhali	0,0046	0,047

As 30, 31, 32 Tables show, concentration of toxicants - Cd, Pb in crops in Makhinjauri research territories at various distances from the highway (5, 20 and 50 meters) is various and their concentration are decreased far from highway similar to previous locations.

Cadmium concentration in potato from 5 and 20 meters distance from the highway is decreased by 2,98 % and at 20 and 50 meters distances - by 4,62%;

In tomato from 5 and 20 meters distance from the highway is decreased by 10 % and at 20 and 50 meters distances - by 22,2%;

In tangerine fruit from 5 and 20 meters distance from the highway is decreased by 15 % and at 20 and 50 meters distances - by 23,5 %;

In corn seed from 5 and 20 meters distance from the highway is decreased by 15,79 % and at 20 and 50 meters distances - by 25%;

In Pkhali from 5 and 20 meters distance from the highway is decreased by 3,57 % and at 20 and 50 meters distances - by 5,6 %.

Plumbum Concentration in potato from 5 and 20 meters distance from the highway is decreased by 5,26 % and at 20 and 50 meters distances - by 5,6 %;

In tomato from 5 and 20 meters distance from the highway is decreased by 17,64 % and at 20 and 50 meters distances - by 21,4 %;

In tangerine fruit from 5 and 20 meters distance from the highway is decreased by 6% and at 20 and 50 meters distances - by 8,51%;

In corn seed from 5 and 20 meters distance from the highway is decreased by 3,13% and at 20 and 50 meters distances - by 13,97 %;

In Pkhali from 5 and 20 meters distance from the highway is decreased by 5,17% and at 20 and 50 meters distances – by 9,09 %.

Table 30

Studying Concentration of Toxicants (Cd, Pb) in Crops in Makhinjauri Research object at 5 Meters Distance from Highway

Plants	Cd, mg/kg	Pb, mg/kg
Potato	0,0067	0,057
Green onion	Trace	Trace
Tomato	0,002	0,017
Tangerine fruit	0,002	0,005
Corn (seed)	0,0019	0,096
Pkhali	0,0056	0,058

Table 31

Studying Concentration of Toxicants (Cd, Pb) in Crops in Makhinjauri Research object at 20 Meters Distance from Highway

Plants	Cd, mg/kg	Pb, mg/kg
Potato	0,0065	0,054
Green onion	Trace	Trace
Tomato	0,0018	0,014
Tangerine fruit	0,0017	0,0047
Corn (seed)	0,0016	0,093
Pkhali	0,0054	0,055

Table 32

Studying Concentration of Toxicants (Cd, Pb) in Crops in Makhinjauri Research object at 20 Meters Distance from Highway

Plants	Cd, mg/kg	Pb, mg/kg
Potato	0,0062	0,051
Green onion	Trace	Trace
Tomato	0,0014	0,011
Tangerine fruit	0,0013	0,0043
Corn (seed)	0,0012	0,086
Pkhali	0,0051	0,05

After identification of toxicants concentrations - Cd, Pb in research objects, it was necessary to prove their existence in products made from the mentioned plants. To this end, concentrations of - Cd, Pb in plant products from all three facilities at various distances were determined (Table 33). The Table shows that Cadmium and Plumbum in products produced from plants taken at research territories is lower to MPC but anyway their existence in products is not excluded. Therefore, it is strictly forbidden to take them in raw.

Table 33

Concentration of Toxicants (Cd, Pb) in Plant Products at Research objects

Products	Cd, mg/kg	Pb, mg/kg
Potato boiled	0,001	0,012
Tomato pasta	0,001	0,01
Tangerine Juice	0,003	0,004
Corn Flour	0,001	0,02
Pkhali Boiled	0,001	0,01

II. 3 Peculiarities of Plumbum Pollution of Agricultural Lands along the Highway

Protection of environment and agro-bio-diversity is one of the most actual problems of nowadays. It has gone far beyond the boundaries of a certain country and became a subject of interest of broad international societies. Ecological conditions of agricultural crops and products received from them depend on pollution nature and quality of atmosphere, soil and water. One of the anthropogenic pollution sources of environment is transportation. To this aspect, special attention takes auto-transportation, the omitted gasses and toxic substances from them, pollute atmosphere and soil from which toxicants happen from plants to human organism through food chains, which to its part is the reason of health problems.

One of the main consisting components of auto-transportation omissions are aromatic and circle hydrocarbon, aldehydes, carbon dioxide, nitrogen oxides, benzpyrene, plumbum. Herewith, such elements as Al, Co, Cu, Fe, Mn, Pb, Zn, Cd and other are accumulated in surface layer near at soil while wearing out tires. Environmental pollution with heavy metals has become one of the hottest issues of all humanity, as their activity jeopardises life of human organisms. From heavy metals Plumbum takes the first place as the most toxic substance, it is one of the basic pollutants of eco-systems alongside highway. The whole 90% of Plumbum omitted in atmosphere is from auto-transportation. 200-400 mg Plumbum happens in the air per 1 litre fuel. The toxicity level of heavy metals depends on mechanical consistency of soils, amount of organic substances in them, soil area reaction, and consistency of secondary minerals, relief, meteorological conditions, and other.

Oppressing activity of Plumbum in treated sod-podzolic soils is expressed when its concentration achieves 250 mg/kg at MPC of Plumbum is 100 mg/kg. In acid area when pH is at 5,5 phytotoxicity of heavy metals is increased and during increasing concentration of organic substances it is decreased. The main mass of heavy metals is accumulated in upper 2-5 cm (humus) layer of soil, where they are classified into fixed and movable parts. Primary forms of plumbum are rarely transformed into movable forms and so, their movement in the depth is significantly decreased. The negative influence of Plumbum is mostly expressed at light mechanical consistency soils. Agricultural corps which are cultivated alongside highways consist by 5-10 times more Plumbum.

According to above-stated ecological conditions of agricultural lands alongside highway are subject to scientific interest. The subject of our research was determination of Plumbum concentration in soils at Sarpi-Poti-Senaki highway Sarpi-Kobuleti Section Urekhi populated area. At Sarpi-Poti-Senaki highway is 119 km length and it is № 2 international importance. Sarpi-Kobuleti Section includes many villages and populated areas from which one of them is Urekhi settlement. This section is 6 km length. At both sides of the road at 3-4 meters distance there are agricultural land plots at which there are cultivated annual crops and perennial subtropical crops. The significant part of the territory is used for ranch-lands. This territory is in the limits of Batumi city and it is at 5-6 km's distance from sea coastline and it is densely populated. The walking part of the road is covered with asphalt and it is crowded.

The data about road load is given under Table 34. As data shows at Sarpi-Poti-Senaki highway Urekhi Section the amount of all vehicles equals to 101520 units. From it 29,69 % - is trucks which mostly work on diesel fuel and the rest on petrol. 33,69% of them - is light vehicles which spend 9 litres of fuel per 100 km. 36,52% - is type of transportნ which spend 8 litres of fuel per 100 km. Herewith it is noteworthy that 80% of light vehicles work without protection filters, 20 % are vehicles of last edition and is equipped with modern protection filter. Gasses ommited from them are cleaned previously. Foreseeing all the above-stated at Urekhi Section of highway 145,411 Plumbum is omitted annually.

Table 34

Road Load

Research object	Type of transport	Recording		Average	Per year	%
		Morning	***Evening***			
Urekhi Settlement	Light	110	96	103	37080	36,52
	Light	90	100	95	34200	33,69
	Heavy	85	83	84	30240	29,79
Sum		285	279	282	101520	100

During the research average annual amount of precipitation is 2597 mm, correlative humidity of air is 80-82%. From soils mostly subtropical Red soils are widely spread. The arable layer of soils were taken for analysis at 5, 20 50 and 80 meters distance from highway. pH was determine din soil with potentiometer method, humus – with Tiurin method, Plumbum concentration – atomic absorption method. Data are given under Table 35. From received data it is identified, that pH is decreased and soil reaction is changed from acid to weakly acid. Therefore, humus is increased from 4,7 to 5,8%. The Plumbum concentration at 50 perimeters form highway at both sides of the road is increased and at next distances (20 meters distance) it is decreased.

Table 35

Agro-chemical Parameters of soils alongside highway

Distance form road, meter	pH in KCl juice	Humus, %	Plumbum concentration	
			The left side	The rights side
5	4, 54	4,66±0,082	150,8±0,012	169,5±0,012
20	4, 57	4,84±0,083	155,5±0,012	172,4±0,012
50	4, 86	5,56±0,081	104,5±0,013	107,3±0,013
80	5, 4	5,84±0,081	92,0±0,013	99,9±0,012

Plumbum concentration at both sides of road exceeds MPC and while increasing distance from the highway it is decreased and at 80 meters Distance from the highway this Parameters is lower MPC. It is noteworthy that Plumbum concentration is higher on the tight side rather than on the left side. This circumstance can be caused because of winds. From received data the following conclusions can be done:

1. From omitted gas from vehicles soil pollution with Plumbum is increased at 50 meters distance from the highway and at 50 meters far from it this parameter is decreased;

2. Secondary vehicles number grow day by day which will cause even higher pollution of agricultural lands with Plumbum and other heavy metals, so, while cultivating agricultural crops the area where they are cultivated and crops variety must be carefully examined.

Hence as a result of research on Plumbum concentration in agricultural lands in the populated area of Sarpi-Poti-Senaki highway Sarpi-Kobuleti Section Urekhi populated area it was identified that this section of highway is highly crowded by vehicles. In arable layer of agricultural lands Plumbum concentration at 50 meters distance from highway is increased and exceeds MPC and Plumbum concentration is decreased and is lower to MPC at next distance from highway (50 meters more). Herewith, at the right part of the road its concentration is more in soils rather than in the left part.

Chapter III. Evaluation of Ecological Conditions of Basic Types of Soils in Eastern Georgia and Crops (Autumn Corn) Cultivated on Them

III. 1 Background (natural) consistency of heavy metals in basic types of soils of Eastern Georgia and influence of fertilizers on concentration of these elements in plant

The influence of systematic application of mineral fertilizers in carbonate brown soils on fluorine and heavy metals concentration in Bazaleti Plateau was studied. Concentrations of the mentioned elements were determined in autumn corn seed as well. Soil and plant samples were taken according to field experiment variants where influence of systematic application of fertilizers was studied at productivity of autumn corn. Herewith, we would like to mention that for correct evaluation of facilities pollution with heavy metals it is necessary to have starting point. Such starting point will be background (natural) consistency of heavy metals in soil.

Selection of background has special importance in monitoring system as the certainty of pollution quality evaluation depends on it. Application of chemical elements "Clarks" in lithosphere or in world soils with average concentration as background which was happening quiet often until today is totally impermissible for us as in this case regional and especially local geo-chemical peculiarities of soil coverage cannot be foreseen in particular natural areas with high and low concentrations of chemical elements. A great opportunity for measurement error is created: natural geo-chemical accumulations can be received as areas for technogenic environmental pollution or vice versa technogenic accumulation of elements will be invisible in soil where its concentration was not high.

For the purpose of identification background concentration of heavy metals in main soil types of intensive agriculture of Eastern Georgia we have used soil samples taken from industrial facilities and intensive load highways, where there were not used chemicalization measures. Samples have been taken totally at 200 points at 0-20 cm depth. Several full cuts have been made from which for studying vertical separation of heavy metals, samples were taken according to genetic horizons and general and movable forms of fluorine and heavy metals. General Concentration of metals were determined with Plasma Atomic emission spectral and their acid-soluble forms (Such called "close reserve", extractant - 1н HCl) with atomic absorption method.

During soil pollution the special importance has not only notification about high concentration of chemical elements in soil but information about their qualities: humus amount, absorption capacity, area reaction, mechanical consistency, etc. in Table 36 some data is given connected to research soil.

Table 36

Description of Research Soils (0-20 cm depth)

Parameters	**Plain area Chernozem**		**Carbonate Brown**	**Meadow-Brown**
	Samgori field	**Shiraki**		
Physycal clay, %	62	63,5	66,0	78
Humus, %	4,0	4,7	3,3	3,3
pH	7,8	7,9	7,8	7,7
Carbonation, %	3,2	2,0	8,0	7,5
Exchange cations (Ca+Mg), mg. equivalent/100 g soil	43	44,9	47,9	53

In Table 37 gives general concentration of heavy metals in Chernozem, Meadow-Brown and Carbonate Brown soils of eastern Georgia. General concentration of heavy metals in research soils is very low, in ex USSR soils average concentration of heavy metals is significantly high (with 3-4 times) compared to the soils of eastern Georgia. The mentioned difference must be caused by different saturation of parent rocks with heavy metals.

General concentration data of chemical elements in soil is not sufficient for practical goals. Special importance has determination of movable forms. Background consistency of movable forms is starting point while evaluation of speed and quality of mobile fund accumulation of heavy metals in soil. In orientation to carried laboratory analysis in soils of intensive agricultural usage of eastern Georgia the numbers specified under Table 38 of this Monographic Research was background concentration of movable forms of heavy metals. Besides, the Table shows Maximal Permissible Concentrations (MPC) specified by Kloke. In soils of intensive agricultural usage of eastern Georgia great difference was fixed in concentrations of one and the same elements. In some cases (Cu, Zn, Co, F) maximal concentration exceeds minimal by 20 times and more.

Table 37

Concentration of Heavy Metals (%) in Some Types of Soils of Eastern Georgia

N Soil, location	Horizon and depth of taking sample, cm	Cd	Ni	Pb	Hg	Ti	Sb	Sr	Cr	Zn	V
Chernozem: Tsiteltskaro, Zemo Kedi	A_{arable} 0-10	0,000026	0,017	0,005	0,000015	0,87	0,0015	0,007	0,016	0,0081	0,0082
	A_1 25-35	0,000024	0,017	0,005	0,000013	0,87	0,0012	0,008	0,016	0,0081	0,0084
	AB 40-50	0,000023	0,015	0,004	0,000008	0,80	0,0011	0,008	0,014	0,0084	0,0084
	BK_1 52-62	0,000023	0,015	0,004	0,000009	0,85	0,0012	0,009	0,015	0,0085	0,0085
	BK_2 70-80	0,000025	0,016	0,005	0,000009	0,86	0,0015	0,014	0,016	0,0087	0,0084
	BK_3 110-120	0,000027	0,016	0,006	0,000010	0,99	0,0016	0,013	0,019	0,0090	0,0087
	C 140-150	0,000028	0,018	0,008	0,000016	0,99	0,0017	0,014	0,022	0,0095	0,0088
Meadow-Brown: Mtskheta, Natakhtari	A_{arable} 0-20	0,000025	0,016	0,005	0,000014	0,85	0,0014	0,008	0,015	0,0080	0,0065
	$A_{deeply\ treated\ soils}$ 30-50	0,000024	0,015	0,005	0,000013	0,85	0,0012	0,009	0,015	0,0080	0,0067
	B_1 70-90	0,000024	0,014	0,004	0,000009	0,83	0,0011	0,011	0,013	0,0082	0,0067
	B/C 100-120	0,000024	0,014	0,004	0,000009	0,84	0,0015	0,013	0,015	0,0084	0,0070
	C_1g 130-140	0,000026	0,015	0,006	0,000011	0,86	0,0017	0,015	0,015	0,0085	0,0070
	C_2g 150-170	0,000027	0,016	0,007	0,000015	0,88	0,0018	0,015	0,020	0,0088	0,0075
Carbonate-Brown: Dusheti, Bazaleti	A_{arable} 0-20	0,000025	0,016	0,005	0,000014	0,86	0,0014	0,008	0,015	0,0080	0,0078
	B 25-38	0,000025	0,015	0,005	0,000012	0,86	0,0015	0,009	0,015	0,0082	0,0077
	B/C 40-50	0,000026	0,016	0,006	0,000011	0,88	0,0017	0,018	0,013	0,0085	0,0080
	C 70-100	0,000027	0,017	0,007	0,000015	0,90	0,0018	0,020	0,019	0,0089	0,0090

Table 38

Background Concentration of Movable Forms (Acid-soluble) of Chemical Elements and MPC in Soil for Ecological Situation Evaluation (per mg/kg soil)

Element	*Most recent background concentration in soil*	*Background concentration of Eastern Georgia*	*Rates of world soils*	*Minimal Permissible Concentration (MPC) according to Kloke*
Cd	0,05-0,1	0,1	0,01-1	3
Ni	3-10	10	1-100	50
Pb	5-15	15	0,1-20,0	100
Hg	0,05-0,1	0,1	0,01-1,0	2
Sb	0,05-1	1	1-2	5
As	0,05-1	1	1-50	50
V	1-5	5	10-100	400
Cr	1-5	5	1-100	100
Se	1-5	5	0,1-10	10
Bi	0,2-0,5	0,5	0,2-2,5	2,5
Cu	1,0-20	20	2-50	100
Zn	1-30	30	10-300	300
Mo	0,5-2,0	2,0	0,2-10	5
Co	0,5-10	10	1-50	50
Sn	0,5-3,0	3,0	1-20	50
Zr	10-50	50	25-300	300
F	1-20	20	10-500	200

III. 2 Separation of Heavy Metals in Soil profile and Influence of Mineral Fertilizers on Their Consistency

Increased amount of heavy metals is usually typical for well-humus soil with heavy granulometric consistency (clay and claye) and low for low-humus concentration light soils. As it is seen small-disperse mineral particles of soil and humus substances have high depositing capacity of heavy metals. Truly, carbonate brown soil contains lesser amount of heavy metals rather than other soils, granulometric consistency heavier and with high consistency of humus (Table 39).

The separation peculiarities of heavy metals in soil profile attract attention. The received data indicate on two maximums of consistency of movable forms of these elements in soil: in Horizon – $\mathbf{A_{arable}}$ and carbonate layer. Concentration of heavy metals is increased at lower horizon which must be the results of soil-producing rock.

We have studied influence of systematic application of mineral fertilizers in carbonate Brown soils of Bazaleti Plateau and concentration of movable forms of heavy metals (Table 40).

In research soil plot of Bazaleti such called "Priority" polluting heavy metals amount is low. In variants where 240-600 kg $\mathbf{P_2O_5}$ is taken per hectare during 4 years, increase of heavy metals and fluorine concentrations is not noted. Concentrations of Heavy metals and Fluorine is low in corn seed the amount of which in the conditions of using mineral fertilizers is significantly low to MPC.

Table 39

Separation of Heavy Metals Movable Forms in Soil Profile mg/kg air dry soil

Soil, location	Horizon and depth of taking sample, cm	Humus, %	Physical clay, %	$CaCO_3$, %	pH H_2O	mg/kg soil								
						Cd	Ni	Pb	Hg	Sb	As	V	Cr	Se
Chernozem: Tsiteltskaro, Zemo Kedi	A_{arable} 0-10	4,7	63,5	2,0	7,9	0,1	9,0	12,0	0,1	1,0	0,9	5,0	5,0	5,0
	A_1 25-35	3,7	63,5	2,2	7,9	0,08	8,5	10,0	0,09	0,9	0,7	4,5	4,0	4,5
	AB 40-50	2,4	64	5,4	8,1	0,06	7,0	9,5	0,07	0,7	0,5	4,0	4,0	4,5
	BK_1 52-62	1,8	72	9,9	8,3	0,05	7,5	10,2	0,05	0,5	0,5	4,0	4,2	4,0
	BK_2 70-80	0,6	68	10,6	8,5	0,06	8,5	10,5	0,06	0,7	0,7	4,5	4,5	4,2
	BK_3 110-120	0,4	78	20,7	8,5	0,08	9,0	11,5	0,08	0,9	0,8	4,5	4,5	4,5
	C 140-150	-	86	16,5	8,5	0,08	8,5	11,0	0,07	1,0	0,9	4,5	4,5	4,7
Meadow-Brown: Mtskheta, Natakhtari	A_{arable} 0-20	3,3	78	7,5	7,7	0,07	7,5	11,5	0,08	0,8	0,7	4,0	4,3	4,5
	$A_{deeply\ treated\ soils}$ 30-50	2,0	80	11,4	7,7	0,07	7,0	10,5	0,07	0,7	0,7	4,0	4,5	4,5
	B_1 70-90	0,6	82	18,5	8,0	0,08	6,5	12,0	0,08	0,9	0,8	4,4	4,5	4,7
	B/C 100-120	-	84	20,0	8,2	0,08	7,0	12,5	0,08	0,9	0,8	4,4	4,7	4,8
	C_1g 130-140	-	86	21,5	8,3	0,07	8,0	12,5	0,08	0,9	0,9	4,5	4,9	5,0
	C_2g 150-170	-	84	22,8	8,3	0,07	8,5	13,0	0,06	0,8	0,7	4,5	5,0	5,0
Carbonate-Brown: Dusheti, Bazaleti	A_{arable} 0-20	3,3	66	8,0	7,8	0,05	6,8	8,0	0,05	0,7	0,5	3,2	3,7	3,8
	B 25-38	2,1	76	11,2	7,8	<0,05	6,8	8,4	<0,05	0,6	0,6	3,5	3,5	4,0
	B/C 40-50	1,07	78	12,4	8,0	0,05	7,2	8,5	0,05	0,7	0,6	3,5	3,6	4,3
	C 70-100	-	84	28,0	8,2	0,08	7,5	9,0	0,08	1,0	0,8	4,0	4,2	4,5

Table 40

Influence of Fertilizers at Fluorine and Heavy Metals Concentration in Soil and Plant (Autumn Corn Seed) mg/kg (Bazaleti, Carbonate Brown soil),

Variant	Harvest, centner per hectare	increased compared to background		Cd	Pb	Ni	Hg	As	F
		Centner per hectare	%						
Fertilizers-free-controlling	22	-	-	0,12* 0,01	15,1 0,04	10,1 0,0	<0,05 0,002	2,6 0,008	12,3 0,6
P90K45 - Background	30	-	-	0,12 0,01	15,1 0,04	10,2 0,05	<0,05 0,002	2,6 0,008	12,3 0,6
PK + P60	36	6	20	0,12 0,01	15,1 0,04	10,1 0,05	<0,05 0,002	2,6 0,008	12,4 0,6
PK + P90	41	11	37	0,12 0,01	15,2 0,04	10,2 0,05	<0,05 0,002	2,6 0,008	12,5 0,6
PK + P120	48	18	60	0,12 0,01	15,2 0,04	10,1 0,05	<0,05 0,002	2,6 0,008	12,3 0,6
PK + P150	49	19	63	0,12 0,01	15,1 0,04	10,1 0,05	<0,05 0,002	2,6 0,008	12,4 0,6

*** in numerator - soil, multiplier - plant**

Conclusions

1. From gasses omitted by means of auto-transportation at 20 meters distance from road concentrations of Cadmium and Plumbum is decreasing while distancing from the road.

2. Agricultural crops express absolutely different dependence according to consistency of heavy metals.

3. The process of normal growth and development of plants and qualitative parameters of products are ruined near at roads.

4. While cultivating perennial plants at protection line alongside highway and selecting species the distance from highway must be foreseen to avoid pollution of crops.

5. Plants pollution with heavy metals depends on highway load and conditions of walking area.
6. Intensity of auto-transportation is increasing annually which will increase the pollution of agricultural soils with heavy metals at present and in the future as well.
7. In soils of intensive agricultural usage of Eastern Georgia great difference was fixed in concentrations of one and the same elements. In some cases (Cu, Zn, Co, F) maximal concentration exceeds minimal by 20 times and more.

8. Increased amount of heavy metals is usually typical for well-humus soil with heavy granulometric consistency (clay and claye) and low for low-humus concentration light soils. Small-disperse mineral particles of soil and humus substances have high depositing capacity of heavy metals.
9. The separation peculiarities of heavy metals in soil profile indicate on two maximums of consistency of movable forms of these elements in soil: in Horizon – $\mathbf{A_{arable}}$ and carbonate layer. Concentration of heavy metals is increased at lower horizon which must be the results of soil-producing rock

Recommendations

1. Short vegetation fruits and vegetables to be cultivated alongside highway territories.

2. Vegetable crops produced at agricultural lands alongside highway to be used in processed form.

3. Maple, poplar, willow, elm, ash, pine, alder, acantha, almond, nut tree, chestnut, hackberry, lilac, murlberry must be cultivated alongside highway which importantly decreases concentration of heavy metals in atmosphere.

4. For correct evaluation of facilities pollution with heavy metals it is necessary to have starting point. Such starting point will be background (natural) consistency of heavy metals in soil. Selection of background has special importance in monitoring system as the certainty of pollution quality evaluation depends on it.

5. General concentration data of chemical elements in soil is not sufficient for practical goals. Special importance has determination of movable forms. Background consistency of movable forms is starting point while evaluation of speed and quality of mobile fund accumulation of heavy metals in soil.

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