Soil Pollutions: Experience of Incidents and Measures Related to Mining in Japan

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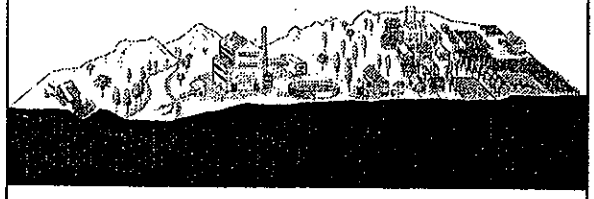
Topics

- Soil Pollution
- Potentially Toxic Elements
- Case Study 1: Ashio Copper Mine Incident (Cu, Pb, Zn, Ba)
- Case Study 2: Kamioka Zinc Mine and Itai Itai Desease (Zn, Cd)
- Lessons Learnt from the Experiences
- Conclusions

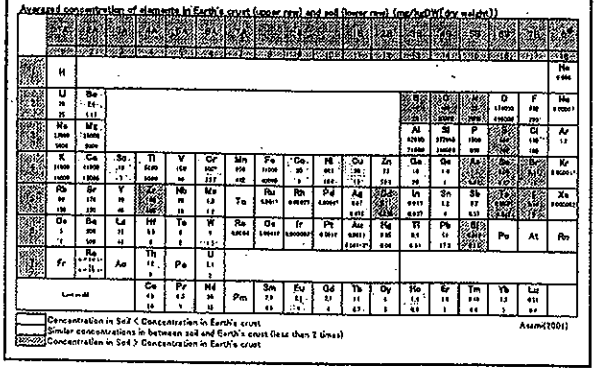
Soil pollution

- Soil forms the foundation for human life and economic activity. It plays a vital role in the sound material cycle and maintaining the biosphere.
- If soil becomes polluted, it will impact human health and living environments, as it migrates into groundwater, and is absorbed by crops.
- It is thus vital to prevent soil pollution and maintain appropriate measures.

Common Causes of Soil and Groundwater Contamination/Pollution

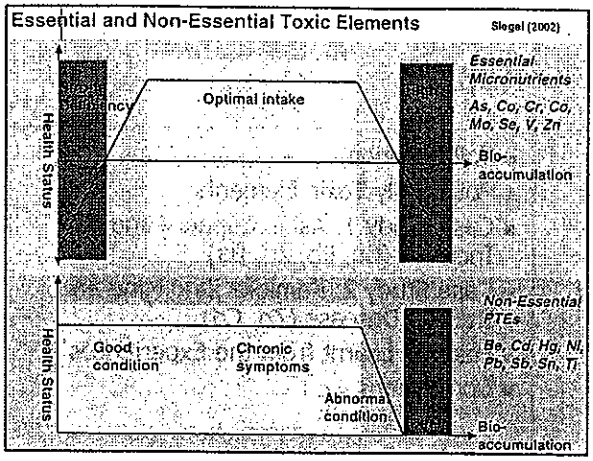


Periodic Table Showing Averaged Concentration in Earth's Crust and Soil



Element Concentration in Soil vs. Earth's Crust

- Enriched in Soil
  - Biological: N, C, S
  - Not identified: B, As, Se, Br, Zr, Cd, Te, I, Bi
- Depleted in Soil
  - Eluvial: Na, Mg, P, Cl, Ca,
  - Not identified: Be, F, Sc, Co, Cu, Mn, Cr, Ni

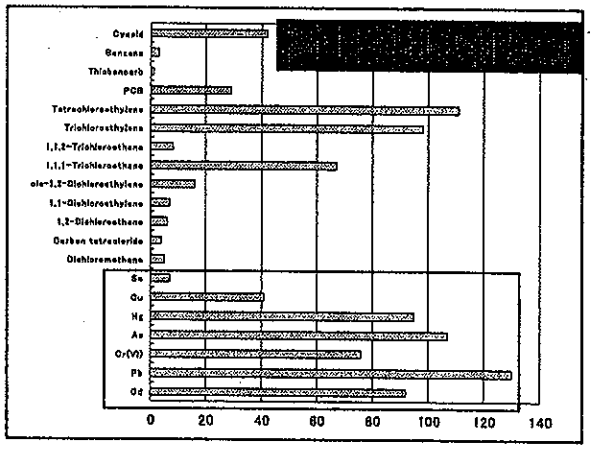


Criteria for screening soil/sediment contamination (PTEs)

	NOAA SquiRTs for Marine Sediment*						Netherlands**			Japan
PTEs	Background	TEL	ERL	PEL	ERM	AET	Ref.	Interv.	Tesl	EQS soil
Al	0.26%					1.8%				
Sb	0.16					9.3				
As	1.1	7.24	8.2	41.6	70	35	29	50	30	50
Ba	0.7					48	200	2000	400	
Cd	0.1-0.3	0.676	1.2	4.21	9.6	3	0.8	12	5	9
Cr	7-13	52.3	81	160.4	370	62	100	380	250	
Co	10					10	10	300	50	
Cu	10-25	18.7	34	108.2	270	390	36	190	100	
Fe	0.99-1.8%					22%				
Pb	4-17	30.24	46.7	112.18	218	400	85	530	150	600
Mn	400					260				
Mo	10						10	200	40	
Hg	0.004-0.051	0.13	0.15	0.696	0.71	0.41	0.3	10	2	3
Ni	9.9	15.9	20.9	42.8	51.6	110	35	210	100	
Se	0.29					1				
Ag	<0.5	0.73	1	1.7	3.7	3.1				
Sn	5					>3.4	20	300	50	
Tl	0.1-0.8									
U	0.7-9									
V	50					57				
Zn	7-38					410	140	720	500	

Environmental Quality Standards for Soil Pollution in Japan

- The Basic Environment Law currently defines Environmental Quality Standards (EQS) for 27 substances, as preferable standards for protecting human health and the living environment.
- The EQS relating to soil pollution consist of
  - elutriation standards, whose goal is to preserve the soils function of purifying water,
  - agricultural standards for preserving the food-production function of soils,
  - and concentration standards, whose goal is to preserve the role as a foundation for human life and economic activity.
- The EQS were determined relied on previous bitter experiences on soil pollution in Japan.

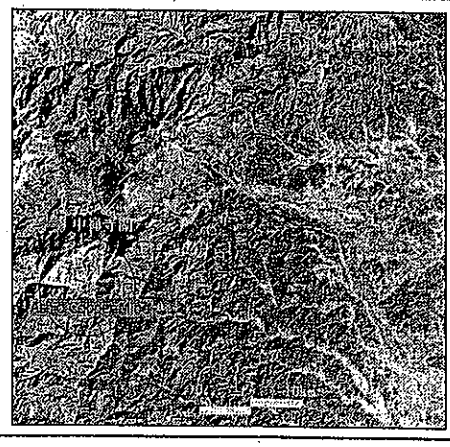


Case Study #1

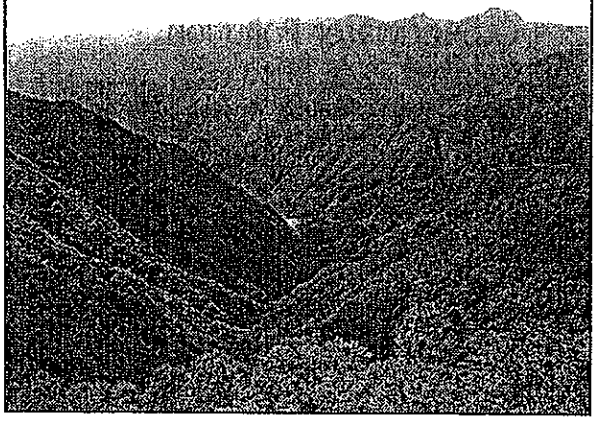
Ashio Copper Mine

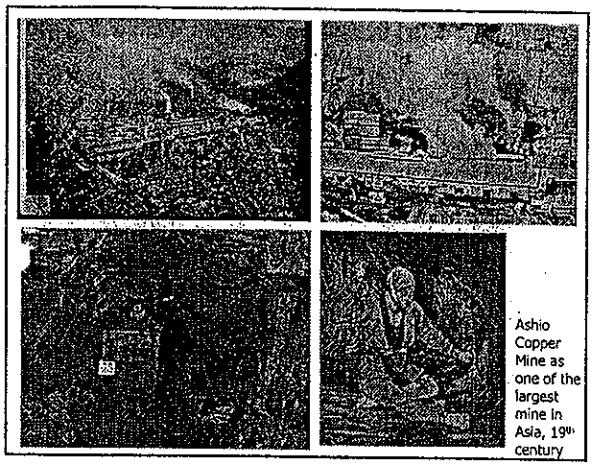
Pollutants: Cu, Pb, Zn, Ba

Landsat Image of the Ashio Copper Mine area, central part of Japan



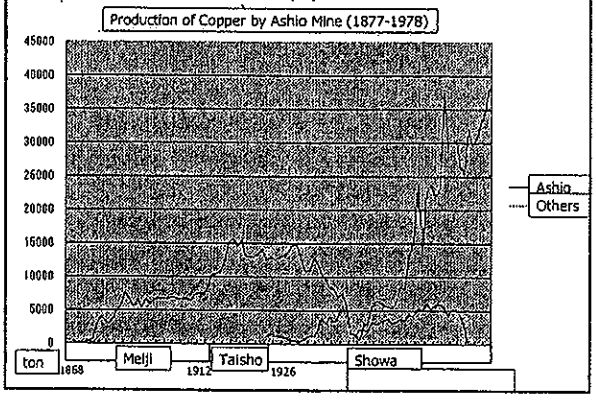
The Ashio Copper Deposits were explored since 18th Century (Yedo Era).



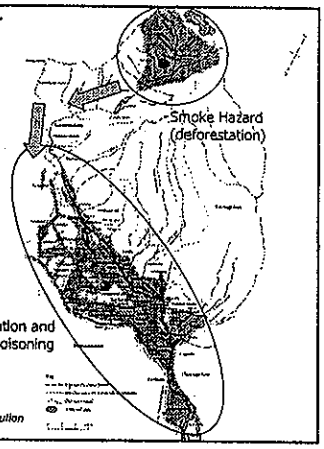


Ashio Copper Mine as one of the largest mine in Asia, 19th century

Production of Copper



Area affected by copper poisoning soil pollution and smoke hazard by Ashio Copper Mine (surveyed in 1897)

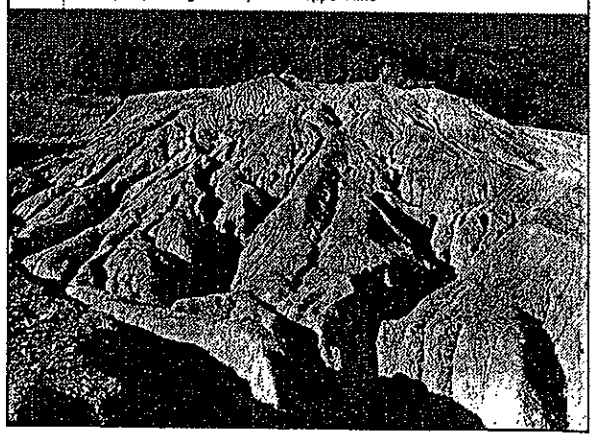


from Shoji and Sugai, in UI (ed.1992):*Industrial pollution on Japan*. UNU Press, Tokyo

The Beginning

- 1885 August: Mass grave of fishes in Watarase river, but the cause was unclear.
- 1885 October: Deforestation around Ashio Copper Mine
- 1886-: Stand dead of crops in the fields irrigated by the Watarase River water or flood zone.

Desert Landscape by Mining Wastes, Ashio Copper Mine



Crop field affected by polluted water in Watarase River

Fukawa(1997)

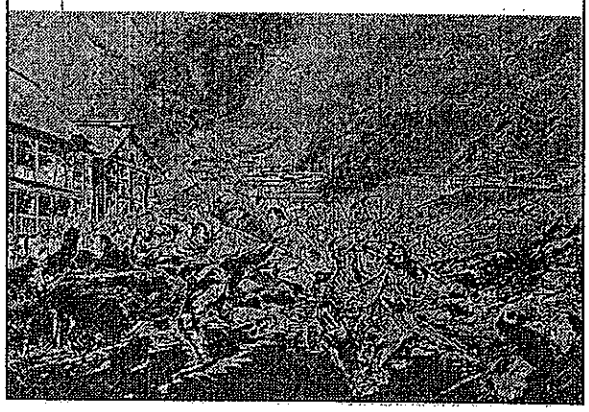
Groundwater Pollution

- Toxic metals migrated into the groundwater from the polluted soils.
- The groundwater was used for drinking water for local people.
- The local villages suffered a number of victims possibly caused by the polluted groundwater (approximately 1064 after the survey in 1899).
- Three villages were abandoned due to the pollution.

Victims by Ashio Poisoning in the 19th century

Print art by Ichiro Oguchi, painter, after Fukawa(1997)

Protest by Farmers against the Ashio Copper Mine



Mr. Shozo Tanaka and his Partisans in Yanaka Village

Fukawa(1997)

Measures against the Pollution

- 1897: The central government organized a committee to survey the pollution. Then, based on the results of survey, the Government ordered to the mining company to improve the facilities of wastewater treatment, waste disposal, and desulfurization.
- However, these facilities had big limitations to control the pollution. The tailing dam for accumulating sludge was often overflowed, and in 1898, the dam was eventually broken.
- The desulfurization facility was also not effective, and the deforestation was continuing.

Present State of the Soil Pollution

Sampling Sites

mg/Kg	Miyata sediment	Hitachi rock	Hitachi sediment	Hitachi karami	Watarase sediment	Watarase soils	Nikkou soils	Akagi soils	Akagi rocks	Ashio rocks
Sr	1870	1330	835	4250	874	788	1158	980	15	114
Cl	532	674	323	23	96	137	228	221	20	51
Sc	19	17	18	15	14	19	23	20	23	9
V	129	128	116	26	153	176	265	202	146	57
Cr	169	43	115	185	51	83	97	23	8	32
Ni	78	22	29	48	24	30	13	14	5	22
Cu	9617	28	155	2060	162	113	30	35	16	30
Zn	1940	138	414	15500	225	172	90	89	68	70
As	105	n.d	4	193	27	8	4	n.d	n.d	10
Rb	27	37	47	27	92	56	43	26	22	127
Sr	228	233	268	227	181	163	223	208	375	171
Y	14	19	14	12	20	20	18	17	15	24
Zr	183	513	109	77	127	150	98	15	79	152
Nb	8	7	8	4	9	9	5	8	3	11
Cd	5	0	0	10	n.d	n.d	n.d	n.d	n.d	n.d
Ba	2460	319	788	2024	557	427	389	266	259	713
Pb	480	19	49	900	47	34	23	17	10	30

神宮・田切(2003)

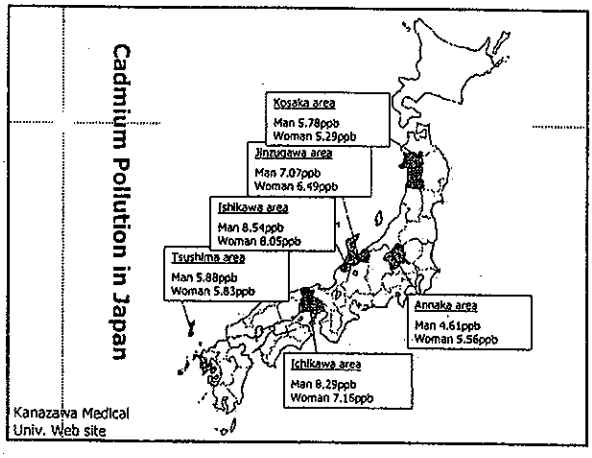
Lessons for today from the Ashio Copper-mine poisoning

- More than 100 years have passed since the first public warnings were issued about mining-related environmental problems.
- The vast desert in this area attests to the fact that, at the end of the 19th century, Japan attempted to catch up with the advanced capitalist nations of the world through policies that stressed the development of industrial capacity and military might.
- The deeply ravaged conditions of the once pristine forest areas around the Ashio copper mine are the result of this primary-order, introduction of technologically based industrial capacity into Japan without the slightest consideration for environmental preservation.

Case Study #2

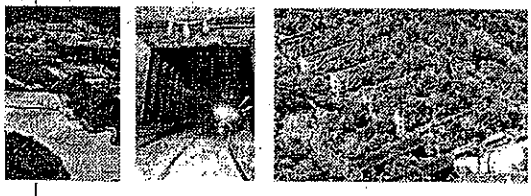
Kamioka Mine and Itai-Itai Disease

Pollutants: Zn, Cd



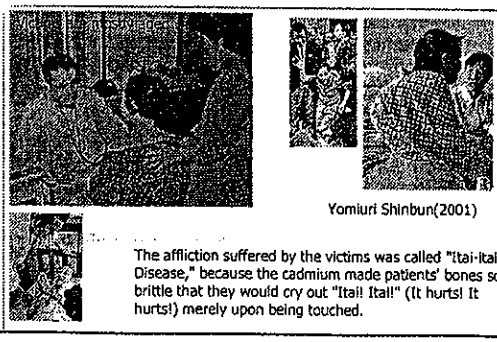
Kanazawa Medical Univ. Web site

Kamioka Mine: One of the Largest Zinc Mines in Asia



The mining wastes associate with cadmium as impurity.

Dr. Noboru Ogino characterized Itai-Itai Disease



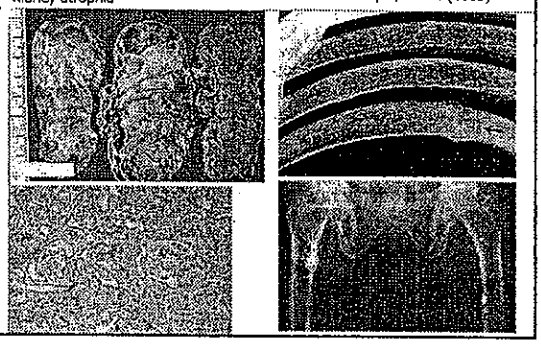
Yomiuri Shinbun(2001)

The affliction suffered by the victims was called "Itai-itai Disease," because the cadmium made patients' bones so brittle that they would cry out "Itai! Itai!" (It hurts! It hurts!) merely upon being touched.

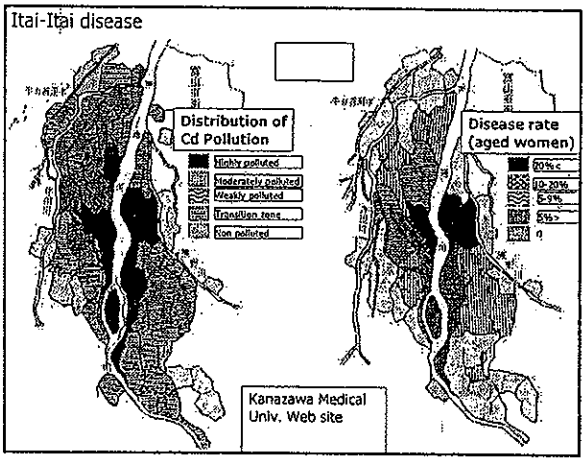
Itai-Itai Disease

Department of Epidemiology and Public Health, Kanazawa Medical University Web site (2005)

Kidney atrophia



Itai-Itai disease



Summary of Japan's Bitter Experiences

- In the late 1870s, there was a major pollution problem in which poisoned mine water from the Ashio Copper Mine containing copper contaminated farmland, damaging crops in the Watarase River basin. More than 1000 people were the victims.
- Then in 1968, an outbreak of chronic cadmium poisoning struck the Jinzu River basin. The disease was caused by cadmium from polluted soil being absorbed into rice and water. More than 1000 people were the victims.
- These events resulted directly from the civil anti-pollution movement, which clearly changed the attitude of government and industries.

Local Government Leadership

- Decentralization of responsibility has been a key feature of Japan's overall environmental policy, for local governments are on the front line when it comes to dealing with specific environmental incidents.
- Indeed, while formal mechanisms suggest that the national government takes the lead for the development policies, historically local governments have been in the vanguard of environmental policy reform in Japan.
- The success of Japan's pollution control strategy therefore rests heavily upon the competence and status of local government officials.

Ex-Post Approach

- Japan's experience in pollution control demonstrates that democracy, public awareness, and mechanisms to integrate people's opinion into policymaking are indispensable for adequate environmental management.
- In Japan, intensive pollution abatement measures taken during the 1970s were an *ex-post* approach. Measures were taken after local people had complained.
- Very few procedures for public participation had been integrated into policymaking before 1970s.
- The first law that fully integrated this process in Japan was the Basic Environment Law (1993).

Law and Enforcement

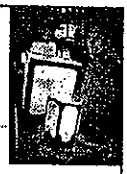
- The government responded by adding the category of "soil pollution" to the Basic Law for Environmental Pollution Control (Basic Environment Law) in 1970, identifying it as one of seven major types of pollution. In that same year, the Agricultural Land Soil Pollution Prevention Law was enacted.
- Under this law, each local government designates areas where the soil has become polluted, and areas where there is a risk of pollution, and plans countermeasures.
- To date, cadmium, copper, and arsenic have been identified as specified hazardous substances, and pollution is removed by soil removing, soil dressing, and changing the water source or otherwise changing the use of the land.

Selected Environmental Quality Standards

Elements	Conditions (Leaching and Concentration)
Cadmium	0.01 mg per liter of sample solution, For agricultural land, less than 1 mg/kg rice
Lead	0.01 mg per liter of sample solution
Chromium (VI)	0.05 mg per liter of sample solution
Arsenic	0.01 mg per liter of sample solution, For agricultural land (rice paddies) <15 mg/kg
Total Mercury	0.0005 mg per liter of sample solution
Alkyl Mercury	Must not be detected in sample solution
Copper	For agricultural land (rice paddies), <125 mg/kg
Selenium	0.01 mg per liter of sample solution
Fluorine	0.8 mg per liter of sample solution
Boron	1 mg per liter of sample solution

Conclusions

Lessons from our Experiences



Sending off the spirits of dead on lanterns floated on the water of a river in Minamata.
© Kumamoto daily News

- Most observers perceive the images of Japanese progress in environmental management in terms of advanced technological (and expensive) approaches, for example, in waste treatment, site remediation, and emissions control equipment.
- Sophisticated technology is indeed an important contributor to Japan's success in cleaning up urban and industrial pollution.
- However, not generally recognized is the broad range of innovation in policy and institutional reforms from civil movements, based on very bitter experience, tragedy, and a number of pollution victims.

Next Presentations:

- Administration System of Soil Contamination in Japan by *Mr. J.Hirano*
- Soil Contamination - Regulation, Criteria and Measures in Japan by *S.Nakamura*
- Tecnology on Survey and analysis for Soil & water Contamination by *T.Mizuno*

Thank you.

Towards the Project

- Soil Contamination Management related to Mining Activities
- Pilot Project in Zletovica basin
  - Survey and Analysis
  - Soil Contamination Map
  - Risk Assessment >>> Land Use Planning
- Master Plan

Soil Screening Process

- Develop Conceptual Site Model (CSM)
- Compare soil component of CSM to soil screening scenario
- Define data collection needs for soils to determine which site areas exceed soil screening levels (SSLs)
- Sample and analyze soils at the site
- Derive site-specific SSLs, if needed
- Compare site soil contaminant concentrations to calculated SSLs
- Decide How to address areas identified for further study

Administration System of Soil Contamination in Japan

by Mr. Hirano

Soil Pollution Incidents and its Measures in Japan

- Poisoning of Ashio Copper Mine
- Itai-Itai Disease along Jinzu River basin
- Hexavalent Chromium contamination in Tokyo

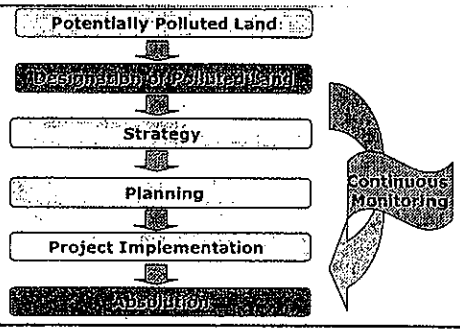
Proactive Measures
→Controls by Water Pollution Control Law and Waste Management Law

Remediation Measures
→Agricultural Land Soil Pollution Prevention Law: Soil dressing on farm land and so on

Agricultural Land Soil Pollution Prevention Law

- Enacted December 1970
- Enforced from June 1971
- The purpose of the Law is to prevent poisoning of agricultural products caused by soil pollution of farm land, which adversely affects human health.

Legislation of Agricultural Land Soil Pollution Prevention Law



Conditions for designation of *Pollution Land* based on the Soil Pollution Prevention Law

- **Cadmium**
  - The land where the concentration of Cd in harvested rice exceeds 1mg/kg, and its surrounding area.
- **Copper**
  - The paddy field where the concentration of Cu in soil exceeds 125mg/kg
- **Arsenic**
  - The paddy field where the concentration of As in soil exceeds 15mg/kg

Environmental Quality Standards for Soil Pollution (issued 1991)

- Environmental quality standards for protecting environment in order to secure human health and life environment.
- 27 substances
- Contract-out areas: soil pollutions clearly caused by natural origin, material deposit sites, landfill sites, and so on

Environmental Quality Standards in Japan

Parameter	Environmental Quality Standards
cadmium	0.01 mg per liter of sample solution, For agricultural land, less than 1 mg/kg rice
total cyanide	Must not be detected in sample solution
organic phosphorus	Must not be detected in sample solution
lead	0.01 mg per liter of sample solution
chromium (VI)	0.05 mg per liter of sample solution
arsenic	0.01 mg per liter of sample solution, For agricultural land (rice paddies) <15 mg/kg
total mercury	0.0005 mg per liter of sample solution
alkyl mercury	Must not be detected in sample solution
PCB	Must not be detected in sample solution
copper	For agricultural land (rice paddies only), <125 mg/kg
dichloromethane	0.02 mg per liter of sample solution
carbon tetrachloride	0.002 mg per liter of sample solution
1,2-dichloro ethane	0.004 mg per liter of sample solution
1,1-dichloro ethene	0.02 mg per liter of sample solution
cis-1,2-dichloro ethylene	0.04 mg per liter of sample solution
1,1,1-trichloro ethane	1 mg per liter of sample solution
1,1,2-trichloro ethane	0.006 mg per liter of sample solution
trichloroethylene	0.03 mg per liter of sample solution
tetrachloroethylene	0.01 mg per liter of sample solution
1,3-dichloropropene	0.002 mg per liter of sample solution
thiram	0.006 mg per liter of sample solution
simazine	0.003 mg per liter of sample solution
thiobencarb	0.02 mg per liter of sample solution
benzene	0.01 mg per liter of sample solution
selenium	0.01 mg per liter of sample solution
fluorine	0.8 mg per liter of sample solution
boron	1 mg per liter of sample solution

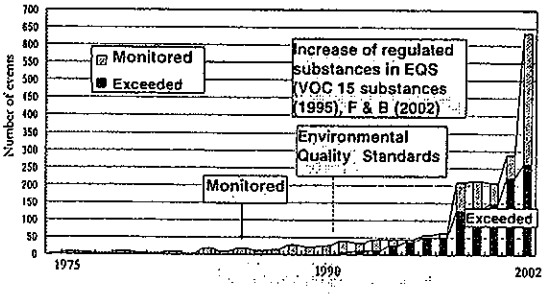
Increases of Soil Pollution Incidents since 1980s

- Shifting of factory sites caused by restructuring of industrial system in Japan
- Redevelopment of urban area for effective use of land
- Clear criteria for identifying soil pollution based on the Environmental Quality Standards (EQS) for soil pollution

Increase of soil pollution identified by the soil survey at land transactions

Increase of soil pollution incidents identified by groundwater monitoring

Number of Soil Pollution Reported



Soil Pollution Prevention Law

- Increase of Soil Pollution Incidents
- Unclear guideline for survey, monitoring, and counter-measures
- Risk for health caused by soil pollution

Soil Pollution Prevention Law(proclamation: May 2002, enforcement: February 2003)

Purpose of Soil Pollution Prevention Law

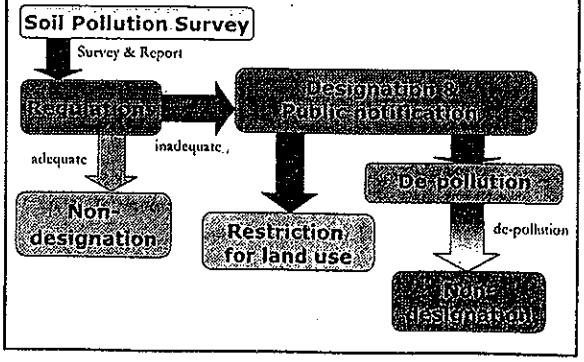
Identifying soil pollution state by regulated toxic substances

Determination the measures for soil pollution protection

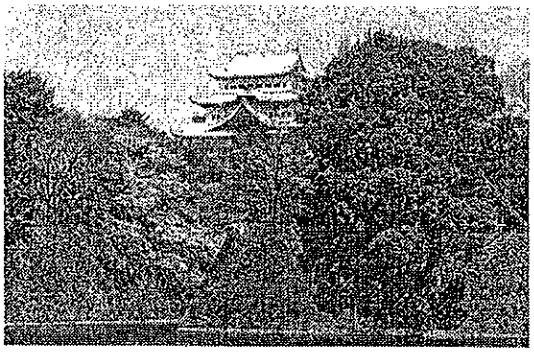
Implementation of the measures for soil pollution

To protect peoples healthy life

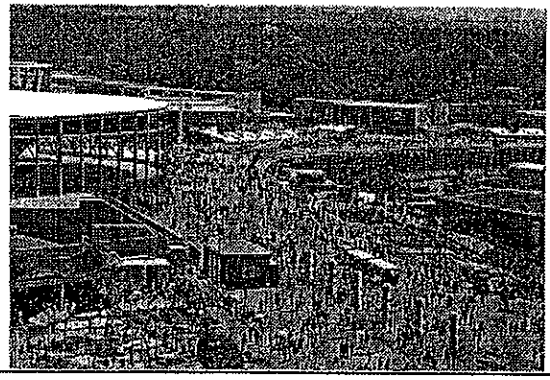
Legislation of Soil pollution Prevention Law



Castle of Nagoya



World Exposition 2005 in Aichi



THANK YOU
VERY MUCH

END

SOIL CONTAMINATION Regulation, Criteria and Measures in Japan

NAKAMURA Satoshi

Environmental Law System for Soil Contamination in Japan

<Soil Pollution Prevention>
- Agricultural Land Soil Prevention Law
- Soil Pollution Prevention Law
- The Law for anti-pollution Measures for Dioxins

<Ground water Pollution through soil>
- Water pollution Control Law
- Environmental Quality Standard for Groundwater Pollution

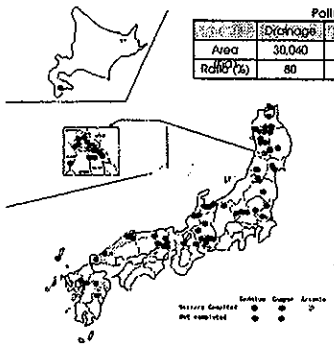
<Pollution through Mining>
- Mine safety Law
- Special Measures for Mine Damages Caused by Metal Mining Industries

<Others>
- Pesticide Control Law
- Fertilizer Control Law
- Waste Disposal Law

Law for Agricultural Land

- Enforced 1970
- Adopted PPP for the measures
- Background : Itai Itai Disease, Minamata, etc
- Specified toxic substance :
  Cadmium (1mg/kg in the Rice)
  Copper (125mg/kg in the soil)
  Arsenic (15mg/kg in the soil)
- Measure : Dressing filling etc.

Polluted Agricultural Land in Japan



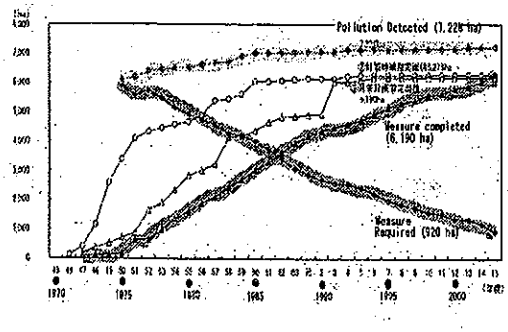
Pollution Source

	Drainage	Flue Gas	Dump site	Others
Area	30,040	4,750	3,320	1,890
Ratio (%)	80	13	9	5

Land Use

Paddy field	31,040 ha
Cultivated land	6,380 ha
Total	37,420 ha

Progress of the Abatement



Law for Urban Area

- Enforced 2003
- Target is limited to artificial pollution
- Duty of the soil survey is imposed to land owner
- Pollution of the past is also targeted
- Necessary measure is limited to Human Health
- Situation of the pollution is disclosed to the public
- One strict criteria is adopted for the judgment of pollution
- Pollution from mining is not included

Duty of the Survey

- **Where** : the area designated facility or material is equipped or used
- **When** : factory / facility stopped its activities
- **What** : Specified toxic substance
- **Who** : the land owner / land manager
- **Surveyed** : by designated institution
- **Inform to whom** : Prefectural governor

* If the situation is judged as harmful for the human health, the governor can order the survey to the land owner even when the condition is different from above

Criteria of Polluted Land

	Item	Elution Criteria (mg/l)	Content Criteria (mg/kg)
Heavy Metals, etc. (Direct and Indirect Intake)	Cadmium	0.01	150
	Hexavalent chromium	0.05	250
	Cyanide	ND	50
	Mercury	0.0005 (Alkyl) ND (total)	15
	Selenide	0.01	150
	Lead	0.01	150
	Arsenic	0.01	150
	Fluorine	0.8	4000
	Boron	1	4000
VOCs (Indirect Intake)	Tetrachlorometane, 1.2 dichloroethane, etc. (5 items)	0.002 - 1.0	-
Pesticide (Indirect Intake)	PCB, Thiuram, etc (11 items)	ND - 0.02	-

If the survey result exceed above value, the land is designated as polluted land. Its result is disclosed to the public and the pollutant have to conduct the measures.

Specified Measures

to prevent direct intake

- Off Limit the area
- Dress filling
- Replace the polluted soil
- Remove polluted soil or In-situ remediation

to prevent intake through groundwater

<If groundwater is no contaminated>

- Monitoring of groundwater quality

<If groundwater is contaminated >

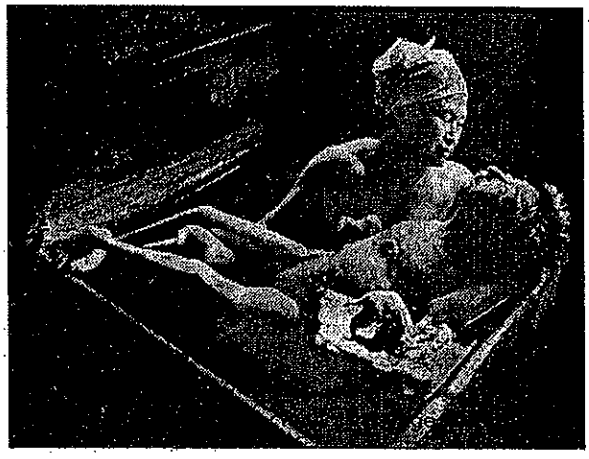
- Remediation, Removal soil, Confinement, Insoluble treatment

Difference with EU and USA

- Land Owner has the Duty for Initial Investigation
- Necessity of the Registration for the Polluted Land
- Specify the toxic substance
- No Description for the Consideration for the Natural Environment
- One Simple Criterion for Risk evaluation

Law for Mining

- Mine safety Law (1949)
- Special Measures for Mine Damages Caused by Metal Mining Industries (1973)
- Purpose : to prevent mine pollution
- Managed by Ministry of Industry (not by MoE)
- Mining company have to prepare pollution prevention plan. The plan have to be approved by the government.
- Reserve fund for the measures have to be deposited by mining company.



Site Assessment For Heavy Metals Soil Contamination

July 2005

Terumi Mizuno

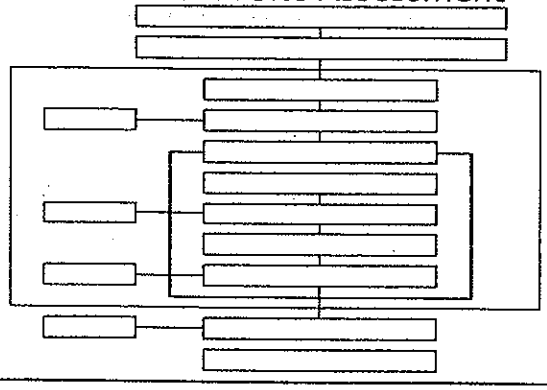
JICA Mission Member

by Mr. Mizuno

Triggers For Site Assessment

1. Periodical groundwater monitoring.
2. Relocation of a plant and/or development of the relocated area.
3. Detection of contamination.

Process of A Site Assessment



Information Gathering

1. Objectives
   - To collect information required for making a on-site study plan.
2. Applicable Information
   - Maps, photographs
   - Land use history
   - Geological/hydro geological records
   - Storm and flood waters
   - Environmental monitoring records
   - Environmental management records

Characteristics Of Heavy Metals Contamination

- Low water solubility (Except Cr and As)
- Easy to adsorb to soil particles

⇩

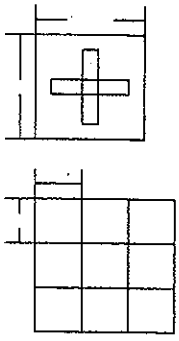
Remain in a surface layer

Preliminary Study

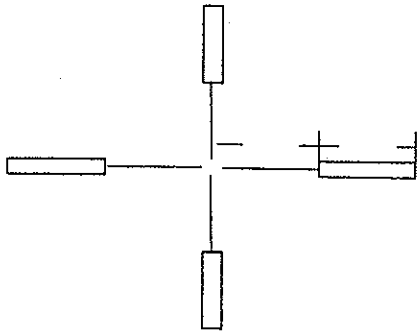
1. Objectives
   - To identify the pollution source
   - To identify contaminants
   - To assess the extent of contamination
2. Method
   - Chemical analysis of surface soil
   - Chemical analysis of groundwater

Grid Design and Sampling Method

- Grid size
  - Category 2: 30 m x 30 m
  - Category 3: 10 m x 10 m
- Sample preparation
  - Mixing the two samples taken at <5 cm and at 5-50 cm in depth



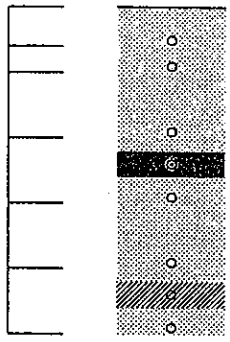
5 Points Mixing Method



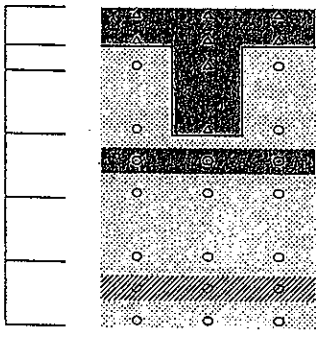
Detailed Study

- Objectives
  - To obtain a spatial distribution of contaminants in soil and underground water.
  - To define the area for remediation.
- Method
  - Geological study of underground.
  - Chemical analysis of subsoil.

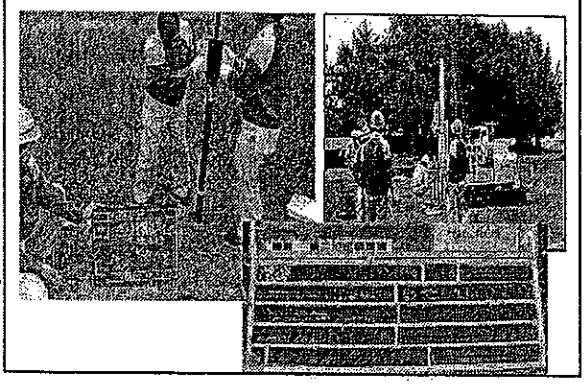
Sub-soil Sampling



Spatial Area Contamination Map



Sampling Equipment



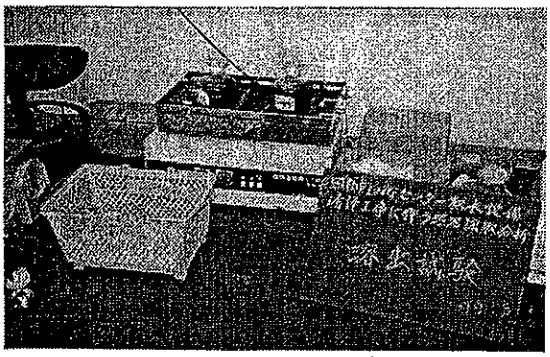
Analytical Methods

- Leaching test
  - Extraction with water
  - Extraction with hydrochloric acid (HCl)
- Decomposition test
  - Acid decomposition
  - Alkaline fusion

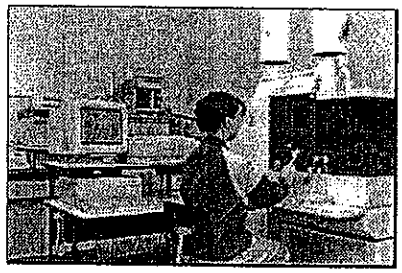
Leaching Test
Extraction With Water

1. Air drying.
2. Sieving with 2 mm non-metal screen.
3. Extraction of heavy metals with water (pH 5.8 – 6.3, w/v = 1/10) for 6 hours.
4. Centrifugal separation (3000 rpm, 20 min).
5. Filtration with 0.45 membrane filter.
6. Analyze the filtrate with AA, ICP.

Agitation Apparatus

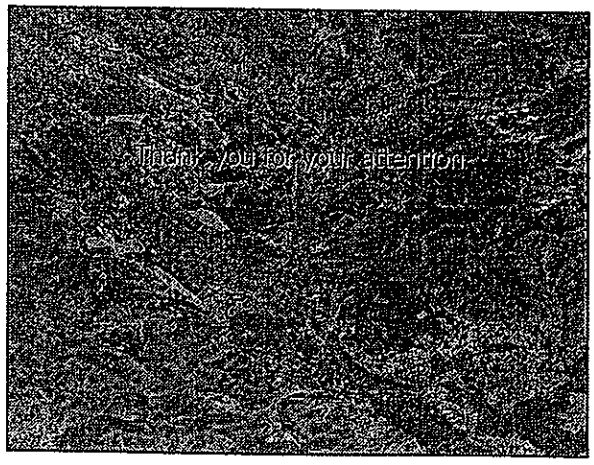


Analysis Of Filtrate
(ICP)



Quality Assurance

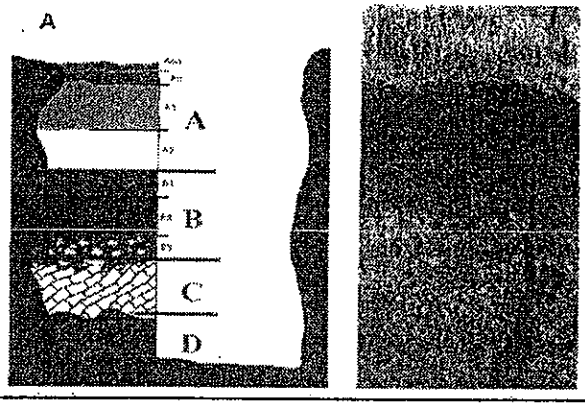
- Matrix spike
  Recovery rate 70 – 120%
- Certified reference ma material
  Within a certified range

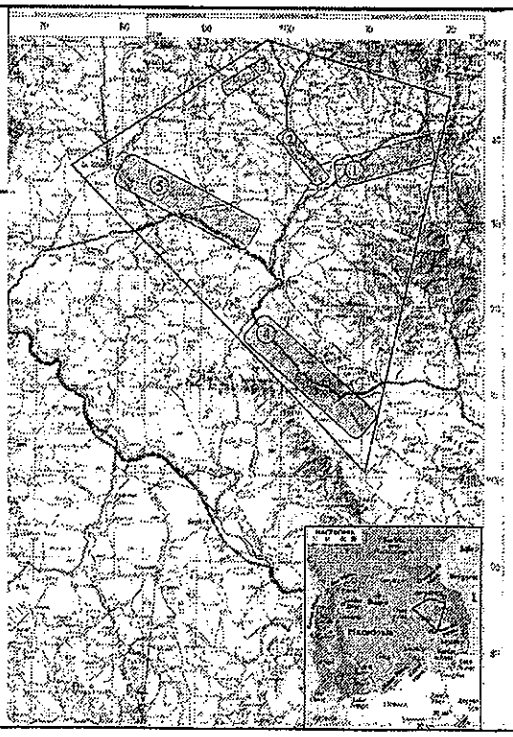


TRACE ELEMENTS IN SOILS OF SOME REGIONS IN THE REPUBLIC OF MACEDONIA

Blazo Boev and Sonja Lepitkova

Faculty of Mining and Geology Stip, University St."Siryl and Methodius"-Skopje
Goce Delcev, 89, 2000 Stip, Republic of Macedonia
e-mail: bboev@rgf.ukim.edu.mk



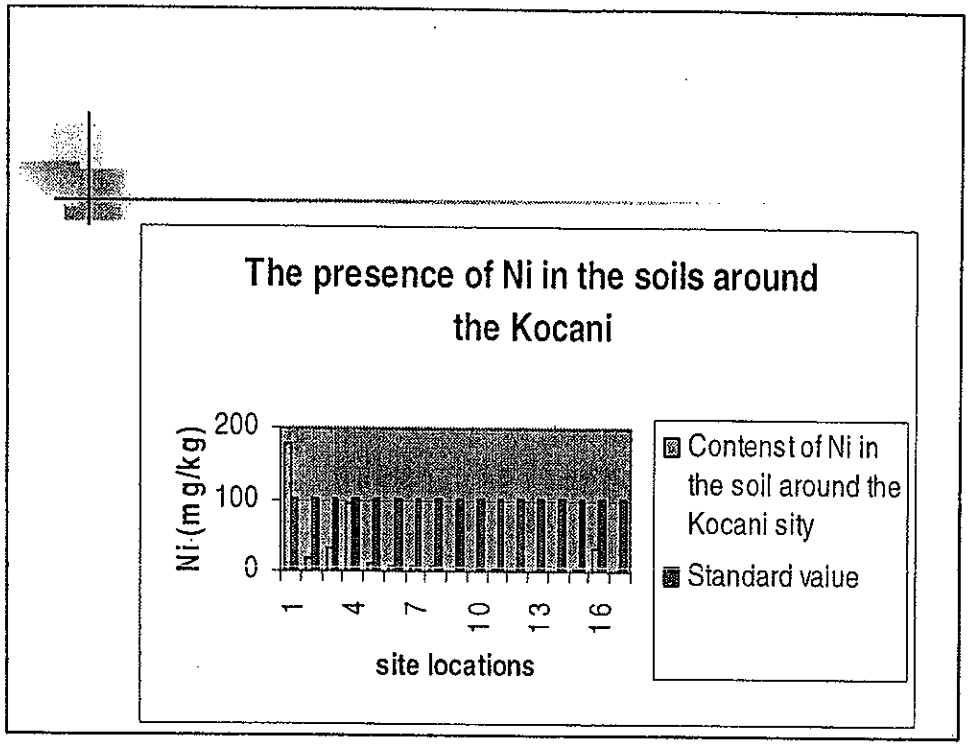


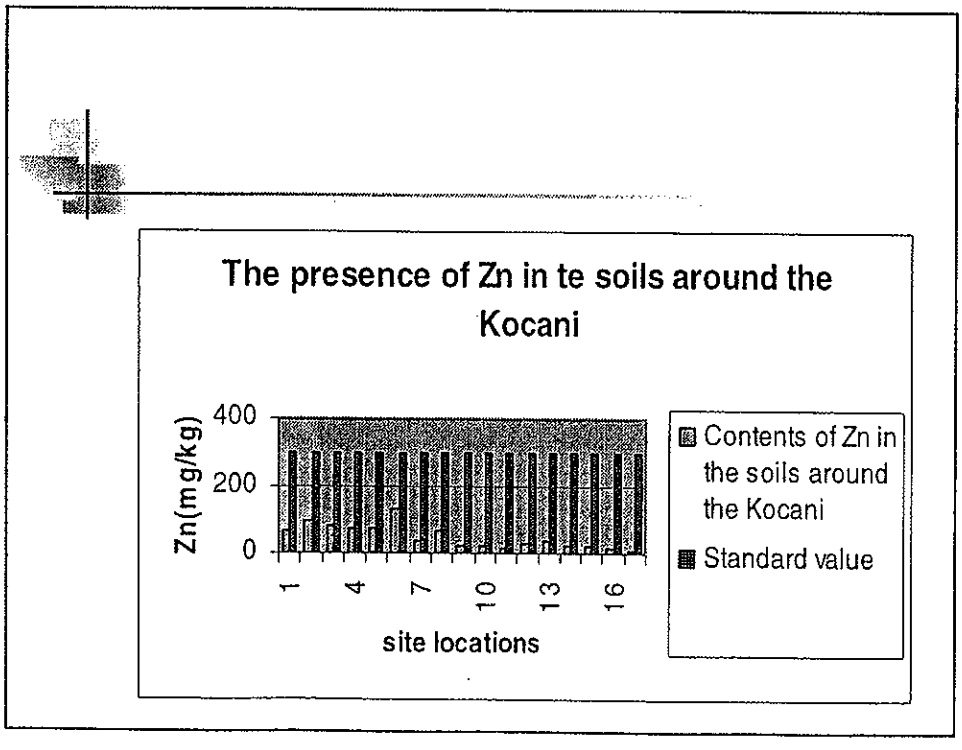
Methods of work

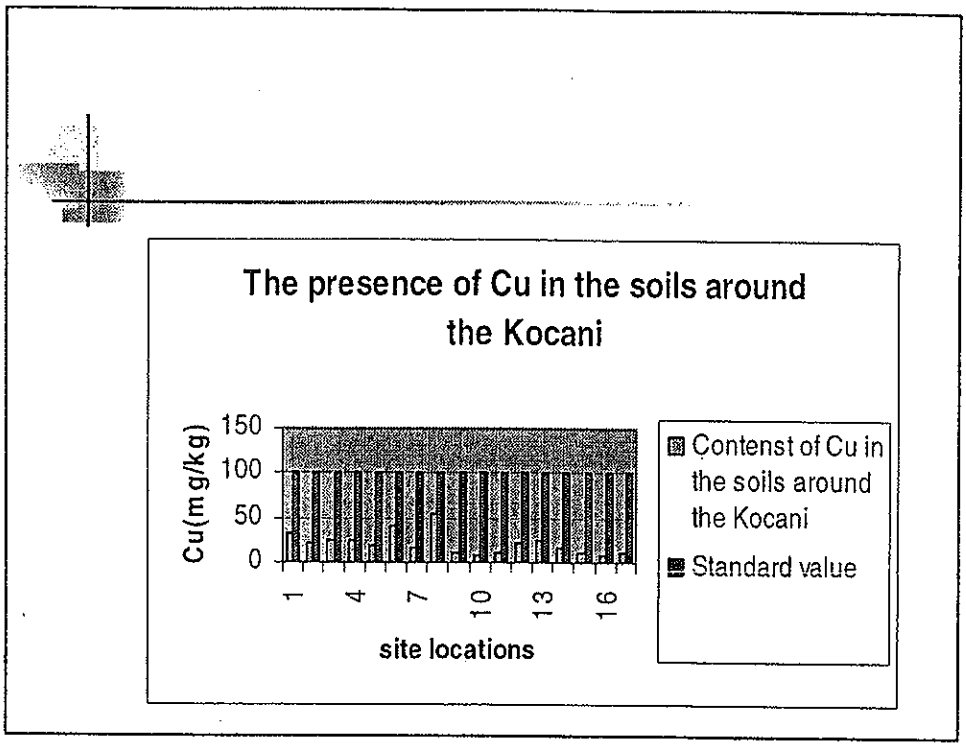
ethods applied consisted of

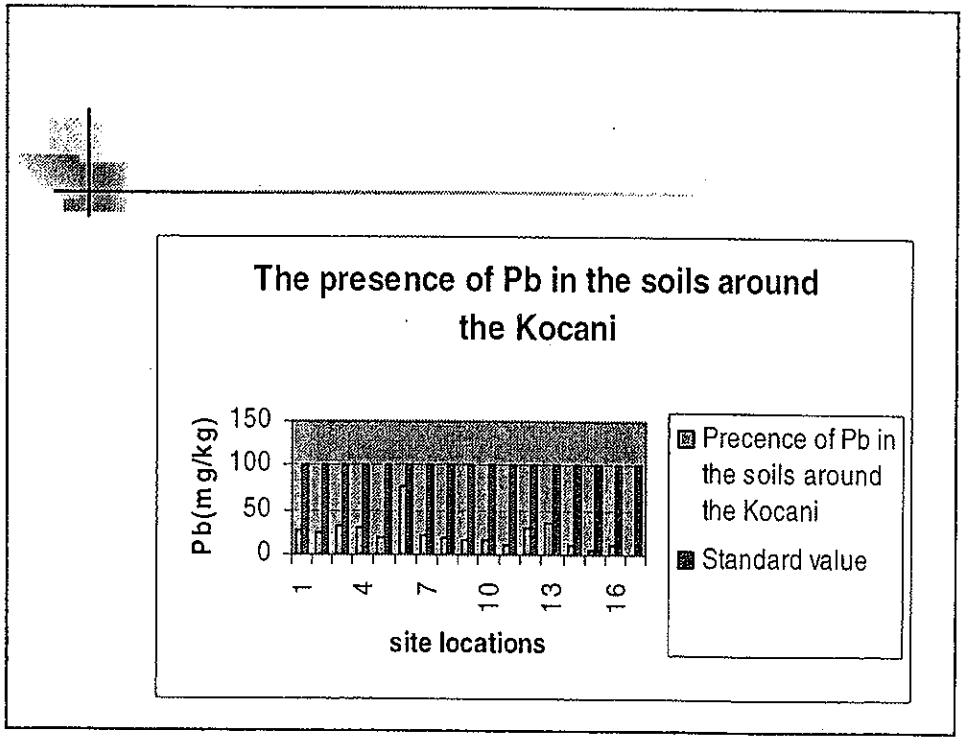
- sampling,
- samples preparation,
- determination of the presence of microelements and trace elements in soils by AES-ICP,
- interpretation of results obtained.

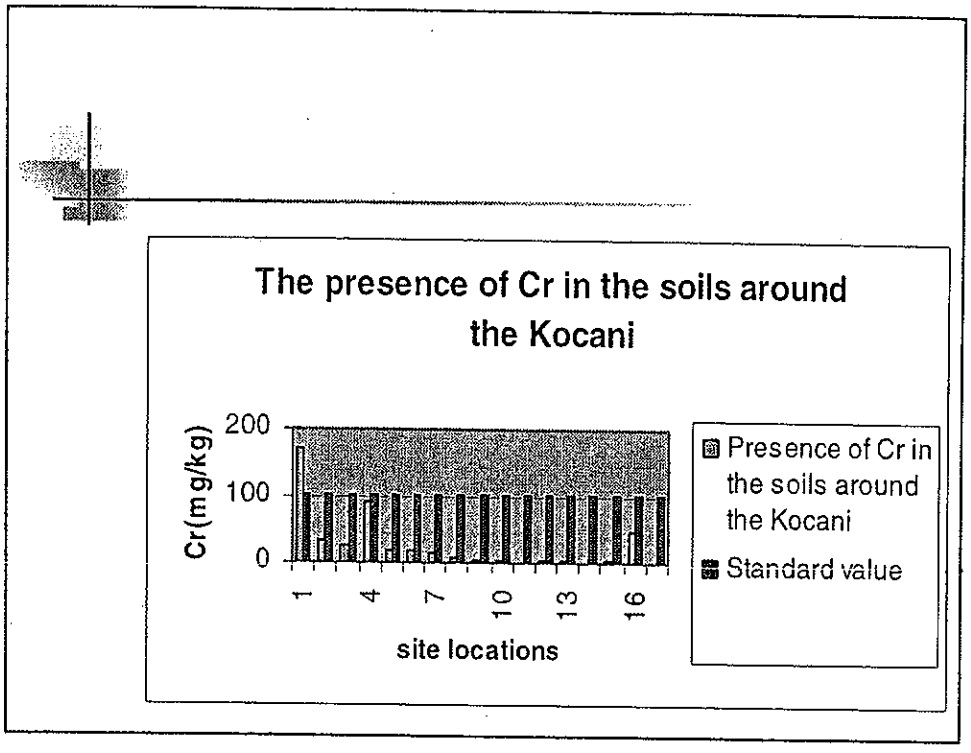
Kocani locality

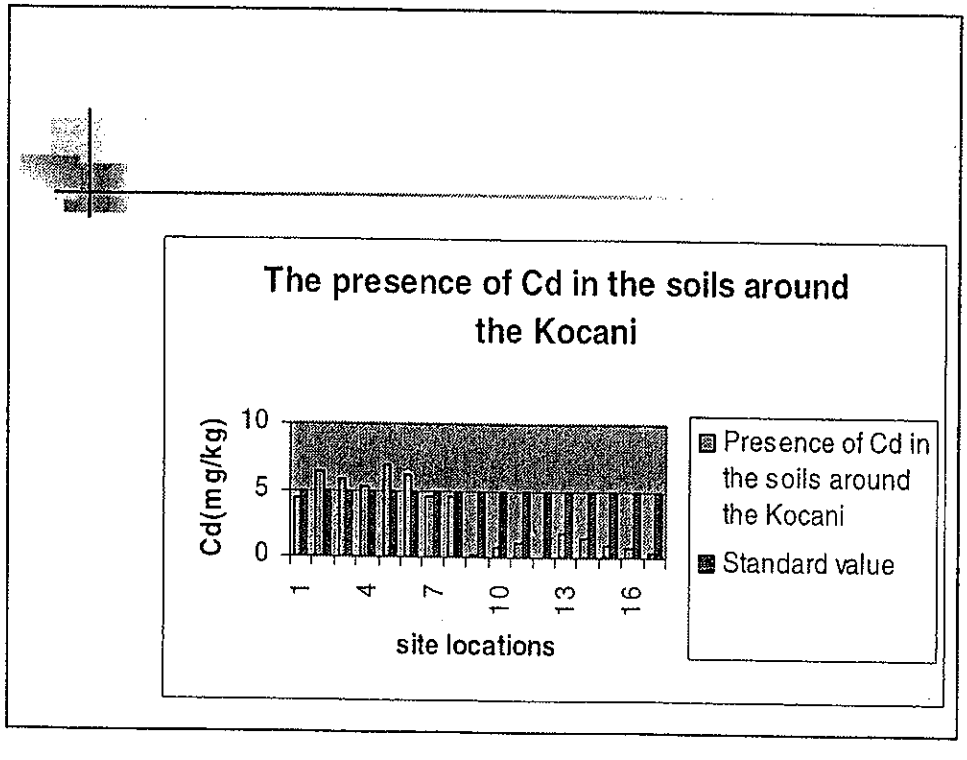

The presence of Ni in the soils around the Kocani
Ni (mg/kg)
200
100
0
1
4
7
10
13
16
site locations
Contenst of Ni in the soil around the Kocani sity
Standard value


The presence of Zn in te soils around the Kocani
Zn(mg/kg)
400
200
0
1
4
7
10
13
16
site locations
Contents of Zn in the soils around the Kocani
Standard value

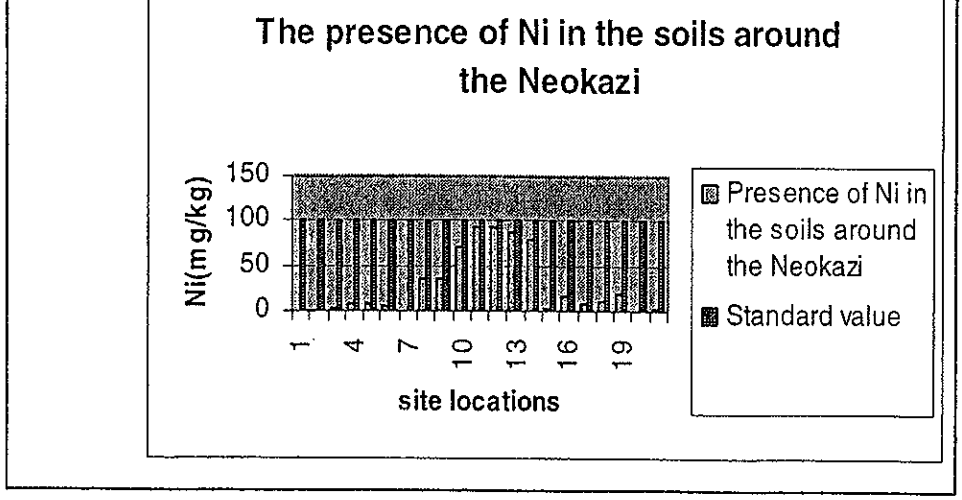

The presence of Cu in the soils around the Kocani
Cu(mg/kg)
150
100
50
0
1
4
7
10
13
16
site locations
Contenst of Cu in the soils around the Kocani
Standard value

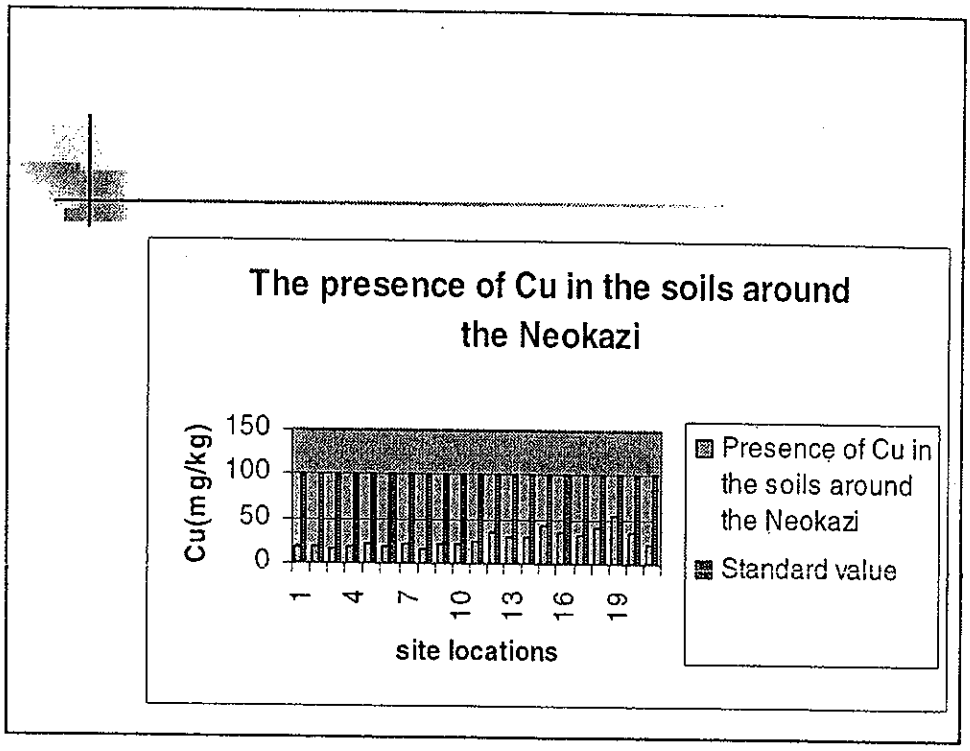

The presence of Pb in the soils around the Kocani
Pb(mg/kg)
150
100
50
0
1
4
7
10
13
16
site locations
Precence of Pb in the soils around the Kocani
Standard value

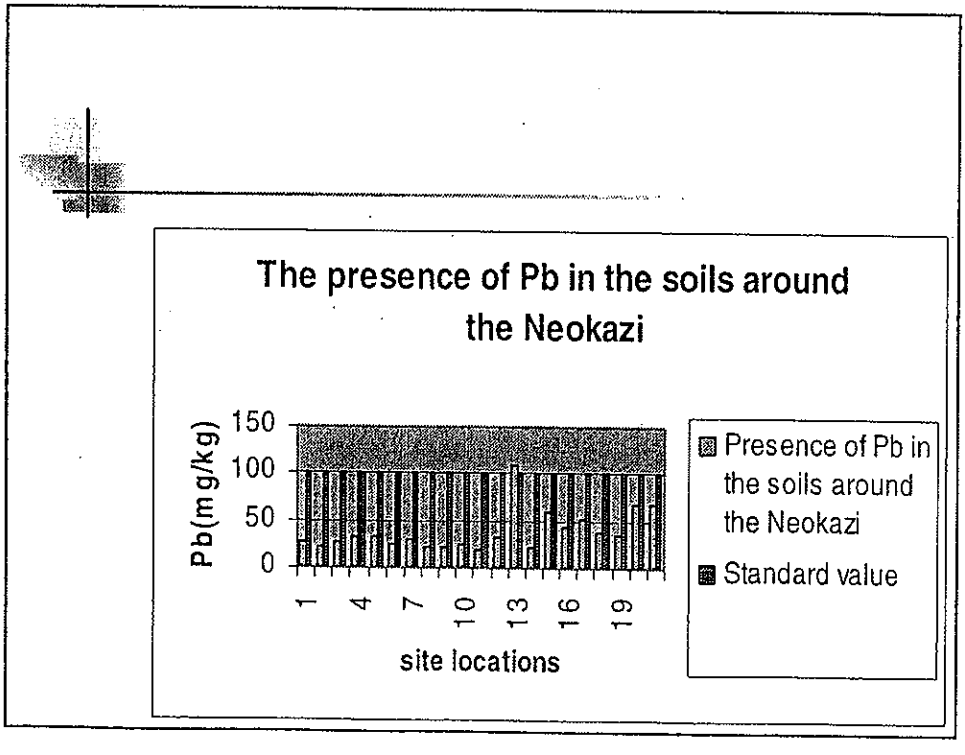

The presence of Cr in the soils around the Kocani
Cr(mg/kg)
200
100
0
1
4
7
10
13
16
site locations
Presence of Cr in the soils around the Kocani
Standard value

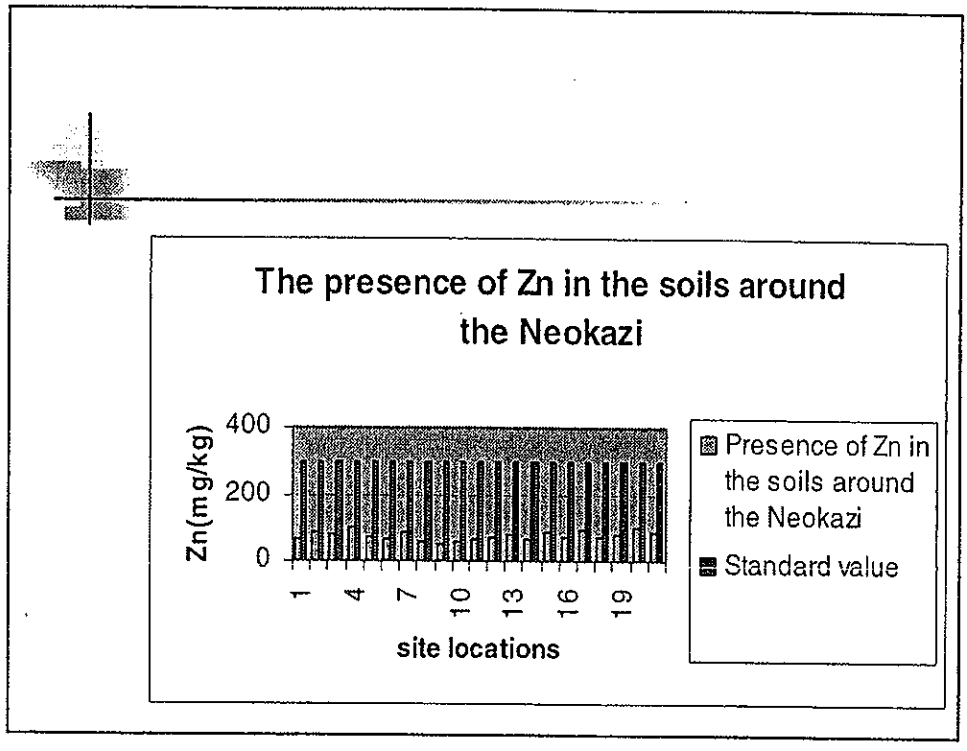

The presence of Cd in the soils around the Kocani
Cd(mg/kg)
10
5
0
1
4
7
10
13
16
site locations
Presence of Cd in the soils around the Kocani
Standard value

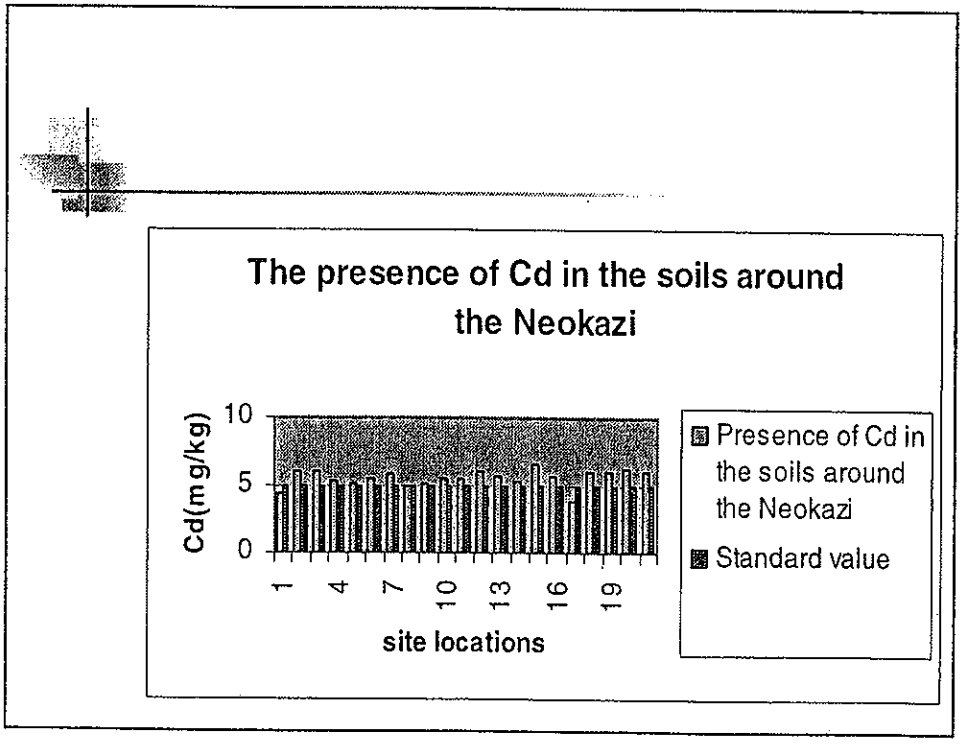
Neokazi (Probistip)



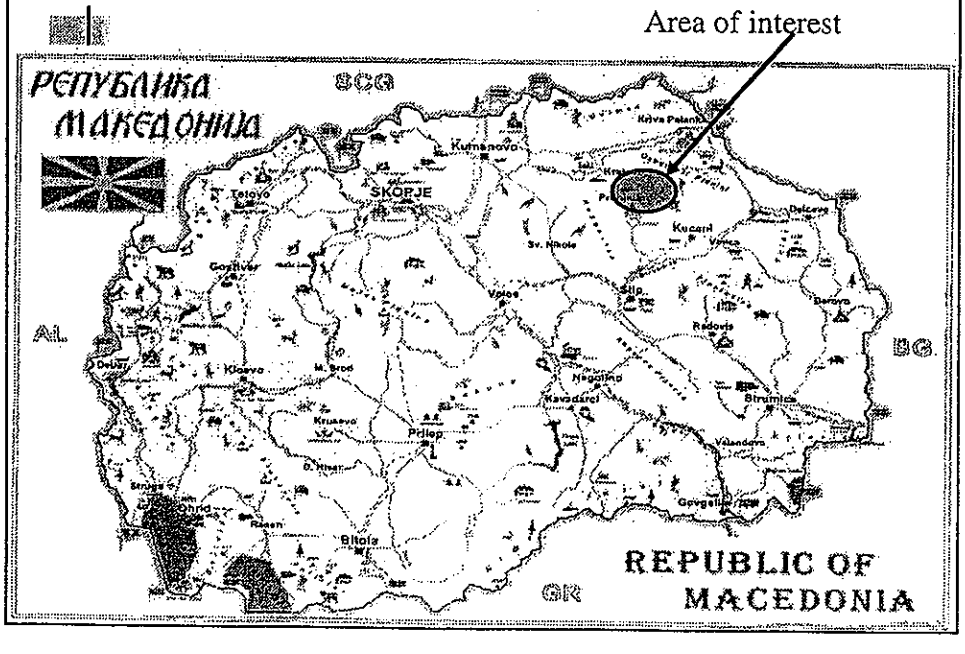

The presence of Cu in the soils around the Neokazi
Cu(mg/kg)
150
100
50
0
1
4
7
10
13
16
19
site locations
Presence of Cu in the soils around the Neokazi
Standard value

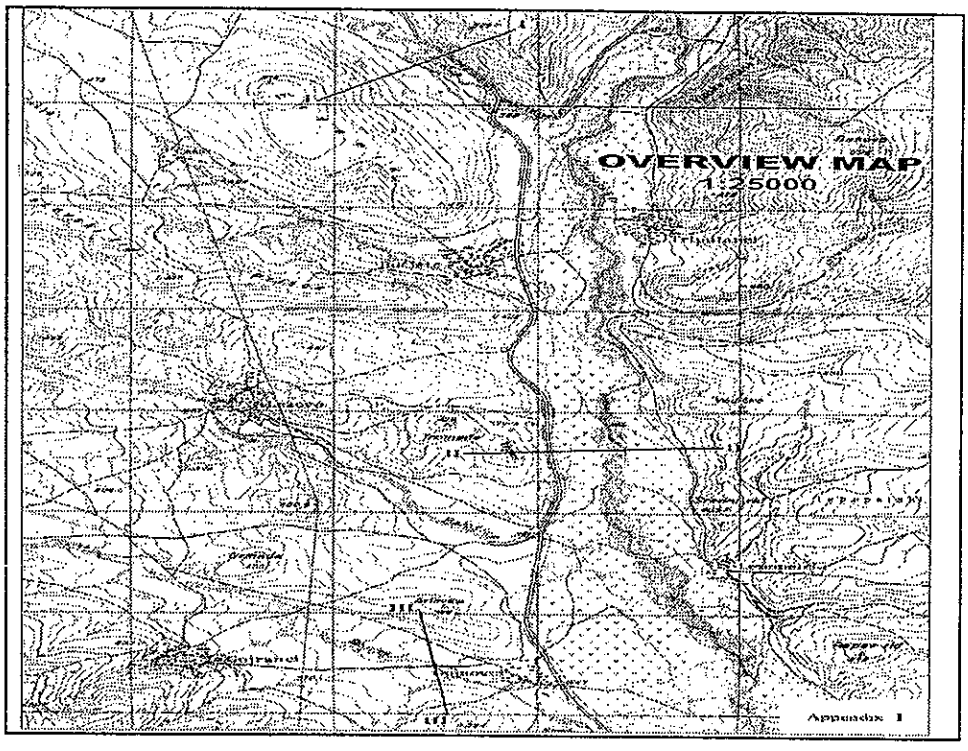

The presence of Pb in the soils around the Neokazi
Pb(mg/kg)
150
100
50
0
1
4
7
10
13
16
19
site locations
Presence of Pb in the soils around the Neokazi
Standard value

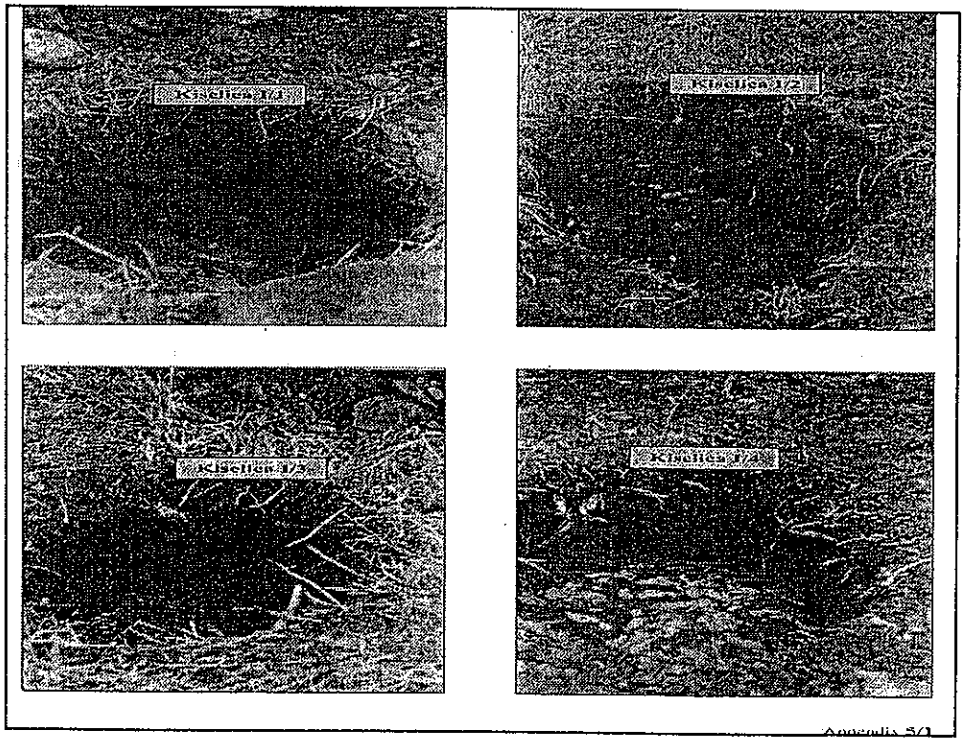

The presence of Zn in the soils around the Neokazi
Zn(mg/kg)
400
200
0
1
4
7
10
13
16
19
site locations
Presence of Zn in the soils around the Neokazi
Standard value


The presence of Cd in the soils around the Neokazi
Cd(mg/kg)
10
5
0
1
4
7
10
13
16
19
site locations
Presence of Cd in the soils around the Neokazi
Standard value

Zletovska River

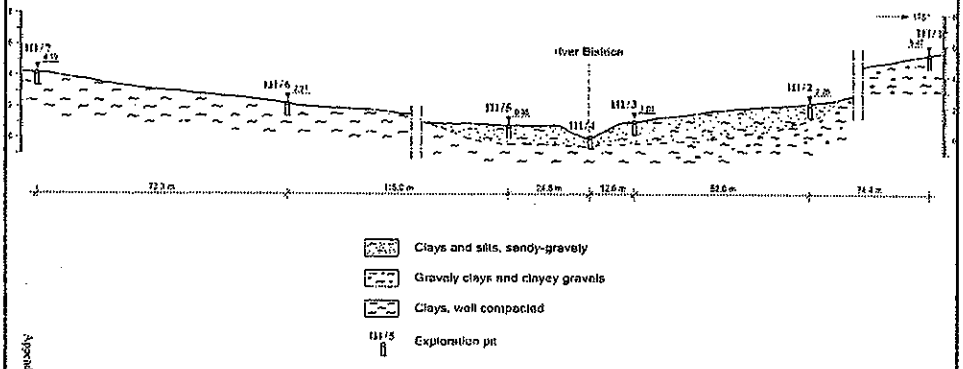



OVERVIEW MAP
1:25000
Appendix 1


Satellite 1/4
Satellite 2/4
Satellite 3/4
Satellite 4/4

LONGITUDINAL GEOLOGICAL PROFILE III – III

Scale = 1: $\frac{1000}{200}$



Clays and silts, sandy-gravely

Gravely clays and clayey gravels

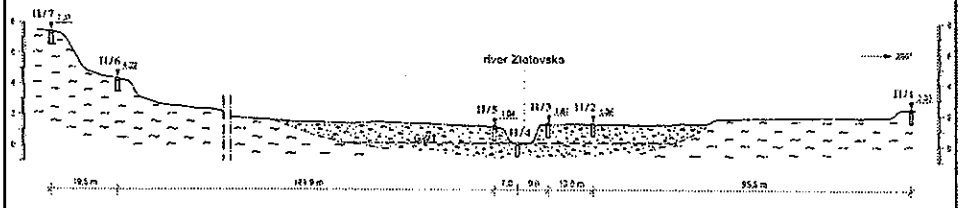
Clays, well compacted

Exploration pit

Appendix 3/3

LONGITUDINAL GEOLOGICAL PROFILE II – II

Scale = 1: $\frac{1000}{200}$



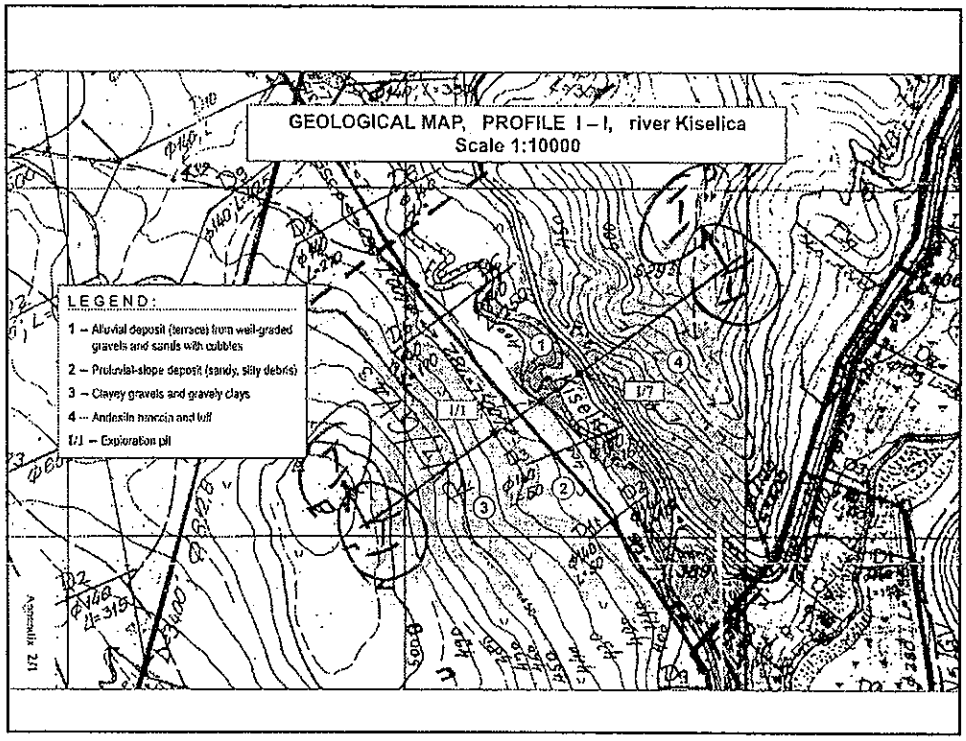
Alluvial deposit (terrace) from well-graded gravels and sands with cobbles

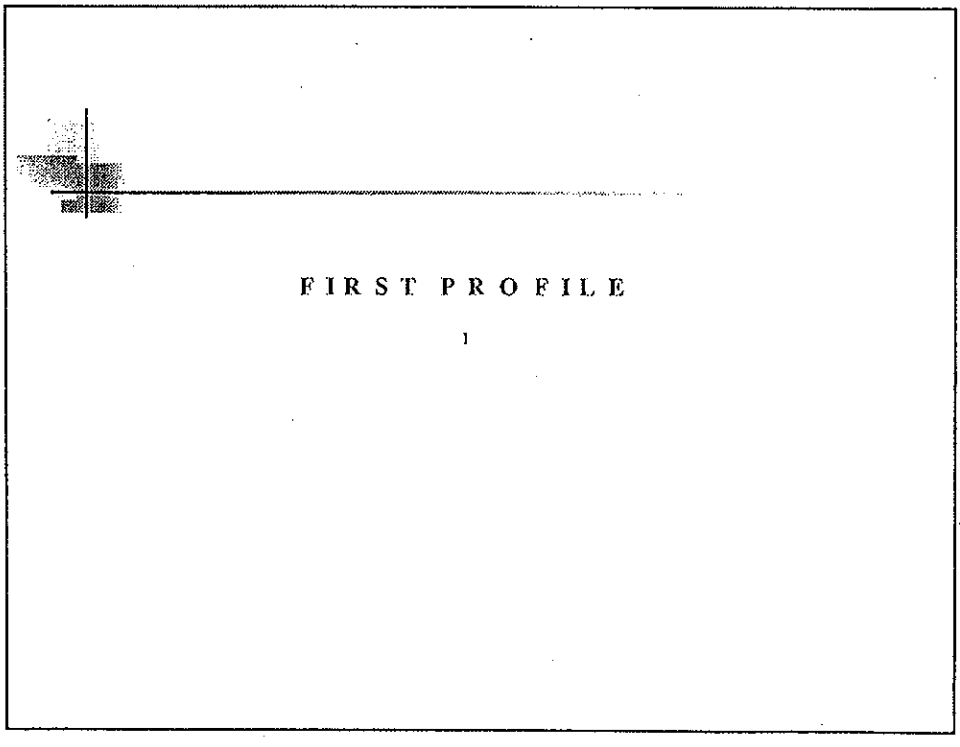
Clays, well compacted

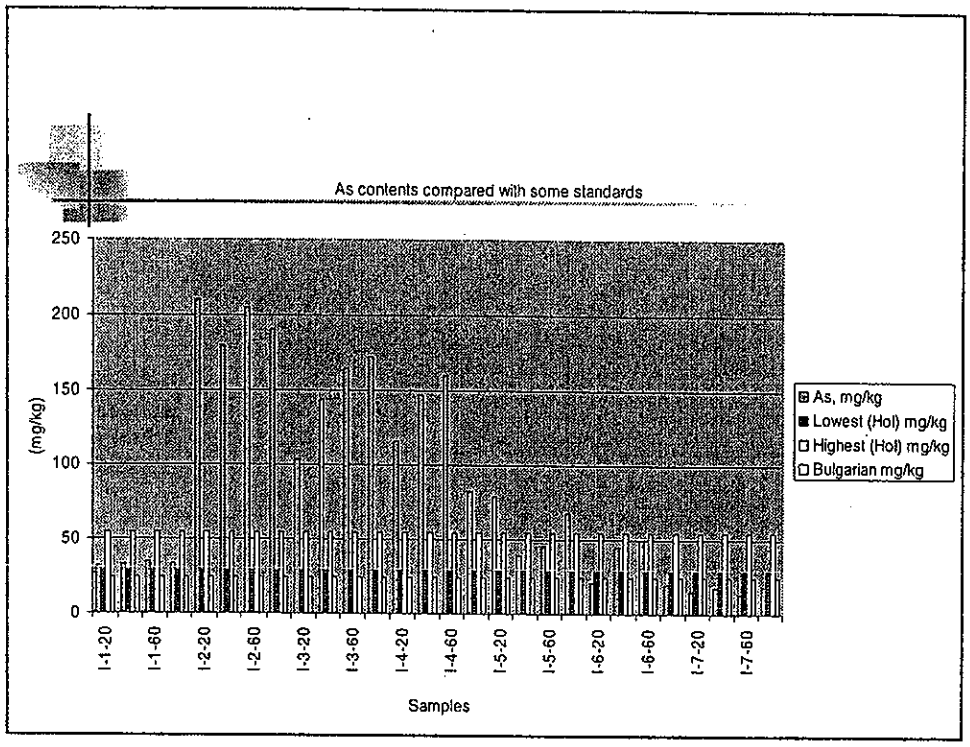
Exploration pit

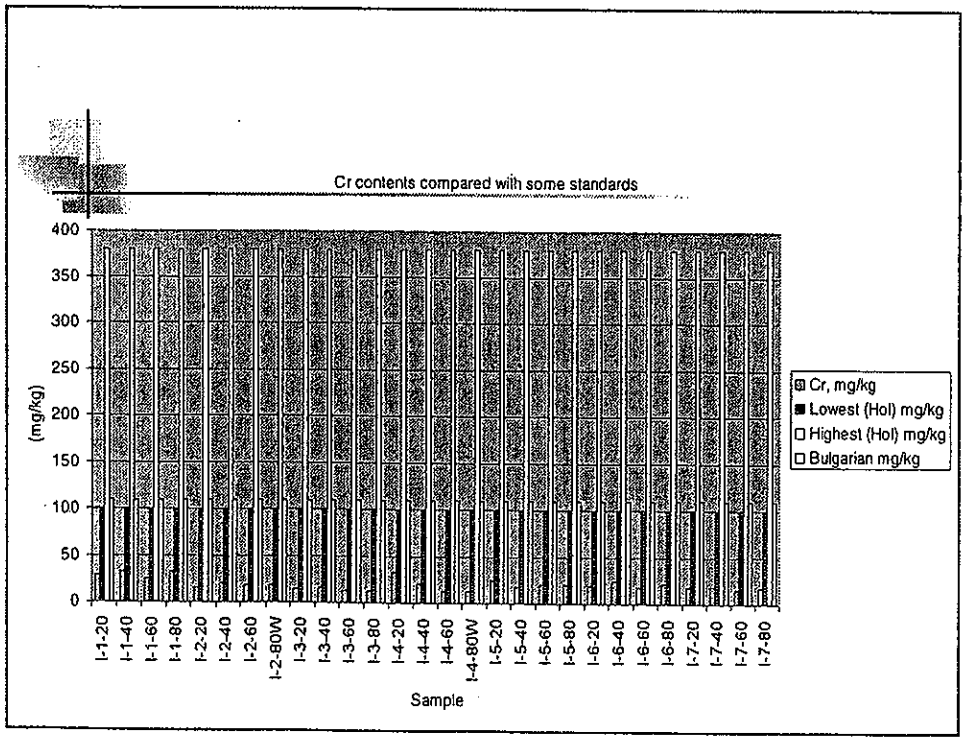
Groundwater table

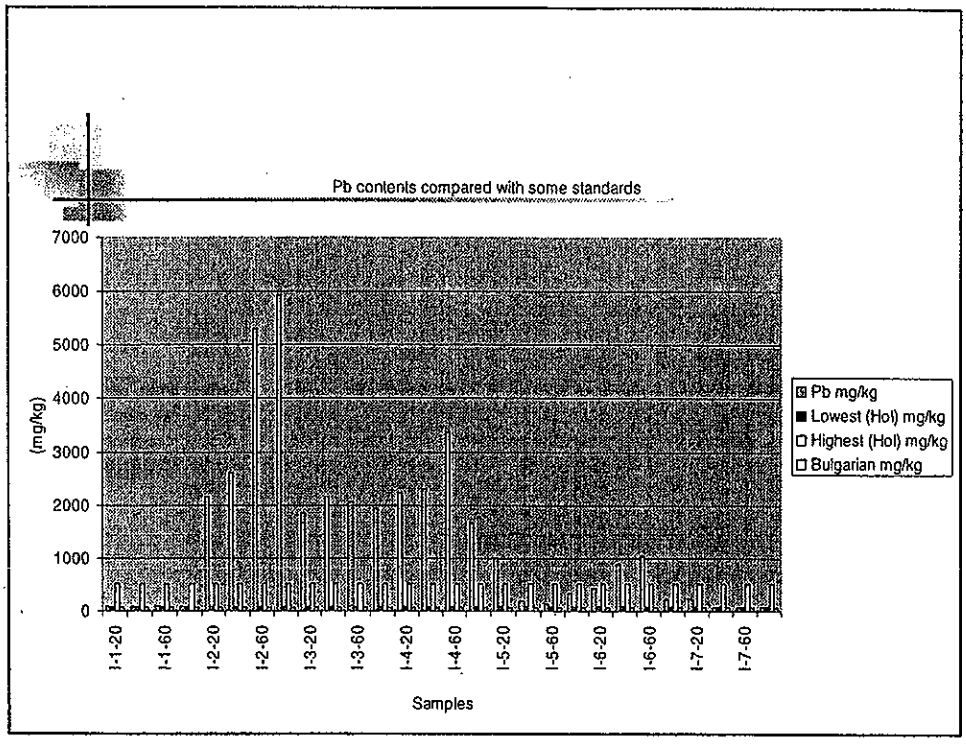
Appendix 3/2

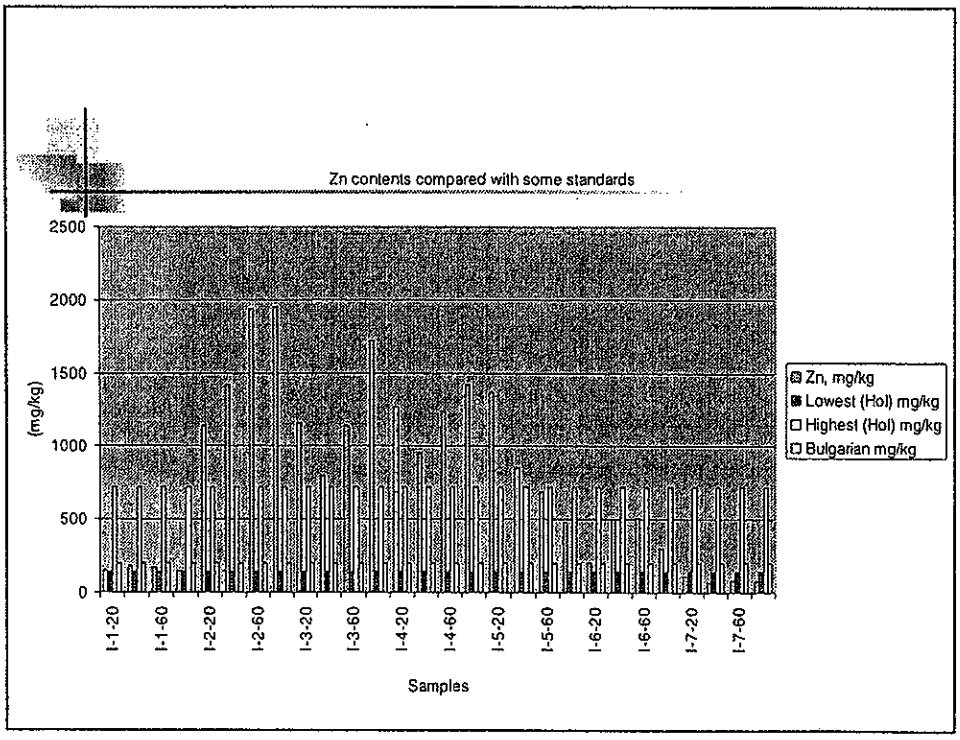

GEOLOGICAL MAP, PROFILE I – I, river Kiselica
Scale 1:10000
LEGEND:
1 – Alluvial deposit (terrace) from well-graded gravels and sands with cobbles
2 – Proluvial-slope deposit (sandy, silty debris)
3 – Clayey gravels and gravely clays
4 – Andesite hancsin and tuff
I/1 – Exploration pit

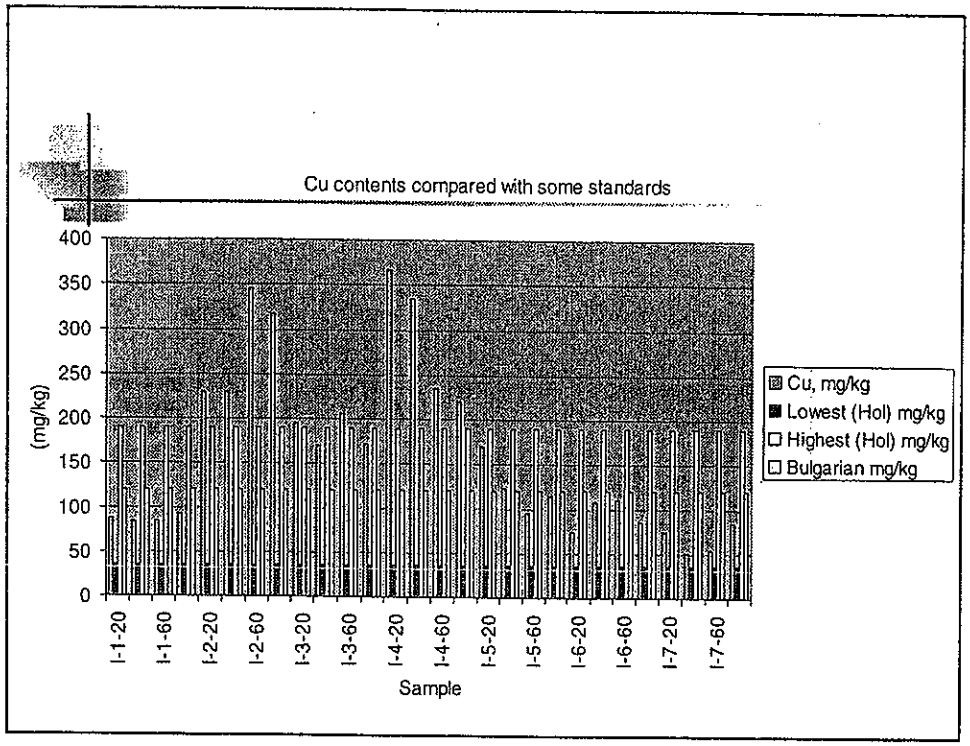

FIRST PROFILE
1

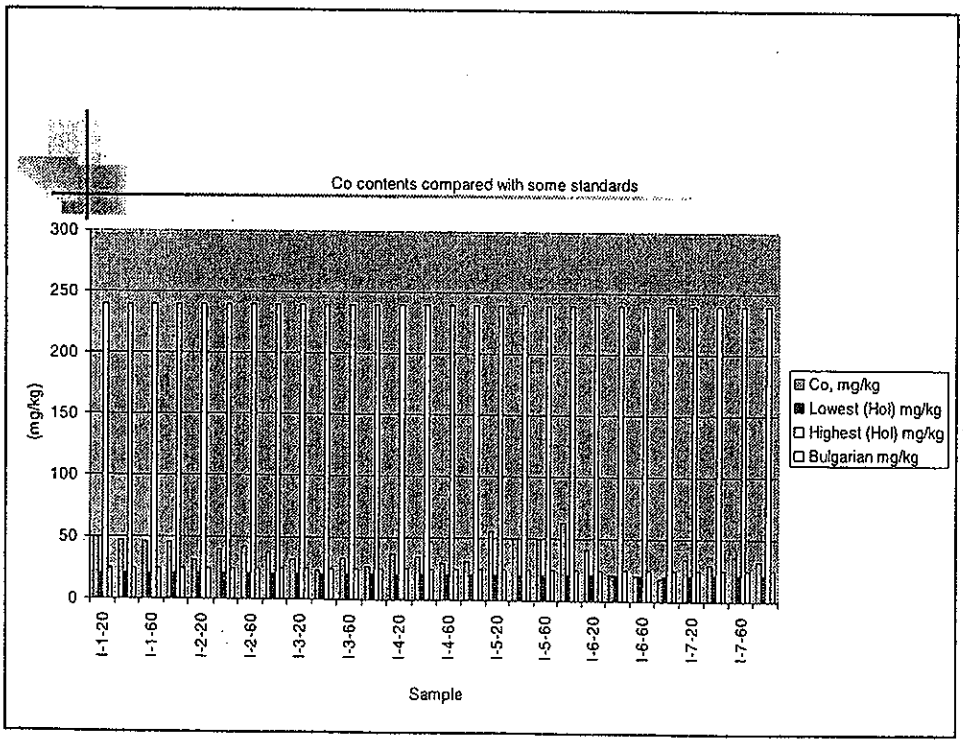

As contents compared with some standards
250
200
150
100
50
0
(mg/kg)
I-1-20
I-1-60
I-2-20
I-2-60
I-3-20
I-3-60
I-4-20
I-4-60
I-5-20
I-5-60
I-6-20
I-6-60
I-7-20
I-7-60
Samples
As, mg/kg
Lowest (Hol) mg/kg
Highest (Hol) mg/kg
Bulgarian mg/kg


Cr contents compared with some standards
400
350
300
250
200
150
100
50
0
(mg/kg)
I-1-20
I-1-40
I-1-60
I-1-80
I-2-20
I-2-40
I-2-60
I-2-80W
I-3-20
I-3-40
I-3-60
I-3-80
I-4-20
I-4-40
I-4-60
I-4-80W
I-5-20
I-5-40
I-5-60
I-5-80
I-6-20
I-6-40
I-6-60
I-6-80
I-7-20
I-7-40
I-7-60
I-7-80
Sample
Cr, mg/kg
Lowest (Hol) mg/kg
Highest (Hol) mg/kg
Bulgarian mg/kg


Pb contents compared with some standards
7000
6000
5000
4000
3000
2000
1000
0
(mg/kg)
I-1-20
I-1-60
I-2-20
I-2-60
I-3-20
I-3-60
I-4-20
I-4-60
I-5-20
I-5-60
I-6-20
I-6-60
I-7-20
I-7-60
Samples
Pb mg/kg
Lowest (Hol) mg/kg
Highest (Hol) mg/kg
Bulgarian mg/kg


Zn contents compared with some standards
2500
2000
1500
1000
500
0
(mg/kg)
I-1-20
I-1-60
I-2-20
I-2-60
I-3-20
I-3-60
I-4-20
I-4-60
I-5-20
I-5-60
I-6-20
I-6-60
I-7-20
I-7-60
Samples
Zn, mg/kg
Lowest (Hol) mg/kg
Highest (Hol) mg/kg
Bulgarian mg/kg


Cu contents compared with some standards
400
350
300
250
200
150
100
50
0
(mg/kg)
I-1-20
I-1-60
I-2-20
I-2-60
I-3-20
I-3-60
I-4-20
I-4-60
I-5-20
I-5-60
I-6-20
I-6-60
I-7-20
I-7-60
Sample
Cu, mg/kg
Lowest (Hol) mg/kg
Highest (Hol) mg/kg
Bulgarian mg/kg


Co contents compared with some standards
300
250
200
150
100
50
0
(mg/kg)
I-1-20
I-1-60
I-2-20
I-2-60
I-3-20
I-3-60
I-4-20
I-4-60
I-5-20
I-5-60
I-6-20
I-6-60
I-7-20
I-7-60
Sample
Co, mg/kg
Lowest (Hol) mg/kg
Highest (Hol) mg/kg
Bulgarian mg/kg