RISK PERCEPTION AND COMMUNICATION IN LAVRION

by *EurGeol* Alecos DEMETRIADES[1]

How does one communicate risk to people that live and work in one of the most extremely contaminated areas in Europe, and where the health related consequences are not so evident? This was one of the most serious and challenging issues that the team of researches from the Hellenic Institute of Geology & Mineral Exploration (I.G.M.E.), the National Technical University of Athens (N.T.U.A.), and PRISMA, faced at the end of the project **"Soil Rehabilitation in the Municipality of Lavrion"** (see below the risk communication information leaflet). The I.G.M.E. geoscientists had a lot more experience, because they worked in the area since 1989 and had personal contact with many local people, teachers, medical officers, local and central politicians, and also were acquainted with the results of three cross-sectional epidemiological studies.

Perception of environmental risk in an area where the people worked in mines and smelters, for almost their whole life, and their homes are built on hazardous wastes, is indeed difficult to communicate. Whole families are known to suffer from signs of mental retardation, because of high blood-lead concentrations. As one medical officer said: "*these people are at a disadvantage, because they are born in area where environmental contamination causes a reduction in their I.Q., which depends on the physiology of each person*".

It is worth mentioning the reaction of a person with noticeable mental retardation, when told that the Lavrion urban area is highly contaminated and may cause health problems: "*we have been raised here, and we are not stupid!*" Evidently, this particular person is not in a position to perceive the health risk. During our work in the Lavrion urban area and Lavreotiki peninsula, we have met families with quite evident mental retardation, but seemingly happy with their lives. Therefore, the first problem of communicating risk lies on the capability of people to understand the hazardous environmental conditions.

The other problem comes from politicians of both the local and central government that do not want to know anything about the health related hazard in the Lavrion urban area and Lavreotiki peninsula, although they are aware of the conditions. The I.G.M.E., as a State research institute, is obliged to submit its environmental impact assessment reports to all interested parties, *i.e.*, Municipalities and Ministries. Up to now three reports have been submitted, *i.e.*, the first in 1992 was concerned with the urban geochemistry of Lavrion and Aghios Constantinos; the second in 1994, covered the whole Lavreotiki peninsula (170 km^2) with soil geochemistry, and the third in 1999 was a very detailed multidisciplinary environmental impact and management study that covered the Lavrion urban and suburban environment (7 km^2). Therefore, the politicians are well aware of the health related hazards, but are not interested to find a viable solution.

To understand the attitude of local politicians the following statement from one of them is mentioned: "*we cannot publicise the results of your study, because if we do, people will be scared and most likely leave. New buyers will not be interested to invest in the area, and, therefore, property prices will be affected*". Although, environmental quality is an issue of concern on paper, and included in the political agenda of all parties, when a real health related environmental issue is raised the first variables examined are property prices and political cost. Therefore, scientists communicating environmental risk, should take into account how this is perceived, not only by the inhabitants, but also by the local and central politicians.

Since, we knew that it will be difficult to communicate environmental risk in the Lavrion urban area, during the compilation of the LIFE project, a number of communication actions were included: (a) compilation of an information leaflet (see below), (b) a video tape showing project results and recommendations, and (c) public presentation of results. The information leaflet with recommendations to the local inhabitants was never distributed; it remained in the storerooms of the Municipality. Not many people came to the public presentation of project results; again the invitations were the responsibility of Municipality officers. The Mayor, during the presentation, intervened by stating that the situation is not so serious, since he and his family lived all their lives in Lavrion and there is nothing wrong with their health. The scenario of the videotape was carefully written to communicate project results in an understandable manner, and not to cause unrest to the local population. The videotape was never shown to the public and schools. The irony of the situation is that the Municipality of Lavrion was the co-ordinator of the project.

How does one communicate risk, therefore, to people that are not interested to hear the truth about the state of their living environment, and to politicians that are mainly concerned about the political cost and property prices, and not the improvement of the quality of the urban environment and the health of people?

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SOIL REHABILITATION IN THE MUNICIPALITY OF LAVRION

Leaflet compiled by

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SOURCES OF FINANCE

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PROJECT OBJECTIVES

The main objectives of the project were:

- To determine the present state of environmental contamination in the greater Lavrion area, focusing mainly on soil contamination, with respect to lead and other toxic elements.
- To define the main sources of contamination in the area.
- To select and apply methods, which will hinder the further contamination of soil by applying preventive measures at the contamination sources.
- To select and apply remedial measures for the rehabilitation or neutralisation of contaminated land, and
- To develop an integrated environmental management scheme for the greater Lavrion urban area.

INSTITUTIONS EXECUTING THE PROJECT

Project Coordinator: Municipality of Lavreotiki

Project Management: PRISMA

Scientific partners: Institute of Geology and Mineral Exploration (I.G.M.E.) and National Technical University of Athens (N.T.U.A.)

Project manager: Nikos Varelidis

Project scientific team:

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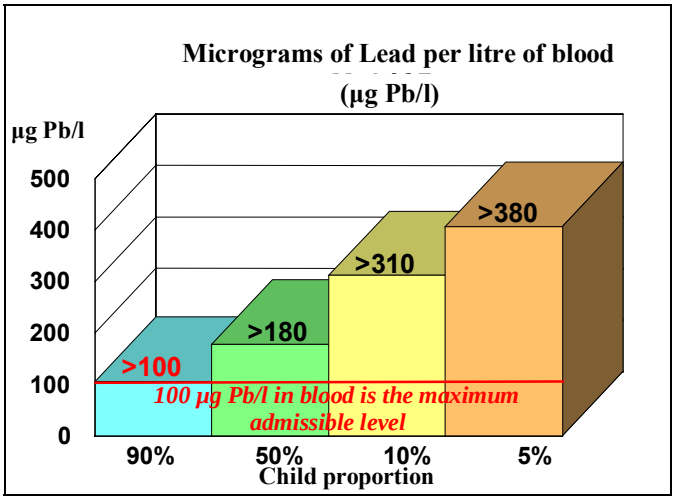
EPIDEMIOLOGICAL STUDIES

The problems and effects of contamination in the Lavrion urban area were detected to begin with by cross-sectional epidemiological studies in the 1980's. Their conclusion was that children of nursery and primary school age had a severe problem of lead-poisoning (plumbosis). In addition, their system had high concentrations of arsenic. The last cross-sectional epidemiological study, which was carried out in 1988 on 235 children from Lavrion, showed the seriousness of environmental contamination on the health of children.

CONCENTRATIONS OF LEAD IN CHILD BLOOD

- 90% of the children (n=235) that participated in the cross-sectional epidemiological study had more than 100 micrograms of lead per litre of blood,
- 50% had more than 180 micrograms of lead per litre of blood,
- 10% had more than 310 micrograms of lead per litre of blood, and
- 5% had more than 380 micrograms of lead per litre of blood.

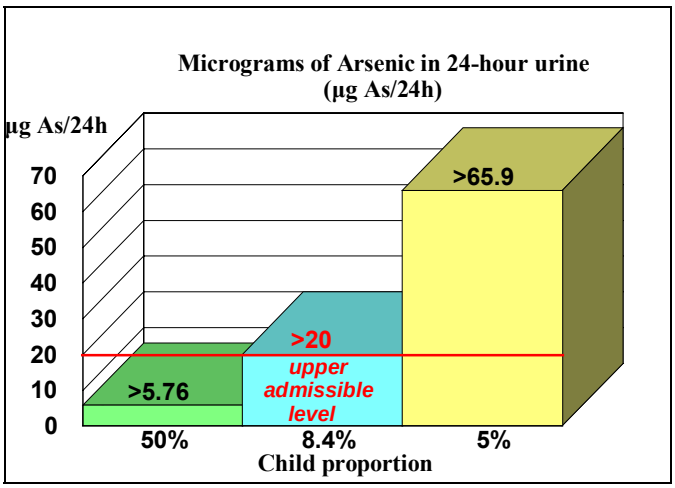


Number of children: 235

It is noted that 100 µg Pb/litre of blood is the upper acceptable limit for children (i.e., 10 µg Pb/100 ml or 10 µg Pb/decilitre).

CONCENTRATIONS OF ARSENIC IN CHILD URINE

- 8.4% of the children (n=235) that participated in the cross-sectional epidemiological study had more than 20 micrograms of arsenic in 24-hour urine, and
- 5.0% had more than 65.9 micrograms of arsenic in 24-hour urine.



Number of children: 235

It is noted that 20 µg of Arsenic (As) in 24 hour urine is the upper acceptable limit for children (20 µg As/24 hr).

The cross-sectional epidemiological studies have also shown that there is a strong correlation between high blood-lead levels in children and

(1) their composite mental functions, *i.e.*, intelligent quotient (IQ), verbal intelligence quotient (VIQ), &

(2) a comparative reduction in their development, especially with respect to the circumference of their head and chest.

METALLURGICAL WASTES AND SOIL CONTAMINATION

The geographical distribution of contamination, in relation to metallurgical processing wastes, has been mapped in detail by the I.G.M.E. geoscientists. The metallurgical wastes, constitute the major source of contamination, and can be grouped into three broad categories: *flotation residues, pyritiferous tailings* and *slag*.

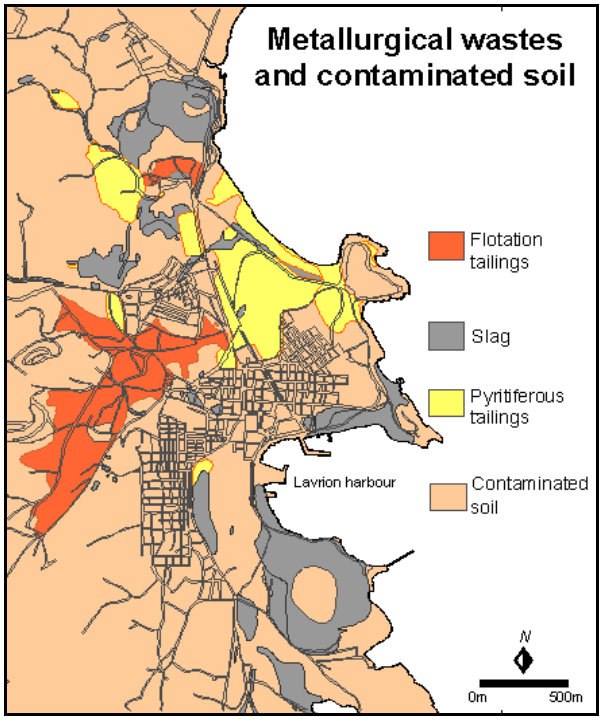
The ***flotation residues*** or tailings from the beneficiation of ore, which are called "savoura" by the inhabitants of Lavrion, cover a significant part of the residential area. They extend from the Alako factory, cover the larger part of "Prasini Alepou", the area with the sport installations, the Mineralogical Museum, the Secondary School, and almost reach the smelter of the French Company. They contain high concentrations of toxic elements, such as lead, cadmium, arsenic, antimony, *etc.* The flotation residues are considered to be the most hazardous metallurgical processing wastes, because a large part of the town of Lavrion is built over them, and the local population, and children especially, come in contact with the contaminated material.

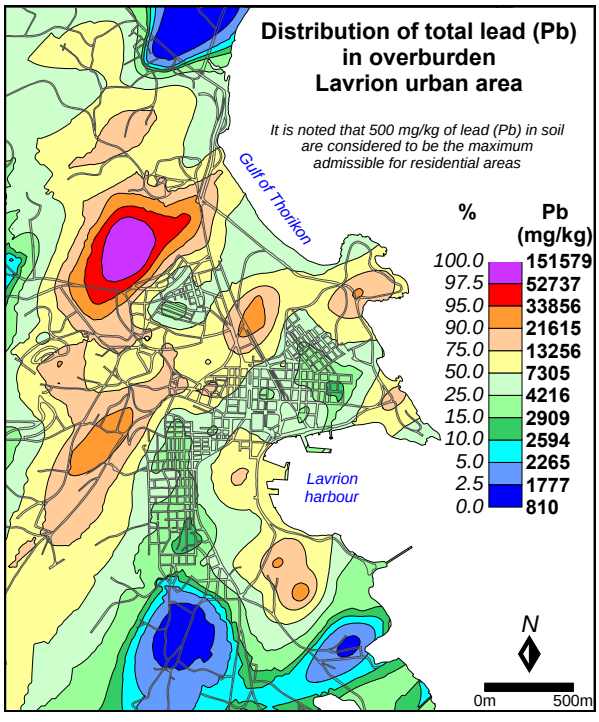
Pyritiferous tailings are wastes from the beneficiation of ore. Pyrite, apart from having high toxic element contents, is oxidised by the action of air and rain, and produces acid drainage, *i.e.*, the water coming into contact with pyrite becomes acid and highly contaminated. Pyritiferous tailings are found mainly along the coastal part of Thorikon and at Kavodokanos.

Slag is the waste from the melting of ore for the production of silver bearing lead. It is found round natural hills in the southern and northern part of Lavrion and on beaches. Slag has been used as hardcore for road construction, school yards, port facilities, *etc.*

The great area covered by the metallurgical processing wastes, their continuous shifting from one place to another, and their use by the inhabitants, as well as the transportation of their fine-grained component by strong winds, blowing in the area, has resulted in the multi-element contamination of soil.

Due to the above mentioned reasons the soil of the Lavrion urban area is at the present time, as a whole, heavily contaminated by toxic elements, such as lead, arsenic, antimony, cadmium, mercury, etc.





Note: Norway for residential areas, and especially kinder gardens, has lowered the Pb level in soil to 120 mg/kg. The variation of Pb in the Lavrion surface soil is from 810 to 151,579 mg/kg, with a median of 7305 mg/kg.

DEMONSTRATION SCALE REHABILITATION PROJECTS

At the N.T.U.A. laboratory different rehabilitation technologies were studied, and the most efficient applied on a demonstration scale at the following sites:

Rehabilitation Sites

1. At the "Kavodokanos" site for neutralisation of pyrite or sulphide tailings, and
2. At the "Neraki" site for stabilisation of flotation residues or the oxidised carbonate wastes.

Site description

"Kavodokanos": The site was flattened and divided into four equal sections. One was kept as a control site and covered only by clean soil. The remaining three sections were encapsulated by:

- Synthetic geomembrane,
- Compacted clay, and
- Carbonate material,

and subsequently covered by clean soil.

Special lysimeters were constructed below the four sections to measure the amount, and control the quality, of infiltrated water, which was collected in volumetric tanks.

"Neraki": The site was flattened and divided into six longitudinal equi-dimensional sections, separated by a strip of one metre width. One section was kept as a control site, and in the other five, the flotation residues were thoroughly mixed with five different mixtures of organic and inorganic materials, and a mixture of seeds sowed, to concurrently achieve chemical stabilisation of contaminants and to develop a vegetative cover. The same mixture of seeds were sowed also in the control section. The five different stabilisers were:

- phosphate fertiliser and compost,
- fly ash and compost,
- biological sludge and fly ash,
- biological sludge and phosphate fertiliser, &
- biological sludge.

Effectiveness of rehabilitation methods

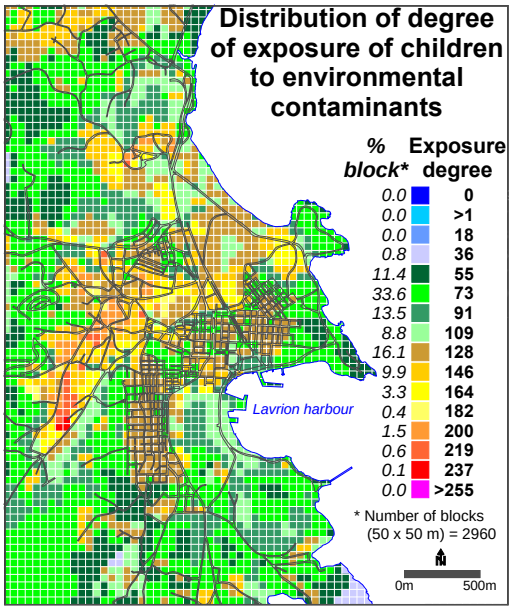
"Kavodokanos": The pilot project works were completed in October 1996, and since then the project is under continuous monitoring. At the control site, as from January 1998, continuous infiltration of water is observed. The volume of collected water corresponds to approximately 21 cubic metres per year per 1000 m^2, and its contaminant load is considerably high. Covering of pyrite with synthetic geomembrane and compacted clay proved to be very effective techniques. During the three years of continuous monitoring of the project, infiltration of water from both sections was essentially nil. *Note: After five years, all rehabilitation methods failed, and this was attributed to under estimation of the acid drainage generated.*

"Neraki": The vegetation cover was completed in December 1997. The project is at present going through its second year of development. The control section remains completely bare, whereas vegetation is successfully reproduced in the five stabilised sections, thus creating the necessary protective cover for reducing the aerial transportation of material. *Note: After ten years, it continues to be successful.*

INTEGRATED ENVIRONMENTAL MANAGEMENT SCHEME

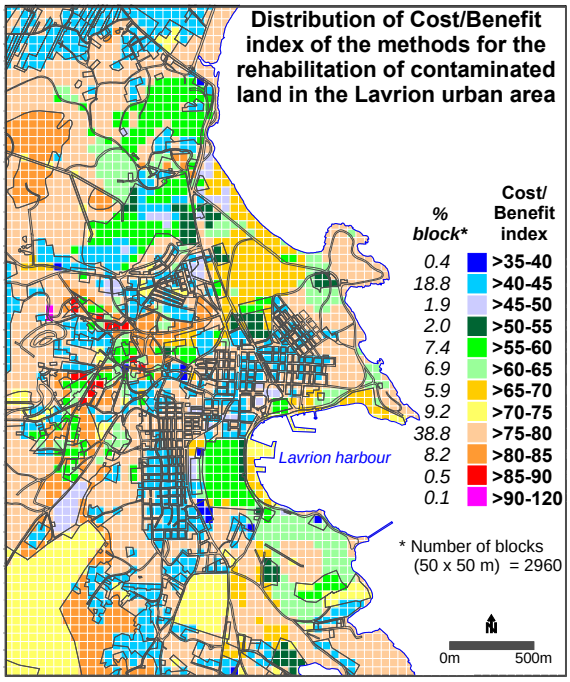
Development of an integrated environmental management scheme for the greater Lavrion urban area constitutes the ultimate aim of the whole study. For its realisation relevant data, generated during the project, were used, *i.e.*, geochemical distribution maps of toxic elements, metallurgical processing wastes map, land use map, hazard and child exposure assessment maps, pilot project rehabilitation techniques, *etc.*

Human exposure assessment to environmental contamination is defined by the concentration of a contaminant (e.g., in air, soil, water) and the available quantity for inhalation and ingestion or dermal absorption.



The map shows the degree of child exposure to different contaminant sources in the Lavrion urban and suburban area. Exposure ratings are on an arbitrary scale varying from 0 to 255. The estimations were made on blocks of 50 x 50 m. The map indicates that the greater exposure to environmental contaminants is in the area with the beneficiation wastes. As it has been shown by the rehabilitation tests, vegetation cannot be developed on these wastes. Therefore, dust is easily generated by wind and human activities.

Utilisation of conclusions, resulting from the work carried out, and after considering the effectiveness and cost of alternative technologies for rehabilitation, the planning and gradual application of remediation actions could start.



The cost/benefit index map shows the distribution of the ratio of the cost index in relation to the benefit index of the recommended rehabilitation methods for the Lavrion urban environment. For its compilation the degree of child exposure to environmental contaminants, and other parameters were used, taking into account that the required objective is the rehabilitation of the surface environment, in an appropriate manner, to reduce child exposure to toxic elements derived from the metallurgical processing wastes and contaminated soil.

It is noted that the lower the cost/benefit index of a block of land, the higher is the priority for its rehabilitation.

Note: The recommendation to the Lavrion Municipality was, after informing the people about the state of the urban and suburban environment, to subsidise each owner to rehabilitate his/her property with supervision by the technical services of the Municipality.

The cost of rehabilitation of the Lavrion urban area is very high, but the investment is worth while for the health of children and of the local population is in general of far greater significance

BASIC INSTRUCTIONS TO THE INHABITANTS

Until the rehabilitation of the Lavrion urban environment is completed, the local population must change certain habits and activities, such as:

X

X Not to cultivate vegetables, olive trees and vines. It is known that all these plants accumulate large quantities of toxic elements, which are hazardous to human health.

X

X Gathering and consumption of wild green plants should stop, for these plants also accumulate large quantities of toxic elements, which are hazardous to human health.

√

✓ House cleaning must be done with an electric vacuum cleaner or wet moping, and not with traditional methods, *i.e.*, common broom, because dust is generated, which is subsequently inhaled and, further, it is transported to other places within the home, and may settle on food.

X

X Carpets and rags must not be shaken or beaten with a stick.

√

✓ Dusting must not be done with a feather, but a lightly moist cloth should be used instead.

X

X Children must not play with soil, for apart from inhalation, toxic elements could enter their body through ingestion, because of hand-to-mouth activity, as well as by dermal absorption.

√

✓ Children must learn to wash their hands often and, especially before meals.

√

✓ Food must be covered, and should not remain expose to dust for a long time.

Note: Informing the people about the state of the surface environment was considered to be a very important obligation of the Municipality officers. The compilation of the leaflet served three purposes: (a) to publicise project results, (b) to communicate project results to the people and the daily health risk they are facing, and (c) to give the people some basic instructions to minimise, as much as possible, their exposure to environmental contaminants.