

# Influence of environment on population health in Copsa Mica

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## Abstract

Copsa Mica is the town with the highest degree of pollution in Romania. A number of highly polluted industrial units have appeared in a concentrated area since 1935. Between 1950 and 1980 the town developed at high speed due to the policy of forced industrialization and eventually the number of inhabitants declined. Because of the faulty distribution of industries, the natural environmental conditions facilitate the spreading of polluting agents not only inside the town's perimeter but also in the neighboring areas. The most intensive polluting agents are the sulphur dioxides, lead, the solid particles in suspension, cadmium, and other similar substances, which are present in the atmosphere, in the subsurface and surface water, in the soil and on the vegetation. Pollution affects the health of the local population as well, mostly that of children. The toxic substances enter the human body through the polluted air, water and food from the affected areas. The spatial and temporal variation of pollution ranges between wide limits according to the intensity of industrial pollution and the environmental conditions. The concentrations sometimes exceed ten times the limit of acceptance.

## 1 Natural and anthropic conditions

Copsa Mica is a typical industrial Romanian town. It lies in the central part of the country, in Transylvania, on the river Tarnava Mare. Before WW I, small industrial units came into being but after the war this process knew uncontrolled acceleration. The fact that the natural conditions - orographical and meteorological- are not favorable for the setting up of polluting industries was also ignored.

The Tarnava Mare valley unfolds on the east-western line, at an altitude of 300 meters under the influence of neotectonic movements, base oscillations and selective erosion. The town is situated in a small extension of the valley structured like a microbasin.

The climate has a temperate-continental character, with an average temperature of 8.6 °C and annual precipitation of 623 mm. The average temperature in January is -1.02 °C and in July 22.2 °C. The distribution of rainfalls varies between 200 mm in spring and in summer and 146 mm in autumn, whereas in winter the precipitation is scarce (78 mm). The most important agent responsible for the spreading of polluting substances is the wind. It predominantly blows westward, in the direction of the large air mass movement, also facilitated by the orientation of the valley.

The river Tarnava Mare carries the polluting agents at considerable distance. The hydrographic basin overlooking the town has a capacity of 2700 km<sup>2</sup> and an average volume of 13.3 m<sup>3</sup>/s, which may also rise to 1000 m<sup>3</sup>/s during floods. The subsurface water reaches as deep as 1-3 m and the depth increases in the direction of the fluvial terraces. Its distribution is influenced by the loose, porous soils and the subsurface stratification.

Greatly affected by pollution, the vegetation has the following configuration: hygrophil plants predominate along the valley, while the fluvial terraces are covered with polders, grassland and strips of forested lands. Agriculture is practiced in the areas with fertile soils.

The industrial area is situated between the railway and the river stretching linearly towards east – west. Three residential areas can be identified here: the old village – east of the industrial zone along both sides of the river; the new village – also in the east, along the road, and the new district of blocks -of –flats, south of the industrial units. Comparatively, the administrative zone occupies the central part. In the allotting of the functional areas the environmental conditions of the region, mainly the dynamics of the meteorological elements, were highly neglected. Thus, two areas of residence together with the administrative area are situated in the direction of polluting-agents transmission.

The number of inhabitants has been declining since 1980, with a total population of barely 5000 people today. A constant decline was recorded especially after 1991, when the industrial activity desisted, triggering massive emigration and a serious diminishing of the birth rate from 9.1 to 4.4 within one year. In 1997 a negative birth rate was recorded for the first time. The industrial regression affects primarily the population engaged in industry, which totals two-thirds of the whole population, as compared to only 3 - 4 % who belong to such sectors as education, health and culture.

## **2 The polluting effect of industrial activity**

The presence of industry in Copsa Mica is justified by the existence of methane deposits in the central part of Transylvania and of non-ferrous deposits in the inner exposure of the Carpathian range.

The chemical processing of methane began in 1935, and for many years and with low profit, carbon black was the major output. The production technology has already been improved several times and the range of products diversified mainly due to the organic acids used in the technology. After 1990 the production diminished gradually.

The first plant for non-ferrous ore processing has been put into function in 1939, the major technology being zinc elevation. The plant started to extend gradually and after the 50s, especially after the 60s, its development was only sporadic. Several other substances, such as lead, cadmium, various oxides, zinc sulfate, sulfuric acid, etc. were now the new outputs. At present, its production has diminished considerably and efforts have been made to raise it to European standards.

The industrial activity has polluted the environment to a great extent and has altered its natural and anthropic constituents. Besides the atmospheric, hydrospheric, pedospheric and biospheric pollution, it has also affected the quality of the inhabitants life and the general development of society.

## 2.1 Air Pollution

Huge quantities of aerosols (dust, smoke) and gases are eliminated in the atmosphere through the plants' funnels. In 1972 this situation was brought before the authorities and a local center of atmosphere survey has eventually been constituted. This center organized a network of collecting stations to monitor the entire area. Between 1976-1998 several measurements were made with only sporadic discontinuities. Maximum pollution is scored when the low wind speed co-exists with the stable stratification of the low atmosphere. Atmospheric pollution advances especially eastward, due to specific local conditions.

The mean annual values of suspended dust before 1990 have constantly exceeded the accepted limit of  $75 \mu\text{g}/\text{m}^3$ . In 1990 and 1992, the quantity of dust was only slightly over the accepted limit ( $78$  and  $75 \mu\text{g}/\text{m}^3$ ). For daily maximal values, the accepted limit is only  $150 \mu\text{g}/\text{m}^3$ , and this has constantly been surpassed - for example in between 1987 and 1988, the records showed an excess of more than four times the limit ( $687$  and  $668 \mu\text{g}/\text{m}^3$ ). After these maximal records, a general tendency of reduction in dust pollution is noticed. The years between 1995-1998 being very close ( $156$ - $230 \mu\text{g}/\text{m}^3$ ) to the accepted limit. The frequency of exceeding rates as compared to the total number of samples analyzed, decreased from 44% in 1989 to 2% in 1998.

The presence of lead and cadmium in the atmosphere represents a risk factor for human health. The lead has the accepted value of  $0.7 \mu\text{g}/\text{m}^3$ , which was constantly outrun in both types of analysis. In 1985 a ten-fold excess was recorded, but after 1990 the records have shown an excess rate of only 2 or 3 times higher. The maximal daily rates were very high for the period between 1985 and 1998, in 1986 amounting to values 300 times in excess ( $213 \mu\text{g}/\text{m}^3$ ) of the accepted limit. Since 1991 they have not been higher than  $20 \mu\text{g}/\text{m}^3$ . The frequency of exceeding the limit is still very high - 50-90%. The concentrations of cadmium are also recorded with continual excess rates of the accepted limit

( $0.02\mu\text{g}/\text{m}^3$ ). Maximal values ( $2.5\mu\text{g}/\text{m}^3$ ) were registered between 1982 and 1983. After 1984, the values have kept within a constant limit of  $0.5\text{--}1.4\mu\text{g}/\text{m}^3$ .

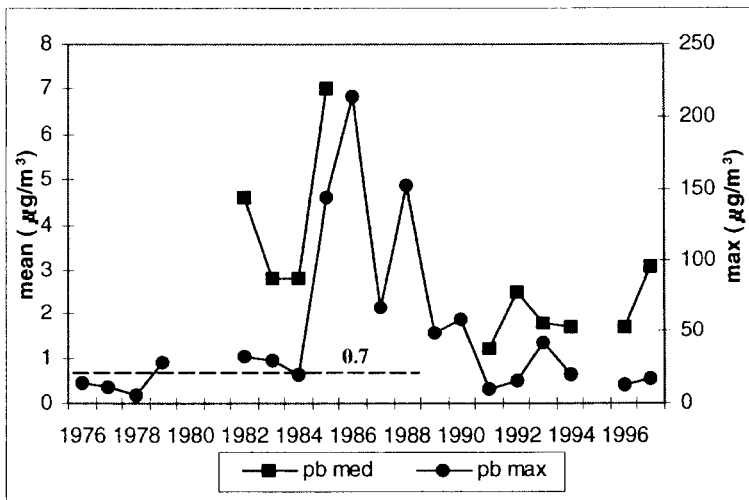


Figure 1: Annual lead concentration

The maximal limit for precipitating dust is not higher than  $17\mu\text{g}/\text{m}^3$  a month. For the period 1976-1984, the values ranged between  $11\text{--}39\mu\text{g}/\text{m}^3$ , during the period 1985-1990, the highest percentages were scores ( $984\mu\text{g}/\text{m}^3$  in 1989), and after 1990 they haven't exceeded the limit of  $9\text{--}25\mu\text{g}/\text{m}^3$ .

The sulphur dioxide at annual mean values has the accepted limit  $60\mu\text{g}/\text{m}^3$ , being exceeded only in 1992 ( $64\mu\text{g}/\text{m}^3$ ). The accepted limit value of  $250\mu\text{g}/\text{m}^3$  of the daily maximal tallies has been over the limit every year, except 1991 and 1998. The maximum degree of pollution was recorded for the period during 1984-1998, with values ranging between  $1483\text{--}2952\mu\text{g}/\text{m}^3$ . Since 1994 the values have kept below  $500\mu\text{g}/\text{m}^3$ .

The nitrogen dioxide concentration has been measured only after 1994 and only once an excess of 1.23 times the limit (1995:  $123\mu\text{g}/\text{m}^3$ ) has been noted.

The strongest concentration of polluting agents stretches out for an area of 1-2 kilometers, but the suspensions are carried as far as Medias, 15 kilometers east of Copsa Mica.

## 2.2 Water Pollution

Emission of polluting agents takes place not only in the atmosphere but also in the surface waters, because only 38 % of the discharge is cleaned. Thus, we can speak about pollution with lead, cadmium, zinc, suspensions, invariable residue, which defile the waters of the river Tarnava Mare, as well as the subsurface waters, and are present in the drinking water as well.

During 1978-1998, samples were collected almost continually from the Tarnava Mare upstream Copsa Mica. To facilitate the estimation of pollution transition, an area downstream the town was also surveyed between 1989-1992 and in 1996.

The concentration of lead upstream of Copsa Mica varies around the accepted limit ( $0.05 \text{ mg/dm}^3$ ):  $0.00025 \text{ mg/dm}^3$  in 1990 and  $0.33 \text{ mg/dm}^3$  in 1978. Downstream from the town very high concentrations were registered in 1989 and in 1992:  $1.6 \text{ mg/dm}^3$ , respectively  $1.28 \text{ mg/dm}^3$ . These values represent an excess of 25 times the accepted limit. The ratio upstream-downstream has been in a constant reduction from 8 in 1989 to 4 in 1996.

The accepted limit of cadmium is  $0.003 \text{ mg/dm}^3$ . Upstream the town the values have exceeded the accepted limit only during the past years. The highest values were recorded in 1979:  $0.83 \text{ mg/dm}^3$ , in 1994:  $0.15 \text{ mg/dm}^3$  and in 1996:  $0.1 \text{ mg/dm}^3$ . Downstream from the town, the values vary between  $0.08 \text{ mg/dm}^3$ , in 1992 and  $3.5 \text{ mg/dm}^3$  in 1990, these values of the accepted limit of over 26, respectively, 1166 times. The ratio values registered upstream from the town were up to 20 but in 1990 it is very high: 140.

The accepted limit of zinc is  $0.03 \text{ mg/dm}^3$ , but it is permanently exceeded upstream from the town. The years with the highest concentration of polluting agents were 1978:  $2.2 \text{ mg/dm}^3$ , 1992:  $1.44 \text{ mg/dm}^3$  and 1996:  $1.49 \text{ mg/dm}^3$ , the value recorded in 1978 being 73 times higher than the accepted limit. Downstream, the values of zinc concentration were 6 (1992) to 250 (1989) times higher than upstream. The decrease in the degree of pollution upstream-downstream in 1996 appears as unexplainable:  $1.49 \text{ mg/dm}^3$ , respectively  $0.54 \text{ mg/dm}^3$ .

Periodic outrunning of the accepted limit has been reported for iron and copper, both upstream as well as downstream Copsa Mica.

The ammonia present in the river water constantly exceeds the accepted limit:  $1 \text{ mg/dm}^3$ . Upstream, the maximal value,  $8.3 \text{ mg/dm}^3$ , was recorded in 1992, and the lowest value,  $0.46 \text{ mg/dm}^3$ , was recorded in 1998. Downstream from the town, high concentrations were recorded in 1989 and in 1990 ( $16.3 \text{ mg/dm}^3$ , respectively  $14.7 \text{ mg/dm}^3$ ), but in 1998 the concentration decreased to  $0.46 \text{ mg/dm}^3$ . The increase ratio varied between 2 to 5 times.

The lead and cadmium concentrations from the fountain waters were also examined. The estimated values were reported to be twice that of the accepted limit.

The towns water supplies come from fountains and from the accumulation lake Ighis (formed in 1978), in which water is pumped from drilled wells or from the river. The lake water goes through a treatment station where it is decanted, filtered and treated with chlorine. Up to 1992, inside the drinking water catering network lead was found in excess with over 0.2 – 2 times the accepted limit ( $0.05 \text{ mg/dm}^3$ ). Since 1992 the concentration has been found to be satisfactory. Generally speaking, the concentration of cadmium kept to the accepted limits and has been in decline after 1994.

### 2.3 Soil pollution

The polluting substances from the atmosphere reach the earth mainly through the rain and are transported in the subsoil by the subsurface water. The collecting stations are situated in the town and in the neighboring areas both on the surface and 35-40 cm under the earth. The results of the sample testing were compared with witness samples collected from the non-polluted areas.

Lead has the natural concentration of 42 ppm, according to witness tests. The surface concentration constantly exceeds this value. In 1989 a huge difference was noted (2333 ppm), but values as high as 400-500 ppm have frequently been registered. Inside the earth the values fall below 450 ppm, but never below 100 ppm. There are some exceptions, however: 250 ppm in 1984, 428 ppm in 1988 and 419 ppm in 1993.

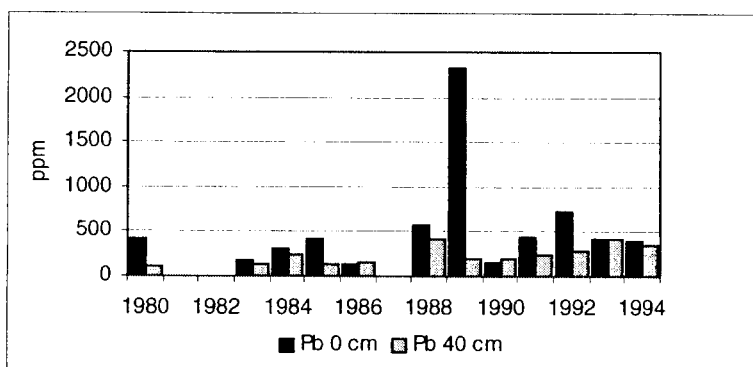


Figure 2: Lead concentration in the soil

The accepted limit of cadmium concentration, established according to the same standards, is 1.9 ppm. It has also been noticed that the intensity of pollution decreases with the depth. It is not higher than 10-20 ppm at the surface – the highest in 1992: 23 ppm and the lowest in 1990: 7 ppm. As deep as 35-40 meters it varies between 5-12 ppm, yet a period with a concentration of 14-17 ppm (1991-1993) has been recorded too.

The concentration of copper has also been measured sporadically. On the surface it varies between 30-138 ppm and increases with the depth to 31 and even to 63 ppm. The gas emanations that precipitate on the soil have induced a high level of acidity with variations of 2-3 ph units.

The intense soil pollution extends for an area of 1 km from the source but goes even as far as 14 km in the dominant direction of the air currents.

### 2.4 Pollution of vegetation

The vegetation is affected by the degradation of the quality of the air, soil and water. The biochemical soil processes are modified due to the chain reactions, which, in turn, bring about ecological imbalance, its primary and most serious

consequence being the upset of the forest eco-systems. Increase of soil acidity turns the plant roots to carbon. The process of photosynthesis and evaporation through perspiration is modified by the carbon black and by various acid compound precipitation which coat the leaves of the plants and the vegetation development is delayed. The forest fund has probably been most affected by the 1960-80 period of calamities. The vegetation has been exposed to various diseases and pests, to frost or fire and has consequently lead to a reduction in forested areas. The loss in wooded mass has been estimated at 84,000 m yearly. The emaciation and waste of vegetation has increased the erosion. The humus has been washed away from the soil and the water circulation has also been unbalanced.

After 1990 several surfaces have been reforested successively especially with acacia. The results range between 18-91%, but the aftermath results are still pending.

Pollution represents a phenomenon with very serious implications on the plants grown for human consumption. They absorb heavy metals from the soil under the form of water suspensions, and the atmospheric powder mixtures are deposited directly on their leaves. The great amount of toxic substances which are absorbed by the plants subsequently develop in the bodies of the animals that eat them raw or in the form of fodder. This is an in situ form of food pollution.

During a research trip organized in 1981 various analyses carried out by that time showed that the concentration of lead was 2 to 15 times higher than in the witness plants. In 1988 the concentration of lead tested on the surface of the plants/ on the vegetation revealed maximal quotas of 11 ppm whereas their tissues stored as much as 423 ppm. Cadmium was found in concentrations of 5, respectively 85 ppm. The values obtained differ greatly from one plant species to another, but, more important, the quantities in excess varied from double to 50 times the limit. The analyses performed in 1998 reflect a reduction in the level of toxic substances, but there are cases when the accepted limit has been exceeded up to three times; the concentration of certain metals in milk and in domestic animals was measured as well. All the analyses performed so far have revealed the fact that the toxic substances stored in the animal body are subsequently transferred into the human body with extremely serious consequences.

### **3 Effects of pollution on human health**

#### **3.1 Assimilation of polluting substances by the human body**

In order to estimate the concentration of polluting substances in plants and animals appreciative calculations were carried out to determine the amounts of these substances taken in by the human body. Thus, the standard daily quantity of animal and vegetal foods for an adult was determined and for both instances, the amounts of lead and cadmium representing the theoretical intake of an individual. These estimations were made only for spring and winter, as human food is more varied and complex during these two seasons.

In spring the human body assimilates daily 3720  $\mu\text{g}$  Pb and 253  $\mu\text{g}$  Cd. The quantity of lead assimilated from plants is 91%, the rest of 9% comes from animal foods. Cadmium is to be found in proportion of 80%, respectively 20%. In autumn, the human body gets 2861  $\mu\text{g}$  Pb and 529  $\mu\text{g}$  Cd per day. Of this 88% is provided by plants and 12% by foods of animal origin. With cadmium, the values are 90%, respectively 10%. Lower levels of lead and higher levels of cadmium during the period from spring to autumn reveal the fact that in spring vegetables and fruit are richer in lead and poorer in cadmium.

These direct and the indirect ways of pollution have already been affecting the population from Copsa Mica for a long time. The incidence of diseases has made it the object of the local authorities attention but their reaction did not live up to the seriousness of the consequences derived from this fact. The number of people affected by pollution has been increasing constantly. The plant workers are the first to be exposed to various toxic substances but on the whole, the entire population has been affected. The most exposed, however, those who have presented the worst symptoms to the accumulation of toxic substances in their bodies, are the children.

### 3.2 Children health

The youngest members of the population have been most affected by various illnesses because they are least resistant and their adaptability is lowest. The toxic substances enter the childrens' bodies directly through the air they breathe in and indirectly through dirty hands.

The body level of lead and cadmium was measured in several groups of children aged between 7-11 who eventually underwent various health tests. It was noted that no child had the level of lead below 10  $\mu\text{g}/\text{dl}$ . In 57% of the tested children the levels of lead ranged between 30-50  $\mu\text{g}/\text{dl}$ , in 25% it ranged between 50-70 $\mu\text{g}/\text{dl}$  and in 7% of the children the lead concentration was 70-100 $\mu\text{g}/\text{dl}$ . Cadmium was present in proportion of over 0.5 $\mu\text{g}/\text{dl}$  in 86% of the children.

The comparative tests underwent by the children from Copsa Mica and from another non-polluted part of the country and their medical records showed that the children from the urban area had a worse more deteriorated state of health.

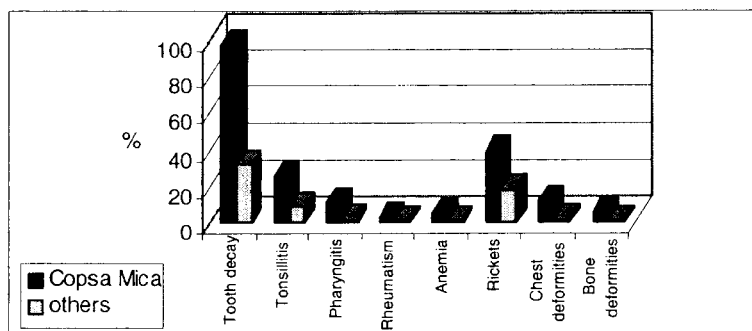


Figure 3: Comparison of the health status

For instance, twice as many of these children suffer from tooth decay, three times as many from rheumatism, rickets and bone deformities; four times as many suffer from tonsillitis, five times as many from anemia; and suffering from pharyngitis and chest deformities it is six times the number of the children surveyed in the witness area.

The monitoring of the teenagers showed the incidence of the following deficiencies: delayed morphologic development (skull circumference, weight, height); breathing deficiencies which subsequently lead to alteration of the pulmonary functions; apathy; memorizing difficulties; low IQ.

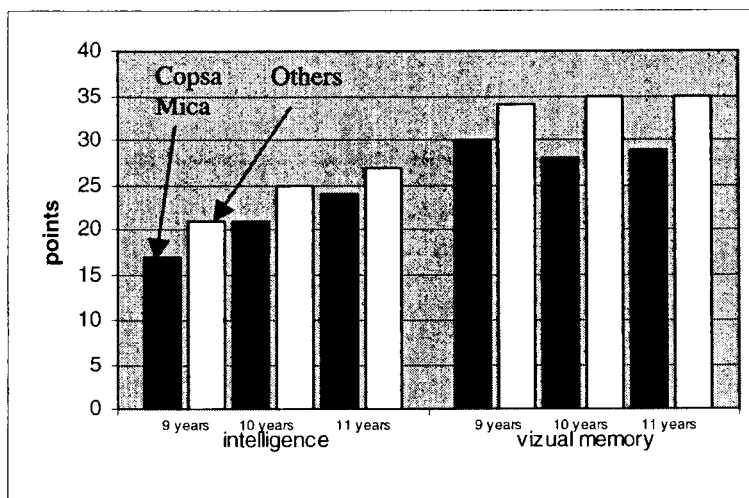


Figure 4: Intelligence and visual memory test

### 3.3 Adult health

Among the adult population the most affected are the workers. The most dangerous toxic agents are lead, cadmium, sulphur dioxide and carbon black. The statistics show that the diseases with the highest incidence are the professional diseases, the pulmonary, dermatological and digestive disorders, various types of neurosis, kidney disorders and rheumatism.

The causes of hospitalization have also modified. If we compare the period 1981-1989 and 1990-1998, we can notice that the professional diseases from the first most serious illnesses became second in order, the first place being held after 1990 by road injuries. The respiratory and the neurological diseases hold the third, respectively, the fifth place for both periods of time. In fourth place, after 1989, are the kidney and dermatological disorders.

The professional diseases were closely monitored beginning 1968. Between 1968-1980 the statistics were as follows: 67 lead poisonings (85% with people aged 35-45), 22 with carbon monoxide, 15 arsenic poisoning, 5 poisonings with cadmium, 3 cases of silicosis. Between 1981-1989 1247 cases of lead poisoning were recorded, out of which 60% with people between 35-45. During this period

there have also been reported 15 poisonings with carbon monoxide, 3 poisoning with arsenic and two with sulphur. After 1990, 847 cases of lead poisoning have been reported, out of which 70% with people between 35-45.

The most frequent and the most serious professional disease is lead poisoning, which is caused by the accumulation of this metal in the human body. Statistics show a constant increase in the cases of poisoning from 7 in 1969 to 160 in 1982. Between 1983-1989, there is a new period of rise with values of 97, respectively 210. Since 1990, the general tendency has been to reduce the incidence of these diseases, although every year variations of different degrees have been reported. The lower incidence of diseases (66) was reported in 1997.

The result of the improper conditions of life is most synthetically reflected by the average life expectancy. By comparing the data collected in Copsa Mica with those collected from a witness territory showed that in Copsa Mica the life expectancy is 95%-74% less than in the witness territory.

## Conclusions

The City of Copsa Mica can be considered as a pollution model due to the forced industrialisation without taking into account the local environmental conditions. Once the natural balance is destroyed with the subsequent negative aspects on the human society, it is much more difficult to re-establish the natural balance and to bring the environmental parameters within the normal range. The precautionary principle of environmental management was overlooked and now the effects are hard to overcome and will be expensive.

After 1990, there is no longer need to obscure the reality of the situation in Copsa Mica. The real situation may be acknowledged now so that drastic steps be taken to lower the level of pollution and to improve the life of the population. The results will appear in time.

Here are some of the proposed measures: introduction of non-polluting technologies; collecting and processing polluting substances; filters to furnace chimneys; new sources of drinking water; more efficient centers for the water treatment; ecological plans for the whole region; hygienic education.

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