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ATTILA KERÉNYI (*) & GYÖRGY SZABÓ (*)

ENVIRONMENTAL POLLUTION IN A SAMPLE AREA OF THE NORTH HUNGARIAN MOUNTAINS

ABSTRACT: KERÉNYI A. & SZABÓ G., *Environmental pollution in a sample area of the North Hungarian Mountains.* (IT ISSN 0391-9838, 1998).

In Hungary ownership changes have been under way since the change of the regime in 1989. Land became also privately owned, although cooperative farms still exist in many places. The various advantages of collective farms are justified by the agricultural achievements of many developed Western European countries. There are conditions for mechanisation, fertilisation and for the proper use of chemicals, i.e. for large-scale farming. However, this form of production also has several disadvantages, especially from the point of view of environmental protection. In the first part of the paper, various environmental problems caused by large-scale crop cultivation are pointed out. A system model is presented to show the opportunities for the reduction of environmental load. In the second part the findings of a study of groundwater and soil pollution in the area of a Hungarian agricultural farm are tackled.

KEY WORDS: System model, Pollution, Groundwater, Soil, Hungary.

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Fondamentali cambiamenti si sono avuti in Ungheria dopo il cambiamento del regime politico del 1989. La terra è stata privatizzata, anche se fattorie cooperative permangono in vari luoghi del Paese. Vi sono favorevoli condizioni per un'ampia meccanizzazione, fertilizzante e per l'uso di prodotti chimici per un'agricoltura intensiva. Tuttavia, queste modalità di lavorazione hanno diversi svantaggi, specialmente dal punto di vista della protezione ambientale. Vari problemi di questo tipo sono illustrati nella prima parte dell'articolo e inoltre viene presentato un modello per la riduzione del carico ambientale. Nella seconda parte dell'articolo vengono delineati principi di uno studio dell'inquinamento delle acque e del suolo in un'area agricola dei Monti Bükk in Ungheria.

TERMINI CHIAVE: Inquinamento, Falda idrica, Suolo, Ungheria.

SYSTEM MODEL OF AN AGRICULTURAL FARM

Mechanised plant cultivation using chemicals significantly contributes to the pollution of the rural environment and also has some other deleterious impacts. The role of man can be well detected in this process with a system-oriented approach to the problem (fig. 1).

The coordinator of crop cultivation on an agricultural farm as a system is man. He fulfills his role through the partial regulation of input and output and through his actions carried out within the system. The following section serves to demonstrate some actions which almost definitely lead to environmental problems in large-scale farming.

The function of the system is ensured by the energy of the sun which is used by the plants in photosynthesis. The different gases of the atmosphere also form a significant part of the input carbon-dioxide is essential for the photosynthesis of plants and oxygen is indispensible for the respiration of plants and animals. The output into the atmosphere is partly oxygen from photosynthesis and partly carbon-dioxide produced by animal respiration. Most of the input to the system is produced through machines (fig. 1). It is obvious that the amount of the input is determined by man in these cases. If the amount of input is carefully decide, there are no (considerable) deterious effects during system functioning. Otherwise, serious environmental problems may arise.

There is a need for the use of various fertilizers to ensure the nutrient supply of plants. As it can be seen, both organic manures and artificial fertilizers can be used for this purpose. The dispersion of both is performed by machines. The danger often occurs that as a result of surface runoff these fertilizers leave the system instead of being absorbed in the soil. The different organic manures increase the organic matter content of the soil, ensuring primary material for humification. Some constituents of the oganich manures turn into inorganic compounds. Chemical fertilizers increase inorganic matter contents in soils. The use of organic manures is regarded less dangerous from an environmental point of view, still, nowadays artificial fertilizers predominate. In the case when exactly the amount of nutrients is added to the soil that the plants are able to use, fertilisation only has positive consequences. However, this

(*) *Department of Applied Landscape Geography, Kossuth Lajos University, P.O. Box 9. H-4010 Debrecen, Hungary.*

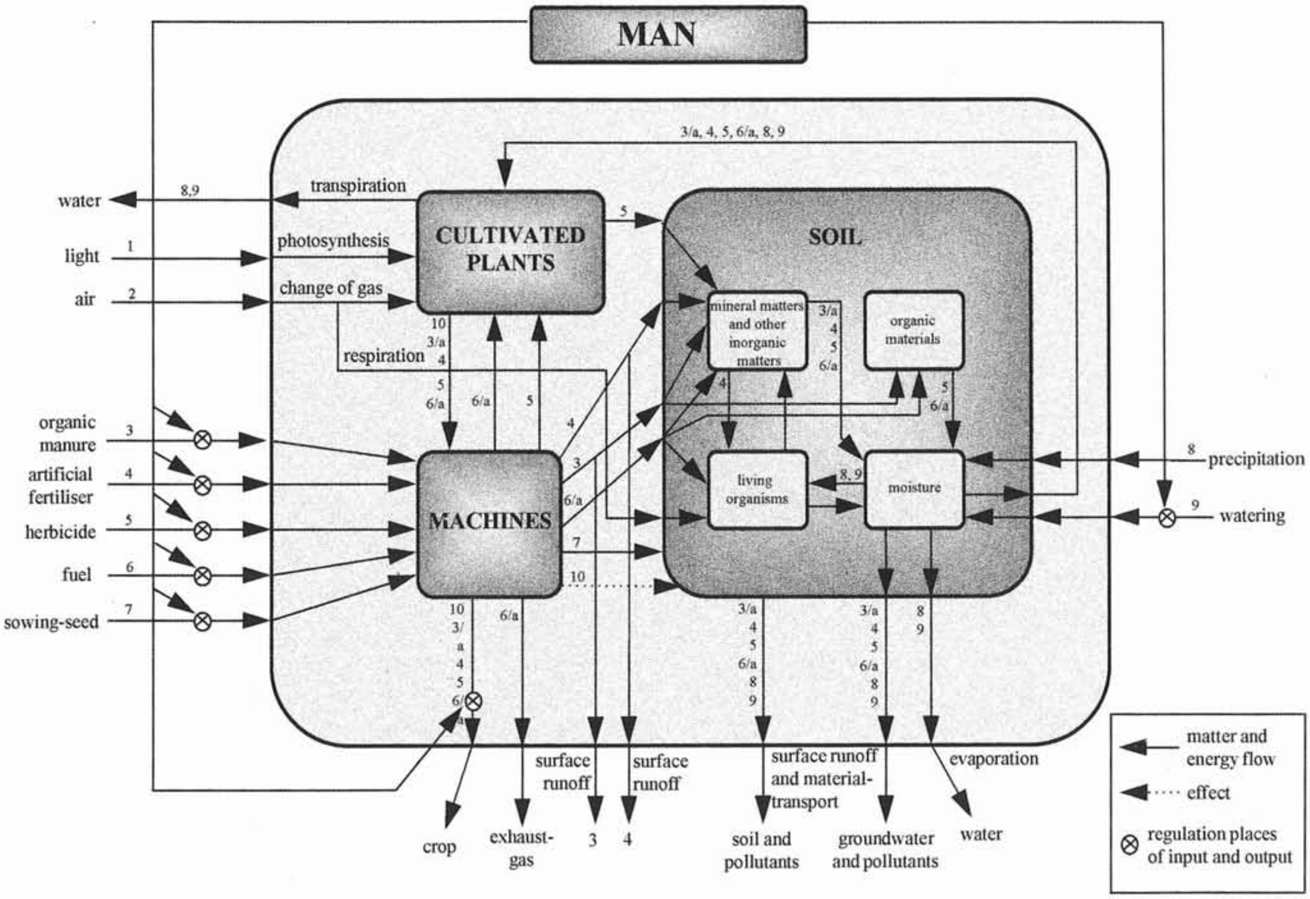

FIG. 1 - The system model of a modern mechanised farm of crop cultivation. The sites of human interferences are marked with the symbol of a tap.

almost never happens in reality, much more frequently more nutrients are added to the soil than needed. Therefore, the easily adsorbed nutrients in surplus may accumulate in the topsoil and their easily soluble compounds might get into the groundwater the soil solution. The phosphorus and nitrogen fertilizers accumulated in the soil may cause eutrophication in the lakes with the removal of soil particles by surface runoff. In addition, the nitrogen fertilisers may also cause the nitrification of groundwater (Pratt & Adriano, 1973). Besides the essential macro- and microelements chemical fertilizers may contain elements which are poisonous for plants, e.g. heavy metals (Laws, 1981).

Therefore, the determination of the optimal amounts of fertilizers, the selection of the appropriate type and the steady and timed dispersion are very important factors. In an ideal case the nutrients should be applied to the rooting zone. This is only possible with the help of the modern technique. However, the method being rather expensive, even countries with the moste developed agriculture do not chose it. Naturally, for the sake of professional fertilization, one must be aware of the nutrition needs of the crop and the actual nutrient content of the soil.

Modern agriculture often uses herbicides in great amounts. These obviously have many undesirable effects as well as obvious advantages. The route herbicides follow through the system can be well detected in fig. 1. Most of the herbicides are sprayed onto the plants by the machines. However, they may reach the soil from the surface with rainwater and with dead plant matter, and, just like the chemical fertilizers, they may contaminate groundwater in dissolved form. A further danger of herbicides is that there are only few of them which are specific to those pests only against which they are employed. Useful living beings are often negatively affected as well. This may seriously endanger the dynamic ecological balance.

Sowing-seed input is also regulated by man. In the case of mechanised sowing, environmental problems are caused not especially by the amount but rather by the type of the sowing-seed. It may involve significant economic and environmental damages if the cultures cultivated on a field are not suitable for the natural endowments of the given area.

It can be seen that the machines have a centrale role in the operation of the system, mainly because most of the input is performed with their help. The exhaustgases resulting from the burning of fuels used by machines, partly form a deposit on the surface of arable soil or of crops and partly leave the system and pollute the environs. Exhaust-gases contain different hydrocarbon by-products and heavy metals. It can be very well seen on fig. 1 that these pollutants reach all of the sub-systems of the soil.

Machines play an important role not only in the mediation of the input but also in the cultivation of the land. This activity has several positive effects but harmful consequences may also occur. For instance, the deterioriation (or complete destruction) of soil structural elements leads to the pulverisation of soil (soil powder) often observed in tilled layers. The compression under the wheels of the machines results in soil compaction, also damaging to soil structure. Especially on slopes, wheel-tracks induce erosional processes. Downslope farming has similar consequences.

Figure 1 shows that the water needed for system functioning comes from two sources: from precipitation, or if necessary, from irrigation. Following the path of the water it is seen that a part of it evaporates from the surface or percolates into the groundwater, leaving the system with groundwater flow. The rest of the water is taken up by plants through the roots and from here leaves the system through transpiration. It can also be seen that nutrient inputs with fertilizers, the remnants of herbicides and the various pollutants (e.g. heavy metals) reach the plants in a dissolved form through water or may leave the system with groundwater flow.

A significant part of the output is represented by the harvest of the crops. Cash crops produced by the use of chemicals may contain substances harmful to human health.

THE TEST AREA

The test area is located in the southern foreground of the Bükk Mountains, North Hungary. It is surrounded by three villages: Bogács, Bükkzsérc and Cserépfalu (fig. 2). It is a typical hilly landscape with moderately steep slopes. Over most of the area, especially on valley slopes of the streams and on interfluves, slope angles are below 5 per cent. Slopes of 5 to 12 per cent are also common. 55 per cent of the study area is suitable for crop. Terraces had been formed on many of the steeper slopes. The northern and western slopes of the asymmetrical hills are the steepest (above 25 per cent). Slope exposure is also favourable: besides the predominant eastern exposure, southeastern, southern and western exposures are also frequent. Northern slopes are the least common.

Soils are diverse; brownearths predominate. Alluvial soils and deluvial soil deposits also cover large areas. Lessivée brown forest soil, ranker, stony-rocky skeletal soil and marsh soil occur only in small patches. There is not too much groundwater on the sample area. In two of the examined villages (Cserépfalu, Bükkzsérc) drinking water is gained from groundwater sources and two-thirds of the population of Bogács are supplied from groundwater

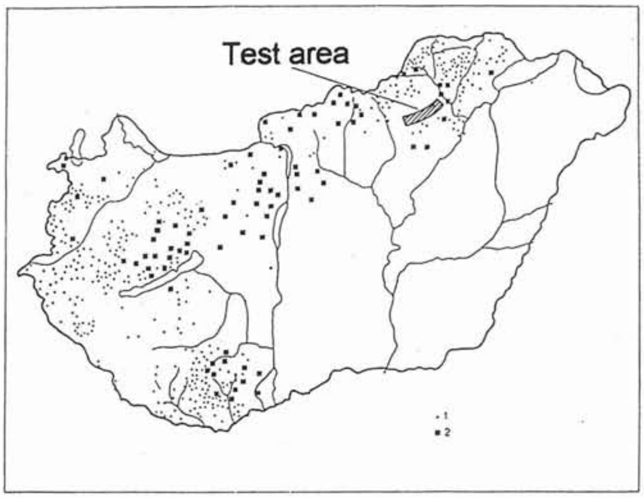

FIG. 2 - Topographic position of the test area at the foot of the Bükk Mountains and the settlements with nitrate pollution in their drinking water in Hungary (Central Statistical Office 1986). 1 = settlements with no pipe water and polluted (NO_3) wells; 2 = nitrate pollution in wells of waterworks.

wells. The depth of groundwater table measured from the surface is between 2 and 30 cm.

Surface and groundwater contamination

In the present study of pollutants of surface waters and the groundwater, a special emphasis is laid on the investigation of nitrate-ion concentration. This is motivated by the following circumstances: it is a serious problem in Hungary (fig. 2); it is known to be the most frequent pollutant in an agricultural environment; in villages lacking public utilities, nitrate comes from pollutant sources; since the inhabitants are provided with drinking water from groundwater, it is important, particularly from the viewpoint of risk to infants, to know whether or not they drink healthy water in the villages of the test area.

The measurements made in surface waters (Hór stream, Cseresznyés stream) showed 10-30 mg/l nitrate concentration. Although these figures are below the «tolerable» limit (40 mg/l), they are still too high for freshwater. The amount of nitrate in groundwater was between 30 and 550 mg/l in the samples taken from 170 wells in Cserépfalu in 1991 (fig. 3). These figures made us to examine more carefully the size and the causes of the nitrate pollution (Kerényi & Pásztor, 1994).

In almost every courtyard in the three villages of the test area there are dug (in some cases driven/drilled) wells. During the years of our research (1988-1994) only a third of the inhabitants of Bogács and a fifth of those of Bükkzsérc were linked to the water-pipes system of the waterworks based on deep groundwater. The people living in Cserépfalu used and still use groundwater in households. At the same time, because of location in the test area, the groundwater of this village is endangered by agricultural pollutants to the greatest extent. The reason for

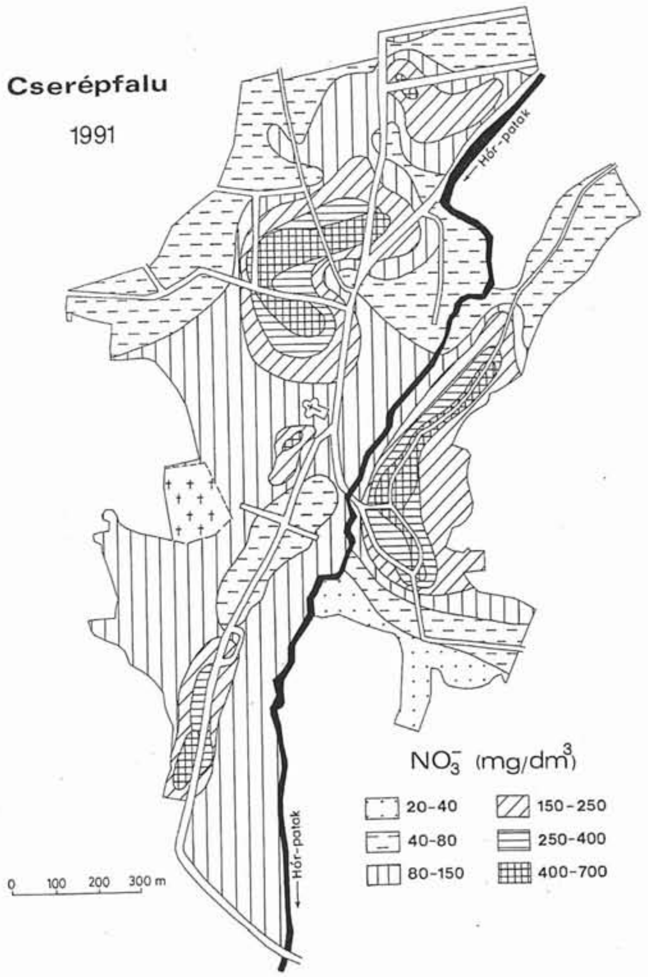

FIG. 3 - Nitrate content of the groundwater in Cserépfalu, July 1991.

this is that is large-scale crop cultivation in the neighbourhood. Soil properties in the area increase the danger of nitrate percolation because several valleys collect water from agricultural fields and conduct it to the inner parts of the village where it may reach the groundwater. The potential contamination sources in the village are also significant from this respect.

The nitrate concentrations of four groundwater-wells were recorded occasionally in 1988 and monthly between 1989 and 1994. No «control» well, free from anthropogenic contamination, could be selected in Cserépfalu, because all wells are heavily polluted in the village. Therefore, we regard the nitrate concentration of a well on the northern border of Bükkzsérc at the edge of the forest as a naturally polluted control well. The agricultural and communal pollution can be excluded in this case. Nitrate concentration was between 5 and 8 mg/l in this well during most of the year and it only above 10 mg/l in late autumn and early spring periods. Nitrate concentration in the four wells studied in Cserépfalu was found several times higher than the «standard» (fig. 4).

Nitrate concentration fluctuated with a high amplitude in the case of the four wells. An autumn maximum can be perceived almost every year. It can be explained by the mineralization processes of organic matter and by the increasing autumn precipitation (Marzner, 1989). Usually lower value was measured in winter than in autumn, mainly because of a fall in temperature and the freezing of topsoil and because of the decrease in organic matter recharge. The increase of the concentration in the beginning of spring can be regarded characteristic. This may be related to reintensified microbiological activity and partly to growing leaching (Campbell, 1983). There is a decrease again by the end of the spring and early summer. This can

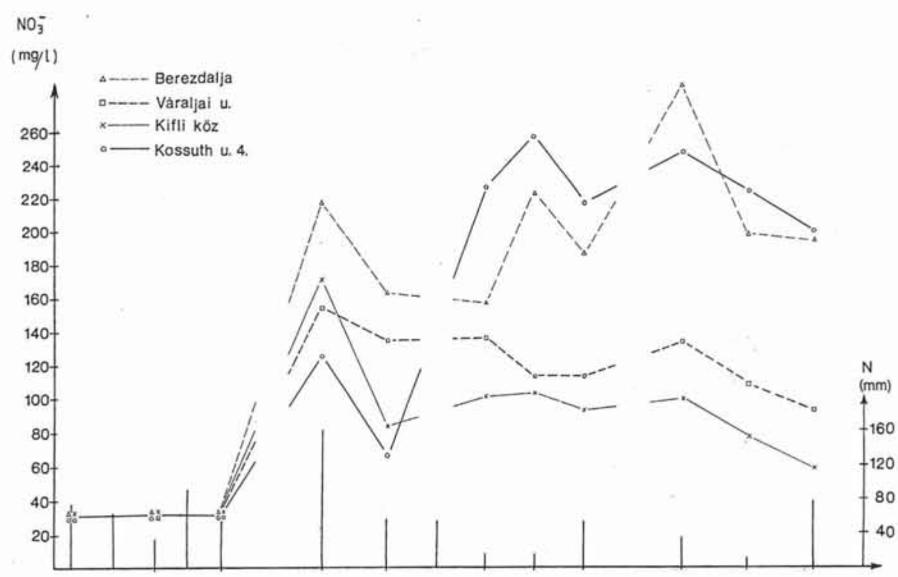

FIG. 4 - Changes in nitrate concentration in the basic wells of Cserépfalu, 1989-1994.

be partly explained by the strong nitrogene intake of plants and by the decreasing moisture.

In the experiments with lysimeter 80 kg/ha N-fertilizer was dispersed on grass-covered soil with mixed NPK artificial fertilizer (N 16 per cent, P 16 per cent, K 16 per cent). The soil selected for study was one of the most characteristic type in the test area: weakly acidic deluvial soil deposit. A detailed description of results has already been published (Kerényi, 1995). This time it is only pointed out that the nitrate concentration of the water seeping through the soil has decreased rapidly in lysimetric experiments. The reason may be that the developing plant consumes nitrogen quickly. By the end of May the nitrate concentration of the water seeping through the fertilized soil decreases to the low value characteristic of the seeping water in control (not fertilized) lysimeters. This is contemporaneous with the changes of groundwater nitrate concentration. In surface runoff water from cultivated plots the concentration decrease is considerable between January and March.

A major achievement during the experiment was to prove the fact that the nitrate concentration in surface runoff is significant late autumn and spring. In the experiment the highest values were between 60 and 70 mg/l. Depending on geomorphological and soil conditions, surface runoff may remove large amounts of nitrogen in nitrate form from the heavily fertilized plots of hundreds of hectares size and nitrate may percolate deep into the soil with the surplus water. This process can be taken as one of the potential reasons of groundwater nitrate pollution.

Soil contamination

The main sources of soil pollution are agricultural chemicals, also including artificial fertilizers. Nitrate concentration in the soil and unconsolidated deposits was investigated in two boreholes of the same arable field (fig. 5). The diagrams show that nitrate concentration has three maxima and this proves nitrate leaching. The differences between the nitrate profiles of borehole no 220 (hilltop position) and no 227 (bottom of a dell) can be explained by geomorphological reasons. In the case of borehole no 220 the three maxima are on the surface, at 110 cm and at 250 cm. In borehole no 227 the socond and third maxima occur much deeper and nitrate concentration is much higher. It seems from the results of the mesaurements that on the bottom of the dell nitrate concentration grew as a consequence of surface confluence and this also explains deeper leaching.

Following these experiments the types of chemical remnants were studied detected in the soil on the largest wheat field in the autumn. Samples were taken from 50 sites from the soil of the large-scale cultivated field north of Cserépfalu in October 1992 and with their homogenisation an average sample was generated. Chemical remnants in the soil were identified with the help of the GC/MS method (GC=gas chromatography, MS=mass spectrometry). A year later the measurements were repeated with the same method and the results proved to be similar. A number of characteristic agricultural pollutants, eg. 4,4 bipiridil (a decomposition product of the herbicide called gramoxon, a very stable chemical, and atrazine, a well known herbicide) have been found. It is very surprising that the DDT the use of which was prohibited after 1967 could be still found in the soil. This calls attention to the fact that the emission of slowly decomposing chemicals to the environment must be handled with care because they are potential hazards for long decades. A great variety of oil derivatives were also found which proves that the agricultural machines accidently «spray» the soil with undesirable substances.

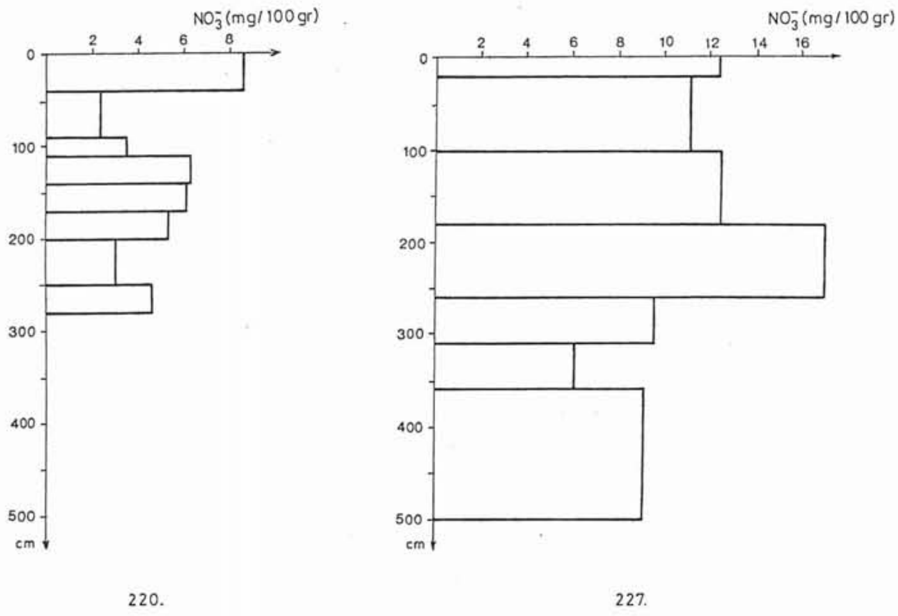

FIG. 5 - Nitrate contens of samples from boreholes nos 220 and 227.

CONCLUSIONS

Today even the rural environment is not free from pollutants originating from production and consumption activities. Three further important tasks are related with this issue: 1) regular environmental controls must be made to gather as much information as possible (observing the principle of cognition). Besides this it is necessary, 2) to act according to the principle of prevention when dealing with those known pollutants which may turn to be dangerous. For instance, several aspects require the use of the principle of minimal tillage in agriculture: erosion hazard decreases, soil structure is preserved and soil and plant pollution could also be decreased. (The same pollutants accumulate in the environment from the exhaust-gases of tractors as during the operation of other road vehicles.) More attention should be paid to the use of chemicals including fertilizers. Finally, 3) the environment must be cleaned from the serious pollutants. This seems to be the most difficult task in the case of the nitrate pollution of groundwater. It is urgent to expand public water-supply systems and, in parallel, to accomplish the environmentally friendly storage of sewage water. The irregularly built draintanks, latrines and manure containers must be demolished gradually.

If these tasks are carried out successfully, the rural environment could be as clean again as it was a few decades ago, and it may become an attractive target of tourism in the future.

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