ENVIRONMENTAL PROBLEMS INDUCED BY CATTLE FARMING IN THE PO VALLEY (NORTHERN ITALY)

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ABSTRACT

This paper deals with the enviromental impact deriving from the presence of widespread farming activities in the Po Valley which, owing to its geologic characteristics, is particularly vulnerable to pollutants. From the schematic hydrogeologic map of the Po Plain shown in the text, the prevailing presence of alluvial deposits is evident. These deposits, due to their grain-size characteristics, are often interested by the presence of vast amounts of groundwaters which are an important resource for man since they are widely exploited for water-supply and irriguous purposes. The high permeability of a great part of these deposits makes them particularly vulnerable to pollutants, also considering that the Po Valley shows one of the highest concentrations of industry and farming not only in Italy but in the whole of Western Europe. In particular, for what concerns animal breeding, the data collected show that the pollutants' load derives mainly from cattle farms which are, therefore, one of the main sources of potential pollution of the aquifers. Indeed, the hydrochemical analysis of groundwaters in the Po Valley has confirmed in many cases the presence of pollutant concentrations above legal levels, owing to an inadequate management of farm-sewage. In order to upgrade the environmental situation it is necessary to apply strictly the existing norms and to improve the depuration and waste-disposal techniques aiming at a management more compatible with the physical characteristics of the territory.

RESUMEN

Este trabajo aborda el impacto ambiental derivado de la elevada actividad ganadera desarrollada en el Valle del Po que, por sus características geológicas, es especialmente vulnerable a la contaminación de sus acuíferos. En la cartografía hidrogeológica esquemática del Valle del Po presentada en el texto, se evidencia la presencia de materiales aluvionales. Estos depósitos, por sus características granulométricas, son propicios para almacenar gran cantidad de agua, lo cual constituye un importante recurso para el hombre, tanto para uso doméstico como para uso agrícola. La vulnerabilidad de estas aguas resulta de la suma de la alta permeabilidad de gran parte de estos depósitos y la importante actividad industrial, ganadera y agrícola desarrollada en el Valle del Po que, además de ser la más alta de Italia, es una de las mayores de Europa Occidental. En concreto, los datos referentes al pastoreo muestran que esta actividad es la que genera la mayor cantidad de los contaminantes que posteriormente pasan a las aguas subterráneas. Además, los análisis hidroquímicos de estas aguas han confirmado la presencia de substancias nocivas por encima del límite legal, probablemente derivado de una deficiente gestión respecto al uso de las deyecciones del ganado. Para mejorar la situación ambiental es necesario aplicar estrictamente la leyes existentes, mejorar las técnicas de depuración de estas substancias y estudiar las pautas adecuadas para la distribución del abono animal, teniendo en cuenta las características físicas del substrato, con el fin de evitar concentraciones elevadas de estos productos en puntos donde suponen un fuerte deterioro de los recursos hídricos.

ZUSAMMENFASSUNG

Der hier vorgelegte Beitrag ist das Ergebnis einer Forschung, die den aus der in der Po Ebene verbreiteten landwirtschaftlichen Aktivitäten hervorgehenden Umwelteinschlag untersucht hat. Der in Erwägung gezogene Bereich, wegen seiner geologischen Charakteristiken, ist nämlich zur verseuchtenden Agens besonders verwundbar. Aus der im Text beigefügten Karte der Po Ebene läßt sich das Vorherrschen der schematischen hydrogeologischen Ausschwemmungen leicht erkennen. Auf Grund ihres Kornaufbau, kann man oft bei dieser Ausschwemmungen die Anwesenheit einer großen Menge Grundwassern bemerken, die eine wichtige Quelle darstellen, weil sie weit für Wasserversorgung und Bewässerungsabsichten ausgebeutet werden können. Die höhe Wasserdurchlässigkeit großer Teil dieser Ausschwemmungen verursacht ihre Verwundbarkeit zu verseuchtender Agens; hinzu soll man in Betracht ziehen, daß die Po Ebene eine der höchste Konzentrationen von Industrien und Gutshofen nicht nur im Italien sondern auch im westlichen Europa zeigt. Was dem Futter betrifft, beweisen die gesammelten Daten, daß die verschmutzende Last vor allem aus Viehzuchten hervorgeht, die deswegen eine der Hauptsachen potentieller Verseuchung von Wässern

und wasserführenden Schichten sind. Außerdem nach hydrochemischer Analyse von Grundwassern in der Po Ebene hat man in verschiedenen Fälle eine Konzentration verseuchtenden Agens bestätigt, die die vom Gesetzt erlaubte Niveau überwindet. Die erhobenen Daten hängen davon ab, daß die Zuchtjauche unadequät geleitet wird. Deshalb, um die Umweltsituation zu fördern, ist es nötig, die existierenden Normen streng anzuwenden, die Reinigung und die Abfallentfernungstechniken zu verbessern, so daß man eine der physischen Charakteristiken des Landes verträglichere Viehzuchtsleitung gewonnen werden kann.

1. INTRODUCTION

The Po Valley is the largest plain in Italy where the great majority of industrial, agricultural and livestock breeding activities are concentrated, with a development which has become extremely intense since the early 1960s. Until the first decades after the end of world war II, cattle were mostly bred on small family-run farms, with relatively low concentrations of animals, while in the following years this activity has been increasingly organized in large industrial breeding farms, with very high concentration of heads on restricted areas. Considering that cattle farms are mainly concentrated in highly vulnerable areas from the hydrogeologic point of view, one can understand that these farming activities may determine serious environmental problems if farm-sewage is not adequately utilized. In fact animal waste disposal on farming soil constitutes in some cases a serious impact of human activities on the environment, as recently emphasized by several European researchers (1, 2, 3).

In the specific case of cattle-breeding, by examining the interrelations between man and environment (Fig. 1), it is obvious how this activity can determine a quality deterioration of the hydric resources. In particular, the pollution of surface waters causes an environmental damage owing to the alterations brought about in the fluvial, marshy and marine ecosystems with consequent phenomena of eutrophication of entire watersheds and of seas characterized by reduced water circulation, such as the Adriatic Sea. Also the contamination of groundwater can create serious economic damage and potential hazard for public health, since in the Po Valley it constitutes the main source for water-supply and irriguous purposes. Therefore the use of groundwater compromised by the presence of pollutants deriving from an inadequate disposal of farm-sewage implies a real health risk.

This paper has been produced within the framework of interdisciplinary research which is being carried out in the field of earth sciences, biological and veterinary sciences in order to give a better comprehension of environmental problems and a more correct and thorough planning of man's activities in the territory.

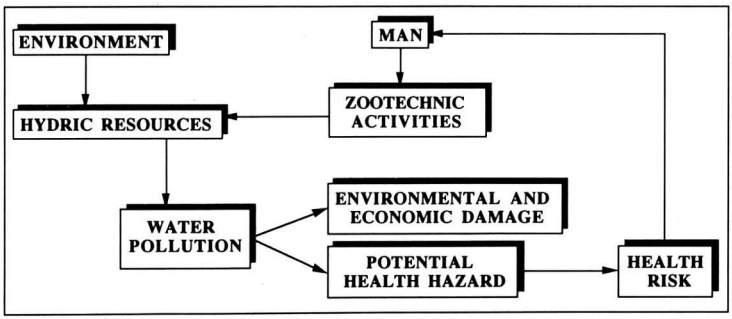

Fig. 1 - Interrelations between zootechnic activities and environment.

2. CATTLE-FARMING IN EUROPE

2.1. The situation in the European Community

The EC occupies the first place in the world for the concentration of farm-breeding resources. In particular,

the concentration of heads per hectare of available farming surface is four times higher than the world average for the pigs and three times higher for cattle and fowl. The amount of bovine livestock resources in Europe is illustrated in Fig. 2 which emphasizes the leading position of France, with a total bovine population of over 21,500,000 heads, whilst Italy occupies only the fourth place with 8,578,000 heads.

Nevertheless, it should be pointed out that in order to properly assess the pollution risks deriving from farm-sewage spreading, the most significant aspect is given by the density of heads per hectare of available farming surface, as shown in Fig. 3, where the histogram stresses that Italy has a much higher density than France and one of the highest in the EC (1).

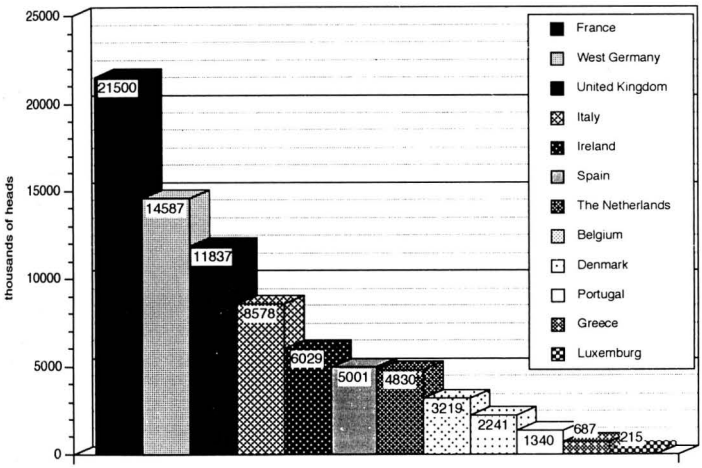

Fig. 2 - Bovine population in the EC in 1990 (after EUROSTAT).

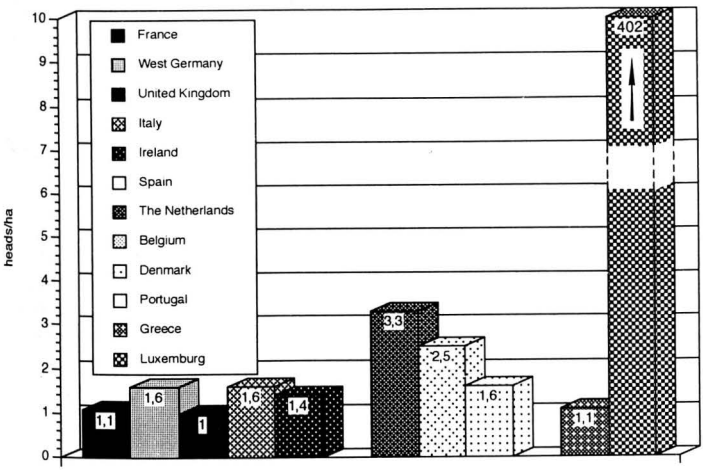

Fig. 3 - Bovine density in the EC in 1985 (no data available for Spain and Portugal).

2.2. Bovine distribution in Italy and induced environmental problems

The most peculiar fact in the case of Italy is given by a marked heterogeneity of the cattle farms' distribution in the territory, the highest density being found in the Po Valley and in the Veneto plain.

Therefore, in these areas the number of heads/ha results even higher. Moreover, within these lowland areas the peak values are concentrated in the central part of the Po Valley, as shown by Fig. 4. As previously said, this portion of the Italian territory is characterized by an extremely high vulnerability owing principally to the physical features of the soils which are made up of alluvial deposits, sedimented by the watercourses during the past 800,000 years. From the grain-size point of view, these sediments are classified into four main classes: gravels, sands, silts and clays. The first two show a very high permeability, thanks to the presence of numerous intercommunicating pores, whilst the latter are made up of very fine sediments in which the underground hydric flow is slowed down by the reduced communication between the narrower soil interstices.

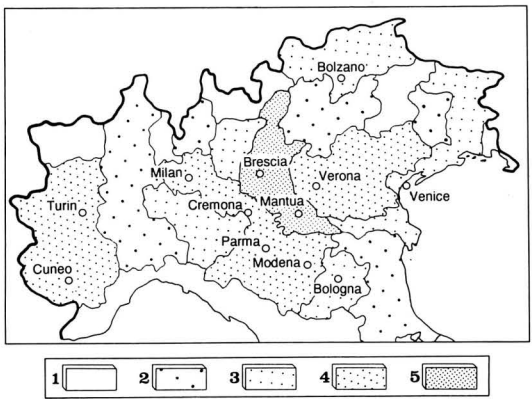

Fig. 4 - Bovine population distribution in Northern Italy in 1982, after (4) modified. Legend (thousands of heads):
1) < 45;
2) 45-90;
3) 90-180;
4) 180-360;
5) > 360.

The soils most vulnerable to pollution are those characterized by high permeability, that is those made up of coarser grains. From the hydrogeologic viewpoint, these soils correspond to the aquifers, where large amounts of groundwater are transferred and stored and where geochemical and biochemical exchanges with the surrounding environment take place.

Within the Po Valley these soils are mainly developed in the areas at the foot of the hills, along the Alpine and Apennine margins, at the outlet of the rivers into the plain (Fig. 5). Just on these most vulnerable areas the majority of cattle-farms are concentrated, as well as the main wells used for water-supply purposes.

The considerable amount of bovine excrements and their frequent spreading on farming soils has in several cases determined a decline in the groundwater quality, with pollutant concentrations that in many circumstances are well beyond the maximum levels allowed by law, inducing therefore risk conditions for the human population (5).

Investigations carried out in the Po Valley for the identification of aquifers exploitable for water-supply purposes have allowed a detailed reconstruction of the groundwater percolation paths and, therefore, of the pollutants by means of hydrochemical analyses and tracers (6, 7). Other investigations, performed in wells placed near the main townships of the Po Valley, have confirmed the existence of such mechanisms of groundwater flow, pointing out that pollutant substances percolated in the high plain, where the soil permeability and the large cattle-farm concentration reach the greatest values, are found in the water of the wells located several kilometers downstream of the inflow points.

For a correct evaluation of the pollution risk, it is not sufficient to examine only the lithologic data of the surface soils, but it is indispensable to assess also the thickness of the alluvial deposits, the depth of the water table and other important hydrogeologic parameters.

The substances that more than any other exceed the maximum admitted concentration of pollutants in groundwaters are the nitrogen compounds. Also the presence of biologic load in animal waste, which is easily propagated both on the surface and in the subsoil, should not be neglected, since in it considerable

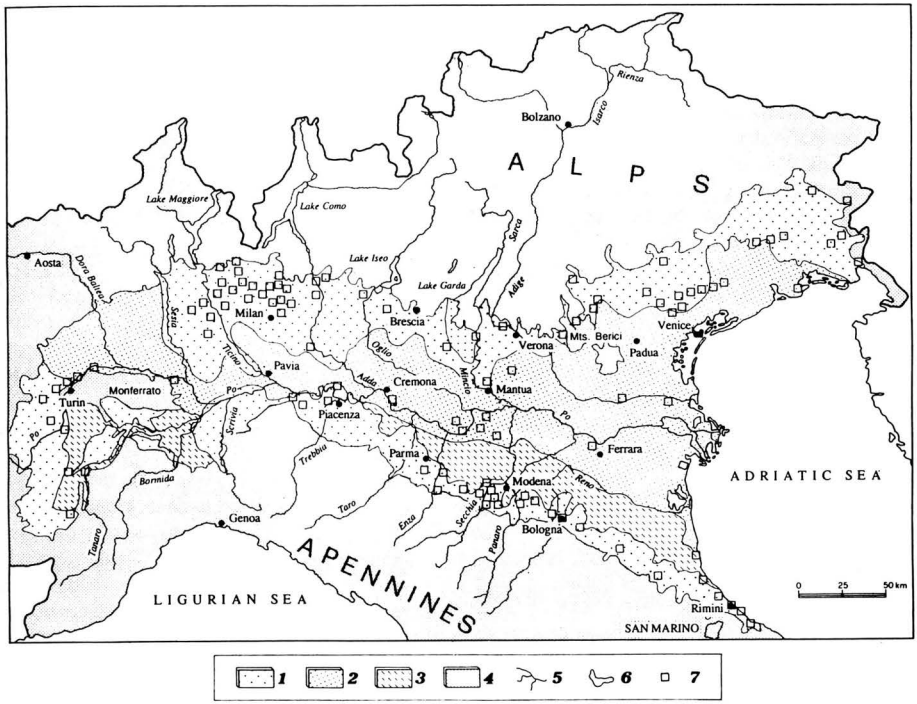

Fig. 5 - Schematic lithologic map of the Po Valley and surrounding areas. Legend: 1) gravels and coarse sands with high productivity aquifers; 2) sands and subordinate gravels and silts with high to low productivity aquifers; 3) silts, clays and subordinate sands with low to very low productivity aquifers; 4) Alpine and Apennine bedrocks; 5) main water courses; 6) lakes; 7) main wells for water-supply purposes.

amounts of pathogenic micro-organisms and germs carrying the transmissible factor of antibiotic resistance can be found, thus increasing the risk for man, as well as for animals and the environment in general. Among pollutants, also xenobiotics deriving from the dosing of drugs and additives in fodders, such as antibiotics, heavy metals, etc., are often found. As for the Po Valley situation, the percentage composition of bovine excrements and total bovine pollutant load per day (8) are shown in Tabs. 1 and 2.

Tab. 1 - Percentage composition of bovine excrements, after (8).

COMPONENTS	PERCENTAGE
Water	87.0
Organic Substance	11.0
Mineral Substance	2.0
Nitrogen	0.4
Potassium	0.20
Calcium	0.18
Phosphorus	0.02

Tab. 2 - Total bovine pollutant load per day in the Po Valley basin, after (8).

POLLUTANT LOAD	VALUE (tonne/day)
Dry Matter	18,483.527
COD	8,709.085
BOD_5	2,985.386
N total	739.248
K_2O	547.649
P_2O_5	476.762

3. PROSPECTS OF INTERVENTION

The adequate distribution of cattle-farms and the correct management and use of animal waste can be faced only within a well defined framework of the physical and environmental characteristics of the territory. To this purpose, particularly useful are the maps of the aquifer vulnerability to pollutants, already set out in several areas of the Po Valley as a result of investigations carried out by the National Group for the Defence from Hydrogeologic Catastrophies of the Italian National Research Council (9). These maps lay down various degrees of vulnerability, defined on the basis of the lithologic composition of the alluvial deposits, the depth of the first gravelly layer, the hydrodynamic characteristics of the aquifer and its relationships with the watercourses.

To solve the problems of pollution deriving from the large production of bovine manure, the ideal solution would consist in depuration. This practice is nevertheless excessively costly both in energetic and economic terms, and also extremely complex from the technical viewpoint. More performable are instead the techniques aiming at a different organization of cattle-farm typology and an optimal distribution of the farms on the territory. Indeed, the waste deriving from bovine breeding farms can constitute an important resource for the conservation of soil fertility, if the maximum amount tolerated by the available farming surface is not exceeded. The fertilizing action deriving from the spreading of farm-sewage does not imply negative effects on crops or on the environment only if the following criteria are strictly followed. First of all the suitable periods and the spreading procedures should be evaluated on the basis of the general characteristics of the territory, therefore taking into account the climatic, agronomic, pedologic and hydrogeologic aspects. The nutritional needs of the crops and the chemical composition of farm-sewage itself should also be considered.

When the production of animal waste is much greater than the amount necessary for fertilizing the farm's own land, the surplus should be adequately stocked and re-used for the production of biogas and biomass, or transferred to the land of other farms, where it could be more easily absorbed without creating environmental hazards. Such disposal techniques have already been successfully adopted within the EC, especially in the Netherlands, a country with an extremely high density of cattle-farms (10).

References

1. GARDI C. (1992) - Deiezioni, un problema di tutta la Comunità. *Informatore Zootecnico,* Anno XXXIX, Gen. 1992, 1-19. 2. CHIAPPINI U. & NAVAROTTO P. (1991) - La gestione delle deiezioni bovine per la tutela dell'ambiente. *Atti Soc. It. Buiatria,* 23, 31-35. 3. ROSSI N. (1991) - Recupero di una risorsa: utilizzo agronomico delle deiezioni zootecniche. *Atti Soc. It. Buiatria,* 23, 37-54. 4. TOURING CLUB ITALIANO (1990) - Allevamento e pesca. In: *"Atlante Tematico d'Italia.",* table 69. 5. SOLDATI M., TOSATTI G. & SOLDATI G. (1990) - Le attività produttive e la vulnerabilità territoriale nelle zone di pianura: il caso della Provincia di Modena. *Selezione Veterinaria,* 31(7), 873-888. 6. PELLEGRINI M. & ZAVATTI A. (1980) - Il sistema acquifero sotterraneo tra i fiumi Enza, Panaro e Po: alimentazione delle falde e scambi tra falde, correlazioni idrochimiche. *Quad. Ist. Ric. sulle Acque,* 51(1), C.N.R., 199-217. 7. ZUPPI G.M. (1986) - Introduzione all'idrologia isotopica. In: A. Zavatti (ed), *"Ambiente, Protezione e Risanamento",* 1, 281-335, Pitagora Ed., Bologna. 8. ACHENE L., AGRIMI U., BOZZANO A., CAPRIOLI L. & MACRI' A. (1989) - Reflui zootecnici e inquinamento. Il caso del bacino idrografico del Po. *Obiettivi e documenti veterinari,* 9, 49-55. 9. VARIOUS AUTHORS (1990) - Metodologie, Tecnologie e Obiettivi. *Atti I° Conv. Naz. sulla Protezione e Gestione delle Acque sotterranee,* Marano sul Panaro (Modena) 20-22 Sept. 1990, Presidenza Consiglio dei Ministri, G.N.D.C.I. C.N.R., R.E.R., U.S.L. 16. 10. VOORBURG J.H. (1983) - Handling, treatment and transport of manure in animal-dense areas and an evaluation of techniques according to analytical results. *4th Consultation of the FAO Cooperative Network on Animal Waste Utilization.*