CRITICAL EVALUATION OF THE FIRST 15 YEARS OF THE NITRATE DIRECTIVE: RESULTS, FAILURES AND URGENT TASKS

Péter Csathó and László Radimszky

Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences, Budapest, Hungary

Abstract

It is now 15 years since the European Union passed the Nitrates Directive, aimed at protecting surface and subsurface waters in EU countries. It is therefore worth reviewing the progress made in recent years in achieving the aims of this major agricultural and environmental regulation. A comparison of changes in the nitrogen (N) and phosphorus (P) balances of the EU15 and NEU12 countries and in the P supplies of the soils over the last 15 years will be used for this purpose.

The negative NP balances and worsening NP status in Central and Eastern European (CEE) countries, including those which have recently joined the EU (NEU12), may result in increasingly low yields and in economic and agronomic problems. These trends are in sharp contrast to past practices in some of the EU15 countries, where strongly positive NP balances and oversupplies with NP may lead to environmental and ecological threats, though, there is evidence that the level of oversupply in many of these countries is on decline.

Co-operation within the European Union should help to solve both the environmental threat facing the Western part of the community, and the agronomic and economic problems in the Central and Eastern part.

A Forum

When investigating the reasons for differences in the quantities of N and P applied as organic manure or mineral fertiliser, it became clear that in countries with a higher national per capita income, combined with greater population density, the agriculture was more intensive, involving greater quantities of N and P both from mineral fertiliser and from organic manure.

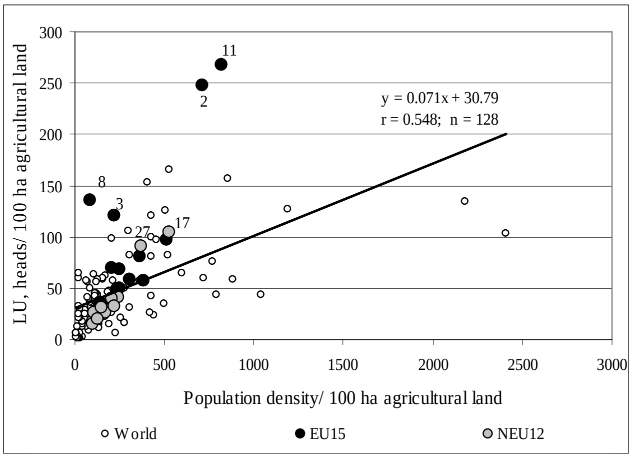

Fig. 1. **Correlation between population density and livestock density in the countries of the world in 2000**

The numbers in Figs. 1–3. and Fig. 5. represent the EU25 countries, as follows: 1 – Austria, 2 – Belgium and Luxembourg, 3 – Denmark, 4 – Finland, 5 – France, 6 – Germany, 7

– Greece, 8 – Ireland, 9 – Italy, 11 – Netherlands, 12 – Portugal, 13 – Spain, 14 – Sweden, 15 – United Kingdom, 16 – Bulgaria, 17 – Cyprus, 18 – Czech Republic, 19 – Estonia, 20 – Hungary, 21 – Latvia, 22 – Lithuania, 23 – Malta, 24 – Poland, 25 – Romania, 26 – Slovakia, 27 – Slovenia.

Per capita GDP was almost 2.5 times higher in the former EU15 countries than in the new EU (NEU12) group. In 2000, 56% more fertilizer (FER) N+P was applied in the EU15 than in the NEU12, indicating differences in the intensity of plant nutrition. The highest fertilizer NP rates were applied in the Netherlands, Germany and Belgium-Luxembourg. Almost twice as much NP was produced from farmyard manure (FYM) in the EU15 than in the NEU12, with the highest figures for the Netherlands (196 kg per hectare) and Belgium - Luxemburg (181 kg per hectare). This is the result of the unhealthily high LU number per agricultural area. The amount of fertilizer + farmyard manure NP was 70% higher in the EU15 than in the NEU12, with levels of over 300 kg per hectare in two countries (the Netherlands: 364 kg and Belgium - Luxemburg: 302 kg per hectare), and around 200 kg NP per hectare in three other countries (Germany: 195 kg; Ireland: 193 kg, and Denmark: 190 kg per hectare) (FAO Database, 2005).

In addition, higher per capita GDP and greater population density were also associated with a higher livestock density per unit area, further increasing the NP load to the agricultural area (Figs. 1–3). The average number of livestock per 100 hectares of agricultural land was almost twice as high in the EU15 as in the NEU12.

The greatest livestock densities per 100 hectares were reported in the Netherlands (268 heads) and in Belgium - Luxemburg (248 heads). The livestock density was extremely high compared with the population density in Belgium - Luxemburg and the Netherlands.

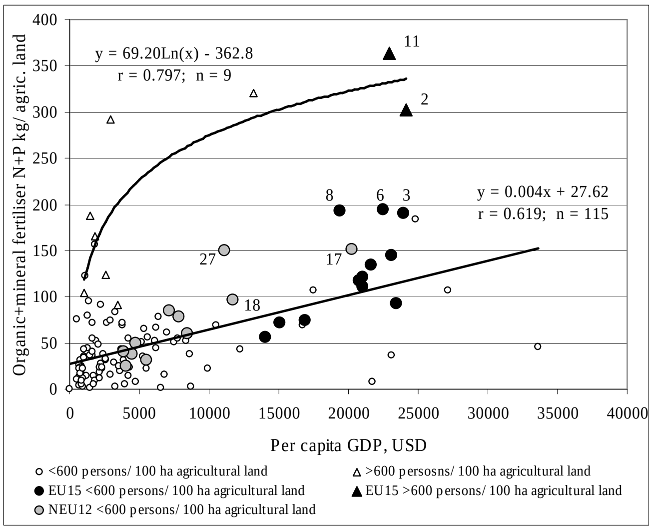

Fig. 2. **Correlation between the national per capita income and the application of organic and mineral fertiliser NP in the countries of the world as a function of population density in 2000 (Numbers 1-27: see text at Figure 1)**

When these two factors were compared for all the countries in the world, it was again these two countries that deviated to the greatest extent from the general trend.

Denmark and Ireland also had above-average livestock densities compared with the population density. Among the NEU12 countries, only Slovenia and Cyprus, the agricultural area of which was only just over 100,000 hectares, had a livestock density slightly greater than the average.

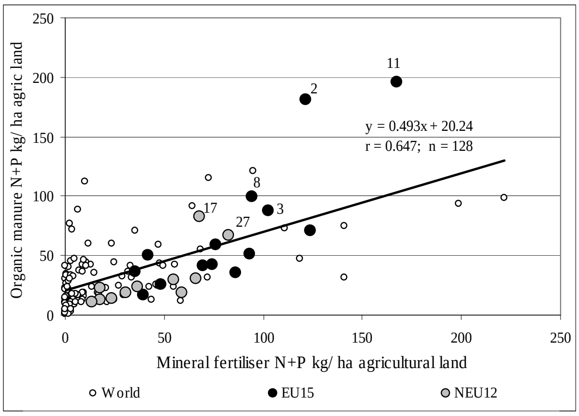

Fig. 3. **Correlation between the NP quantities applied as mineral fertiliser and produced as farmyard manure in the countries of the world in 2000. (Numbers 1-27: see text at Figure 1)**

One fundamental characteristic of fertiliser recommendations aimed at environmental sustainability is (or should be) that on areas poorly supplied with a given nutrient a quantity larger than that taken up by the crop is applied, slightly more than crop uptake on soil with moderate supplies, an amount equal to or slightly less than crop requirements on soils with good supplies, little or none on soils with very good supplies, and no P(K) fertiliser on soils with an excessive supply level (Fig. 4).

Fertility Class	Fertiliser Ratio	
E: Very high	0	
D: High	0.5	
C: Moderate	1.0	C= Maintenance
B: Low	1.5	
A: Very low	2.0	

Figure 4. **Phosphorus fertiliser recommendation for fields in Germany based on soil fertility class (STP) based on Vetter and Fruchtenicht (1974), cit: Tunney et al. (2003)**

If this logic is followed, in the EU15 countries of Western Europe, where the soils were far better supplied with phosphorus in the early 90s, far lower rates of (N)P should be applied and far lower (N)P balances are justified both from the agronomic and environment protection point of view than in the countries of Central and Eastern Europe, where P supplies were far poorer in the early 90s.

Let us see how far this theory is put into practice. Fig. 5. illustrates the correlation between the P supply index, indicative of the P status of the soil, and the P balance.

P balance data of the countries in Fig. 5. were published by Steén (1997), Csathó et al. (2007) and OECD (2007). In order to calculate the P supply index, a value of 1 was applied for areas very poorly supplied with phosphorus, 2 for poorly supplied areas, 3 for moderately well supplied areas, 4 for well supplied areas and 5 for very well supplied areas. This was

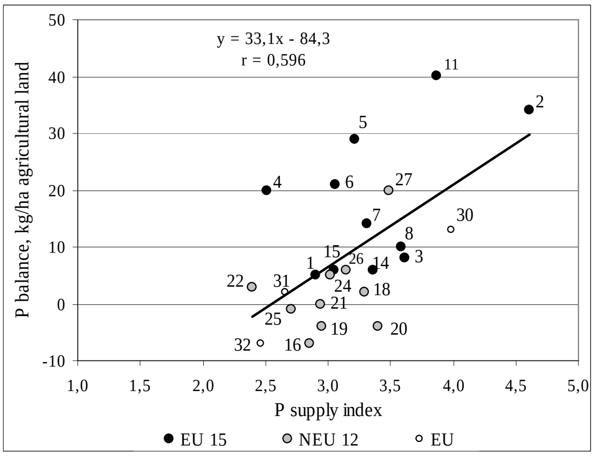

Fig. 5. **Correlation between the soil P supply index and the P balance in the countries of Europe in the early 1990s (Numbers 1-27: see text at Figure 1; 30: Norway; 31: Serbia and Montenegro; 32: Ukraine)**

then multiplied by the % of land belonging to the given supply category, i.e. by 0.1 for 10% of the land, by 0.2 for 20%, etc. The figures obtained for each category were then summed to give the P supply index of the country. A country very poorly supplied with phosphorus over 100% of its area would thus have a P supply index of 1.0, while the other extreme would be a country with very good supplies over 100% of its area, having a P supply index of 5.0. The introduction of a 6th category for excessive supplies of P would also be justified, but the necessary data are not available at present.

If P fertilisation was carried out in a manner acceptable from the agronomic and environment protection point of view, a negative correlation would have been plotted in Fig. 5., with P balances declining as the P supplies improved. By contrast, the opposite was observed in Europe in the early 1990s: the P balances in Central and Eastern Europe, where the P supply index was lowest, were the smallest, and in some cases negative (between –5 and –10 kg P/ha), while Western European countries, which had the highest P supply indexes, had the most positive P balances, with surpluses of 18–40 kg P/ha each year. This unfavourable situation (i.e. the polarization between the Western and Eastern part of the EU) was even accelerated and has become much worse since the time the Nitrates Directive was introduced, as is clear from the cumulative nitrogen and phosphorus balances of European countries over the last 15 years.

The cumulative N balances of certain European countries, many of them EU member countries, are presented in Fig. 6. for the period 1991 to 2005 and the P balances for the same period in Fig. 7. For countries where data were only available until 2002 or 2003, NP balances for the missing years were taken as being equal to the last recorded year.

The Netherlands and Belgium lead the field for both N and P balances. During the 15 years, that have elapsed since the time the Nitrates Directive was introduced, the total N surplus was 2800 kg/ha in Belgium and 3500 kg/ha in the Netherlands, and was also well above 2000 kg/ha in Denmark.

The cumulative N balance was also above average in Germany, Norway and Ireland, while the countries of Central and Eastern Europe came last, as expected (Fig. 6).

The P surplus accumulated over this 15-year period was more than 400 kg P /ha in the Netherlands and 300 kg P /ha in Belgium (Fig. 7).

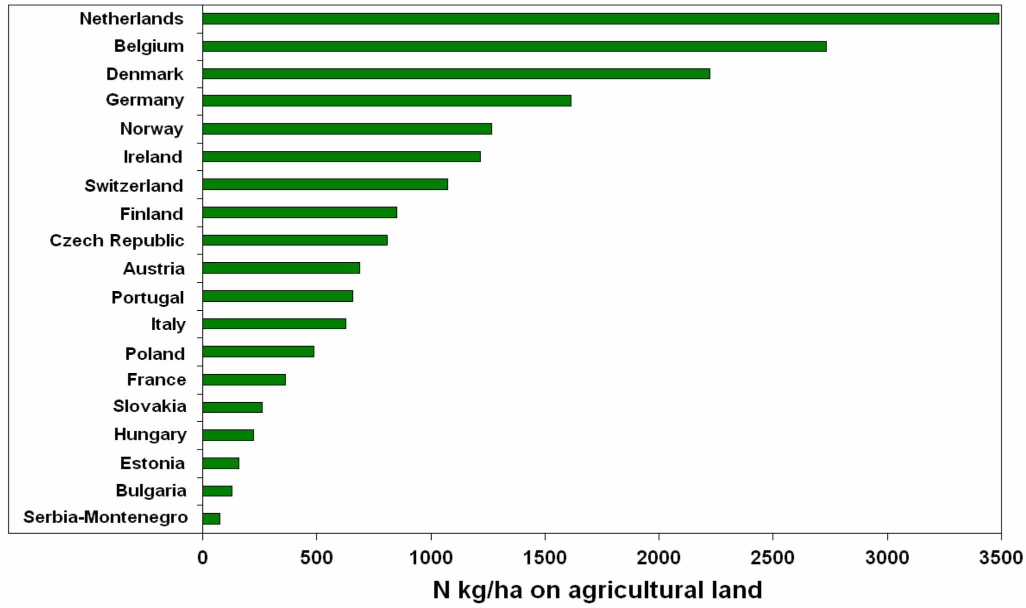

Fig. 6. **Estimated cumulative N balance of European countries, 1991–2005**

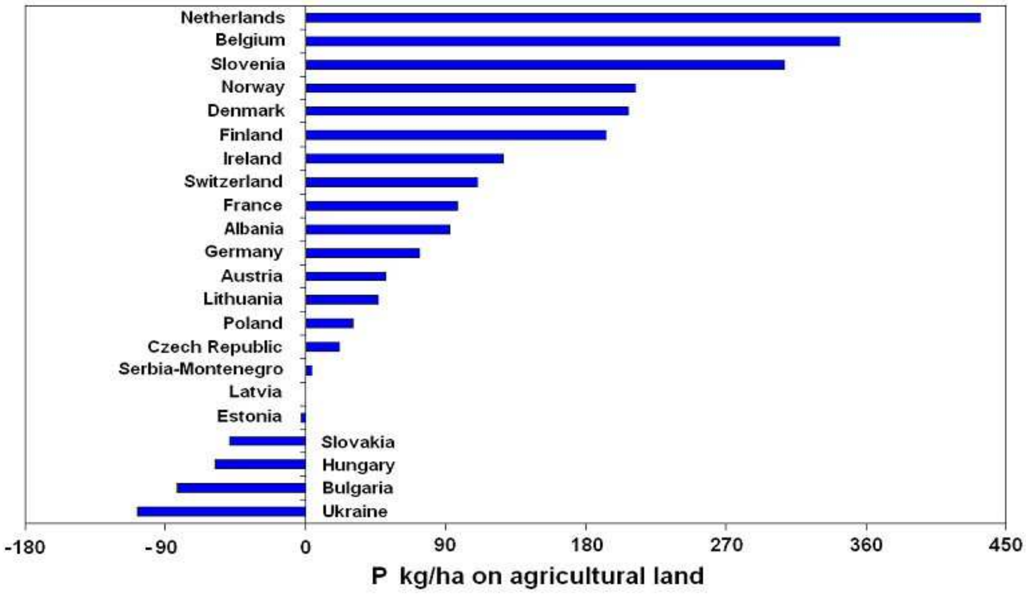

Fig. 7. **Estimated cumulative P balance of European countries, 1991–2005 (P kg/ha agricultural land)**

The "best" soil P supplies (really the worst from the environmental point of view) were recorded in these countries in 1991. Slovenia, Norway, Denmark and Finland also registered above-average increases in P over the last 15 years, and the Central and Eastern European countries were again at the bottom of the list.

Insights

In a perfectly correct and justifiable manner, the European Union made investments in environment protection a strict condition for the accession of the Central European countries to the EU. One essential obligation was the satisfactory disposal of sewage, as a water protection measure. The necessity for this decision was underlined by the results of analyses carried out with PHARE funding in the framework of the Integrated Danube Research Programme, which estimated the proportion of surface water (N)P loads caused by various sectors (Ijjas & Bögi, 1994; Németh et al., 1994; Vollenbroek, 1994). Due to the introduction of untreated sewage directly into surface waters, the NP load contributed by population waste was outstandingly high in Central Europe in the early 90s. The steps taken by the EU to protect surface waters have thus led to a dramatic reduction in point-source pollution caused by the (N)P contained in sewage.

The EU should be just as consistently strict in curbing the massive diffuse NP pollution caused by agriculture.

In some respects Europe lags behind the United States in terms of agricultural environmental protection. In many states effective legislation has been passed to reduce P loads of agricultural origin, despite the fact that the situation is far less serious than in many European countries (Gartley and Sims, 1994;Sharpley et al., 1994).

The preservation and rehabilitation of the environment will require **the following modification of the EU Nitrates Directive**:

A) Irrespective of nitrate sensitivity, regulations should be passed making it compulsory for fertiliser recommendation systems in EU countries to reduce the recommended mineral fertiliser N rates by the quantity of N applied in the form of farmyard manure/slurry, expressed in fertiliser N equivalency, and taking into account the rate at which farmyard manure is utilised by the crop, within the 3–4-year period (see next paragraph). The fertiliser N equivalency of FYM or slurry nitrogen can be considered as 50% on average, varying according to the livestock species and the technology (Kemppainen, 1989).

B) On nitrate-sensitive areas, while retaining the maximum permitted application of 170 kg N/ha of organic origin, the rate at which farmyard manure is utilised by the crops should also be considered in the directive, calculating with 50% in the first year, 30% in the 2nd and 20% in the 3rd on sandy or sandy loam soils, and 40% in the 1st year, 30% in the 2nd, 20% in the 3rd and 10% in the 4th on loam, clay loam and clay soils. For slurry N, the rate of utilisation should be calculated as 75% in the first year, and 25% in the 2nd year. If organic manure or slurry is applied every year, the total quantity of organic manure/slurry that will exert its effect in the given year should not exceed the 170 kg N/ha limit on nitrate-sensitive areas.

C) Only fertiliser recommendation systems that have been tested under field conditions for a number of years and that meet strict environment protection and economic criteria should be authorised for use in practice. Most case, the application of a total nitrogen quantity equivalent to more than 200 kg N/ha mineral fertiliser (applied as farmyard manure/slurry + mineral fertiliser) cannot be justified from the agronomic point of view and should be officially banned in the interests of environment protection.

D) In each EU27 country, annual and cumulative nitrogen balances should be prepared following the OECD environment protection approach for every year of the passed 20th century, as it is prepared for each year of the 21th century.

As eutrophication is caused by an excess of P rather than N in the majority of EU countries, a **Phosphates Directive** should be urgently compiled, incorporating the following principles:

A) When distinguishing soil P supply categories the P fertiliser responses of the crops should be taken into consideration. The upper limit of good P supplies, and thus the lower limit of very good supplies, should not be more than 1.5 times the lower limit of good P supplies. In the same way, the upper limit of very good P supplies, and thus the lower limit of

Table 1. **Lower limits for good soil supplies, and suggested lower limits for very good and excessive P supplies for the main soil P test values used in EU countries, mg P/kg**

Method	Lower limit for good soil P supply	Suggested lower limit for very good soil P supply	for excessive soil P supply	References for good soil P supply
H_2O	10	15	23	Jungk et al., 1993
Olsen	20	30	45	Johnston et al., 1986
Bray-1	22	33	50	McCallister et al., 1987
Mehlich-3	27	40	60	McCollum, 1991
AL (for acid soils)	44	66	99	Csathó, 2002, 2003
CAL	47	70	105	Spiegel, 2007
DL	60	90	135	Baumgärtel, 1989
AL (for calcareous soils)	66	99	149	Csathó, 2002, 2003

excessive supplies, should not be more than 1.5 times the lower limit of very good P supplies(Table 1).

B) Irrespective of phosphate sensitivity, regulations should be passed making it compulsory for fertiliser recommendation systems in EU countries to reduce the recommended mineral fertiliser P rates by the quantity of P applied in the form of farmyard manure/slurry, expressed in fertiliser P equivalency. In field experiments, the phosphorus in manure/slurry has often been observed to be just as effective as that in mineral fertilizer (Kemppainen, 1989).

C) Only fertiliser recommendation systems that have been tested under field conditions for a number of years and that meet strict environment protection and economic criteria should be authorised for use in practice. The application of a total phosphorus quantity of more than 50 kg P ha^{-1} (applied as farmyard manure/slurry + mineral fertiliser) cannot be justified from the agronomic point of view and should be officially banned in the interests of environment protection.

D) The concept of excessive P supplies should be compulsorily introduced in all EU countries. The application of phosphorus in either organic or mineral form should be **prohibited** on soils with excessive P supplies.

The use of P fertilisers should be banned above this level, at least on environmentally sensitive areas, but preferably throughout the country, and this principle should be introduced in the whole of the EU.

E) In each EU27 country, annual and cumulative phosphorus balances should be prepared following the OECD environment protection approach for every year of the passed 20th century in order to obtain a picture of the dynamics and extent of either soil P enrichment or depletion.

F) In addition to the annual publication of OECD P balances, it should be compulsory to prepare an annual evaluation of the P supply levels of all agriculturally cultivated land for submission to the OECD, the EEA, EUROSTAT, etc.

The benefit from all the changes should go to the local communities.

This way the aims of the EU Nitrates Directive, the EU Water Framework Directive (WFD) and the EU Common Agricultural Policy (CAP) for sustainable and environmentally friendly agricultural production that contributes to the achievements of ecological/ environmental quality targets of the water resources can be met.

Acknowledgement

The authors wish to thank Prof. A.E. Johnston, IACR, Rothamsted, UK, for his valuable advice on how to improve the manuscript.

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