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Phosphorus Derived From Animal Production: A Review

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Abstract: We make a review of the importance of Phosphorus manure (P) as an environment contaminant and its relationship with organic and sustainable agriculture. The P elimination pathway related with intensive livestock production in described as well as the soil harmful effect. The natural resistance against high levels of soil P shown by some plants is pointed out. Also, procedure to reduce manure P excretion. The poor handling of livestock manure coming out from intensive farming has a very high P contents with represent a dangerous challenge to the environment. Two main tools are available to reduce for P harmful effect one are the phytase inclusion in feed stuffs and two the growing of P resistant plants.

Key words: Organic agricultural production, manure handling, dairy cow, ewes, phosphorus

INTRODUCTION

Organic agriculture: The food production system that includes human and economic aspects, natural resources and the natural environment, to maximize the quality of agricultural and natural resources is known as organic agriculture (Ramirez *et al*., 2004).

The beginning of modern organic agriculture is credited to Alberet Howard's and Eve Balfour's studies from the 1940's, which show that plant health, soil, livestock and people are related. For this reason, the farming methods must be in harmony with nature using products from the farm. More recently, the organic agriculture was popularized by J.I. Rodale evoking farm harnessing through an understanding of natural systems.

The 60's and 70's include the relation between agriculture and resource conservation emphasizing the use of limited non renewable resources. In the 80's, there was a growth of the public aware of the negative impact from normal agriculture and terms like low ingress, ecologic, sustainable proliferated to describe an agriculture benefic with the natural environment, economically sane and socially fair, finally the term sustainable includes all the other terms including organic (Klonsky and Tourte, 1998). The concept of sustainable development, as it is publicized these days, can be found in 1983, when the United Nations (UN) made the World Commission on Natural environment and Development, presided by Gro Harlem Brundtland and denominated it the Brundtland Commission. In his report, the concept of Sustainable development is defined as following: the sustainable development is the development that covers the necessities from the current generation, without compromising the capacity of the future generations, to satisfy their own, therefore the system of sustainable agriculture is seen from three vantages points; food self-sufficiency quality and care to the natural environment and sustainable agriculture in a determined community (Tamez-Guerra *et al*., 2001).

Objective: The main objective of this study is to bring attention to the hazard that phosphorus eliminate by livestock manure, represents to the environment. And the growing difficulties to recycling it by animals and plants, due to the high phosphorus saturation of soil.

MATERIALS AND METHODS

This research was realized by the analysis of published information related to manure phosphorus

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elimination in high density livestock populations, as well with the addition of some empirical data reached by experimental research that soon will be publish.

RESULTS AND DISCUSSION

Manure and agricultural crop yield: One of the principles of organic agriculture is the use of products from the farm (Klonsky and Tourte, 1998). The excretions from the livestock and compost are applied to the soil to add organic matter and nutrients and increase its physical properties, because of its important influence on water infiltration and control of erosion; manure has showed it can suppress some pathogens in the soil (Klonsky and Tourte, 1998). And the residual effects from organic matter in soil properties can contribute to improve quality some years after the application has ceased; increments on soil levels of N, P, K, pH and C levels can increase the performance of the crop years away from the application (Eghball *et al*., 2004). The application of manure or its compost results in an increase in concentration of nutrients and organic matter in the soil (Chang *et al*., 1991; Eghball, 2002) with significant residual effect that has been observed with applications of dairy cattle manure in levels that vary in a range of 22.5-270 mg in dry weight ha^{-1} (530-6400 kg of N ha^{-1}) but the best increments in crops are observed in levels between 180 and 270 Mg ha^{-1}. Four years after the application, the residual effect of one manure appliance from fattening cattle in proportions that vary from 123-590 mg of dry manure ha^{-1} (1280-6140 kg N ha^{-1}) that results in a quadratic increment in grain production (Eghball *et al*., 2004).

In this way, the manure use is justified as a source of agricultural use nutrients therefore, in this revision, we analyze the effect of manure's phosphorus and its environment impact. Manure defined as excrement and urine as it is poured by the animal and without bedding matter.

The annual livestock production and its byproducts has increased continuously during the last century, also it is evident a strong increase in livestock's productivity (defining it as the amount of meat, milk and eggs produced by a certain livestock), the increase in productivity where given in a greater number of born animals and a greater weight at the sacrifice and a larger quantity of milk and eggs, these gains in productivity have been possible because of the genetic selection and also better diet formulation and its processing, improvements in housing and environmental management like comfortable building, far from the manure and ventilation management, veterinarian and medical attention, these improvements in productivity also reflect in less food for the production of a given quantity of products and as a consequence less quantity of manure per animal (Air Emissions From Animal Feeding Operations Current Knowledge, Future Needs (2003). Mexico's case doesn't escape this growth phenomenon in animal production as observe in the Table 1.

Phosphorus in intense animal production: The advances in animal production at large scale, where a great number of animals are kept in a few land extensions and a great quantity of nutrients are imported to maintain the productive operations, like dairy cattle, beef cattle, poultry or pork production, all that has generated an increasing concern on the possible negative impact of these systems of animal production on the natural environment, especially in countries of regions with high animal density, by example in zones with high concentration of poultry and pigs, the application of P and Cu in the soil exceeds by far the quantities extracted in the crop, leading to a saturation in soil's P fixation capacity (Jongbloed and Kemme, 1997; Dao and Cavigelli, 2003).

In the last 20 years, there has been a spectacular development in knowledge in all types of animal production. This has driven to great changes in the structure of swine production, resulting in high concentrations in few extensions of land, for example in Denmark, Netherlands and France it fluctuates in 750, 1,000 and 720, pigs km^{-1} in 1995, respectively (Dourmad and Seve, 1997; Jongloed and Kemme, 1997). Table 1 shows some figures from high density animal population Mexican regions.

It is estimated that dairy cattle stock in United States of America produces 2×10^{8} Mg of manure (Toth *et al*., 2006). In areas with big concentrations of farms with intensive production, the contents of P in soils is increased due to the application of P as fertilizer and animal manure that exceeds the necessary rates to maintain an optimal fertilization for the production of the crops (Koopmans *et al*., 2003). On the latest decades, the interest in soils test and system of phosphorus recommendation has been renewed because of the concern about P and water quality (Magdoff *et al*., 1999). Phosphorus is the main limiting nutriment in corn and soy production in a lot of regions (Wittry and Mallarino,

Table 1: Cattle and Swine population in some Mexican regions

Regions	Cattle km^{-2}	Swine km^{-2}
Tizayuca pachuca	204.81	35.85
Huandacareo	122.29	1484.05
Gomez palacio	117.57	6.48
Tlazazalca	100.17	329.94
La piedad michoacan	39.88	1268.13

2004). Studies of the spatial variability of phosphorusand other nutrients have revealed a great variability inside the fields as a result of natural process and also management procedures (Wittry and Mallarino, 2004).

Phosphorus in feed stuff: Phosphorus contained in feed stuff both in organic and inorganic form. Mainly as orthophosphates (PO_4^{3-}) and in organic form as molecules like ATP, nucleic acids, phospholipids, phosphoproteins and phosphoglucids, the hydrolysis of organic P in the digestive track frees PO_4^{3-}, which is the only form that an animal can absorb and use it, in vegetables the organic P represents the longest fraction, being the phytic acid the most abundant phosphoglucid, around 60-80% of the total P contained in grains and its sub products are the phytic acid and its salts, generally as Ca, K and Mg phytates, on the contrary, in feed stuff there is a predominance of inorganic P as orthophosphates in solutes inside the cell medium generally as calcium phosphates in osseous tissue and in milk, around 80-85% of P in animal organisms is found in the skeleton as Calcium phosphate $Ca_3 (PO_4)_2$ and Calcium Hydroxyapatite Ca10 (PO_4) 6 $(OH)_2$, the other 15-20% is found as organic Phosphorus in muscular and nervous tissue, particularly in the red blood cells, blood contains between 35 and 45 mg of P/100 mL in majority inside cells because the plasma only has between 4.5 and 6 mg P/100 mL in adults and between 6 and 9 mg P/100 mL in young animals (Rebollar and Mateos, 1999). Seeds in development synthesize and store great amounts of calcium, magnesium and potassium phytate that are know together as phytine (Dao, 2003).

Phosphorus in vegetables: Due to the facts that phosphorus in vegetables is found in inorganic form in low proportions and mostly bound to phytic acid (about 28% in phosphoric acid radicals) and that monogastric animals, in general, have few or none enzymes in the small intestine that can hydrolyze the fitates that's why phosphorus has limited absortion on those animals (Rebollar and Mateos, 1999). Phytic acid normally is between 60-90% of the reserves of P and myo-inositol in great numbers in cultivated grains and in soy bean (*Glycine max* (L.) Merr.) phosphorus is stored mainly as phytic acid in a way that isn't available for monogastric animals and birds, meanwhile manure contains partially digested fibers and grains, where P is bound to organic compounds that include myo-inositol 1, 2, 3, 5/4, 6-hexakis dihydrogenphosphate, phytic acid (Dao, 2004; Walker *et al*., 2006). Feed stuff with various proportions also contains IP and myo-inositol hexakis dihydrogenphosphate that is mainly indigestible by pigs and domestic birds and its excreted in manure.

Phosphorus in manure and its effect on soil: The level of P in diet influence P concentration in manure and can affect the loss of P in manure applied lands, a diet for dairy cows with inorganic P in excess increments the potential of eliminated P by surface runoff of manure applied to lands even when applied in the same proportions (Ebeling *et al*., 2002). The mineral sources for P more often used in animal feeding are Na, Ca, K, NH^{4+} orthophosphates and their combinations. The various sources of P can contain variable quantities of meta-($(PO_3)^{3-}$) and pyro-($(P_2O_7)^{4-}$) phosphates in function of temperatures reached during the process of obtention, other mineral phosphates of lower practical importance due to their low disponibility in monogastric, are rock phosphates, Na, K and Ca metaphosphates, Ca and Na pyrophosphates and NH^{4+} and Na polyphosphates (n $(PO_4)^{3-}$) (Rebollar and Mateos, 1999). Nitrogen, phosphorus and potassium are the main nutrients of agronomic importance, but nitrogen and phosphorus also have an environmental risk (Adeli *et al*., 2003).

For decades, the majority of agricultural soils in Europe had been fertilized with P to optimize production. Phosphorus as a fertilizer suffers chemical reactions that influence its disponibility for the plant, generally the absorption and precipitation processes and the union of both cannot be distinguished in most of the cases (Delgado and Torrent, 2000).

Bovine manure production: The cow's eliminated manure average with milk production average of 29 is 89 kg day^{-1} for every 1000 kg of corporal weight and 60 kg of feces for every 1000 kg of corporal weight, for cows with milk productions of 14 kg day^{-1} produce in average 65.9 kg of manure for each 1000 kg of live weight and 41 kg of feces for each 1000 kg of corporal weigh, for non dairy cows the manure production was 34.8 kg day^{-1} for each 1000 kg of corporal weight and 15.1 kg day^{-1} of feces for each 1000 kg of corporal weight, for growing bovines and heifers, there's a production of 32.6 kg day^{-1} of each 1000 kg of corporal weight (Wilkerson *et al*., 1997). In average a dairy cow diet in USA contain 4.8 g kg^{-1}, while they only need 3.8 g kg^{-1} to optimize the production and reproductive efficiency, a low of 6.5-4.5 g P kg^{-1} for dairy cattle diets doesn't influence in a consistent way over reproduction nor over production. In Mexico's La Comarca Lagunera there are 400,000 heads of bovine livestock and a similar number of goat livestock with a cattle manure production that surpasses the million kg/day (Salazar *et al*., 2004).

Phosphorus properties and transformations in manure and soil: In France in 1999, 7300 reproductive pigs and 12, 500 growing pigs, produced 7,800 and 25,400 ton of

P year^{-1} (17,900 and 12,5000 in P_2O_5 form), respectively (Dourmad and Seve, 1997). The P in manure is found either in organic or inorganic for, the inorganic form varies between 5-25% of total phosphorus, the soluble organic compounds of P in liquid phase in pig wastes (a mixture of feces, urine and cleaning water) represent the 1% of the total P, of high molecular weights related to deoxyribonucleic acid, that is, orthophosphate diesters (Koopmans *et al*., 2003; Dou *et al*., 2000; Sharpley and Moyer, 2000).

When, pig wastes are used as fertilizer the organic P has a molecular weight characteristically similar to soluble organic P compounds, therefore some organic P compounds for animal manure can be better mobilized in soil that inorganic P (Koopmans *et al*., 2003).

This way, in soils treated with great quantities of manure, it is expected an increment in organic and inorganic P contents and as a consequence the contribution of these P compounds and P contribution to soils are different and a prolonged application of manure and P fertilizers provoke an inorganic P accumulation resulting in a potential risk related with inorganic P mobilization in the 5 cm layer of the soil and also the superficial water, the main routes of P transport in crop fields is erosion, surface runoff and lixiviate, this way P can be transported in both particle and soluble P forms (Borling *et al*., 2004; Koopmans *et al*., 2003; Sims *et al*., 1998). Soil's soluble phosphorus is dictated by the combination of fertilizers and crop practices, soils properties and time interrelated factors (Calhoun *et al*., 2002).

The constant manure application to lands in bigger proportions than what is extracted by crops, modify the chemistry of phosphorus in land and are accumulated to levels that has already cause global concern, studies in Switzerland show that the arable layer has accumulated between 600-700 kg of P since 50's mean while in the low region of Sahara the crop of N, P and K is bigger than one that was applied, this is reflected in a reduction of crops (Borling *et al*., 2004; Sharpley *et al*., 2004; Powell *et al*., 2004). In Netherlands, intensive farms are found mainly over sandy soils and these soils are characterized by a low P absorption capacity and as a result the P can lixiviate (Sims *et al*., 1998).

It has been found a great fraction of hydrolysable phytase in bovine manure, even though the microbial flora of the rumen, which has enzymes to break IP6 (Dao, 2003). Myo-inositol hexakis dihydrogenphosphate is dephosphorylated by the phytase (Myo-inositol hexakis dihydrogenphosphate phosphohydrolases) and the phosphatase of plants, soils, water and animal manure (Dao, 2003) adding Aspergillus ficuum (Reichardt) Henn. phitase EC 3.1, 3.8 has the capability of hydrolyzing a net average of 2.2 mmol of P kg^{-1} of solid manure form dairy cattle and in this enzymatic process increments the contents of manure's inorganic P dissolved that is variable in time and space (Dao, 2003).

When, the application rate is based in the correct disponibility of P and N, with manure of fattening bovine, the production of grain is equal or better than the one with fertilizers in 3 years of experimentation, the annual application on a P basis is the most effective method to be used in soils, in which the increase of P is a worry, since in soils with high levels of P the absorption of applied phosphorus is normally lower (Eghball and Power, 1999). Of the total fattening bovine manure's phosphorus that is retained, the phosphorus in corn grain varied from 61-83% (Eghball and Power, 1999).

Swine wastes in agriculture: The big quantities of manure derived from the operations of pig in confinement feeding in big farms in general are dumped in anaerobic oxidation lagoons to ease decomposition and digestion, obtaining in this way a solution with multiple nutrients N, P, K, Ca, Mg included and micronutrients (Sutton *et al*., 1982; Burns *et al*., 1985; Adeli and Varco, 2001; Adeli *et al*., 2003). The rate and time of application of pig's effluent for the crop irrigation is important to minimize the adverse effect on quality of soil and water (Adeli *et al*., 2003). In the same way to reduce, the potential environmental risk due to the excessive levels of nutrient derived from effluents, the rate of application doesn't have to exceed the soil and the plant's capacity (Adeli *et al*., 2003).

The efficiency in N and P use derived from oxidation lagoons of pig waste is critical to minimize the movement of nutrients to the exterior, the existing N in effluents is mainly in NH_4/NH_3-N in an 84% with minimal contents NO_3-N contained with only a 2.2% the dominancy of ammonia N reflects the nature of the process of anaerobial decomposing in the oxidation lagoon, the pH slightly alkaline is a reflection of the anaerobial nature, just as the N, the majority of P that is dissolved in water is ortho-P in an 80% suggesting that N and P disponibility would be similar to the ones from commercial fertilizers, however, due to the presence of organic compounds it is speculated that N disponibility could decrease due to a bigger immobilization and also to losses because of denitrification and volatilization of NH_3 (Adeli and Varco, 2001). The same way more inorganic P can be immobilized due to the presence of organic compounds (Adeli and Varco, 2001).

The crop fields that had pig manure applied in levels estimated in 371, 61 and 629 kg/ha/year of N, P and K for 8 years before the study, the studied bermuda grass had a higher retain rate of P and N in comparison to other grass, the P retain varied inside a range f 10.1-43.8 kg/ha/year in common bermuda grass and 9.7-34.8 kg/ha/year in coast bermuda, the P concentration is increased in all grasses, but in Jonson grass the P concentration was 2.9 P kg^{-1} but bermuda grass produced a higher quantity of dry matter having as a result a higher N and P retain that Johnson grass, the concentrations of P were higher in common bermuda grass than in other species, except for the Johnson grass (McLaughlin *et al*., 2004).

Pig manure or agriculture fertilizer application doesn't increase the P concentration in vegetal tissue in a significant way, in some cases the P concentration declines, suggesting that total P accumulation in the grass is probably more related to the production rate of dry matter instead of P content in the tissue, in bermuda and annual grasses, the dry matter production didn't have high correlation with P concentration in tissue, however, for Johnson grass the relation was significant, but the P concentration generally decreases when the rate of manure and fertilizer increases (Adeli and Varco, 2001). The relative plant capacity to remove P and other nutrients in soils with high P levels is more important, the bermuda grass respond well to high levels of fertilizing with pig manure, it removes an average of 382 kg N/ha/year and 43 kg of P kg/ha/year (Burns *et al*., 1985).

Bermuda Alicia grass responds to manure level increase by increasing the dry matter production and P retain, even a N fertilizing equivalent to 448 kg ha^{-1} (Adeli and Varco, 2001) analyze the P concentration in Johnson grass that developed in soils fertilized by pig effluents and report concentrations that vary from 1.9-2.8 g of P kg^{-1} in the 1st and 3rd year of treatment), but high levels of N effluents don't produce strong increments in dry matter. Even, when a good fertilizer is used, in long term it results in an enrichment of other nutrient, such as Ca, K, Mg and P (Simard *et al*., 1995).

Dairy cattle wastes in agriculture: The use of effluent of dairy cattle provide nutrients and water for the growth of crops and allows the recycling of nutrients (Macoon *et al*., 2002). To recycle the nutrients through application of dairy cattle effluents on land requires the use of crops capable of using these nutrients, for example the production of rye (*Secale cereale* L.), Bermuda zacate (*Cynodon* sp.), corn (*Zea mays* L.), peanut (*Arachis glabrata* Benth.) at levels higher than 450 kg ha^{-1} of N has low answer (Macoon *et al*., 2002).

Poultry wastes in agriculture: Evaluating the dynamics of nutrients in the soil though the year with chicken manure as only source of nutrients, it was found that concentrations of total extractable Mehlich-3 phosphorus are increased mainly from 5-10 cm of deepness, indicating a lixiviation of P, concluding that bermuda grass production *Cynodon dactylon* (L.) it's possible with chicken manure as the only source of fertilizing, even though it can happen in the long term a great unbalance of nutrients in the soil of inadequate proportions use (Sistani *et al*., 2004).

Natural plant resistance to phosphorus: Maguire *et al.* (1998) found that total phosphorus and the phosphorus accessible to the plant are increased but the water soluble P decreases when the soil's aggregates also decrease in size. Muir *et al.* (2001) studied *Panicum lignocelluvirgatum* L. and found that phosphorus isn't crucial to this grass in the northern south central region of Texas, which indicates that this native grass in effective enough to extract the phosphorus bound to the soil to avoid the need of providing bigger quantities of P to the land as fertilizer.

Phosphorus as an environmental contaminant: As crop fields overflow, the water that runoffs and drains contribute to environment P, the magnitude of P that is discharged by the water is related with the soil's chemical and physical properties, sediments and much other variable environmental factors such as water-soil redox potential, water deepness, temperature and turbulence (Sallade and Sims, 1997; Young and Ross, 2001). Even though, a lot of soils have a high capacity to absorb P, the extended application of chicken manure often result in a saturation of P, particularly near the surface (Kingery *et al*., 1994). In general, the P enriched soil's surface are a source of dissolved P (Sharpley *et al*., 1994).

Eutrophication dynamics: The risk of lake, reservoir or river eutrophication has restrained the use of P in soil in a lot of agricultural areas with superficial waters as well as the development of methods to determine such losses (Torrent and Delgado, 2001). In normal situations, the phytic P consumed by the animal appears in the feces almost completely, once in the terrain this P is liberated by soil microbe phytase action that later passes to rivers and lakes giving place to eutrophication in water currents and aquatic reservoirs, under this circumstances there is an accelerated algae growth and an exhaustion of contained oxygen in the water that causes mortality in aquatic fauna (Sims *et al*., 1998; Rebollar and Mateos, 1999). The accumulative quantity of lixiviated phosphorus studied in columns, after five simulated rain events, significant differences were observed between sources of organic phosphorus and contents of water extractable phosphorus, proportioning a good estimation of the phosphorus lost though lixiviation (Sharpley and Moyer, 2000; Leytem *et al*., 2004). In Netherlands, it was established that concentration of ortho-P in subsoil water and superficial waters doesn't have to exceed. About 10 mg L^{-1} and the quantity of manure that can be applied by hectare of terrain is bases in its P contents (Jongbloed and Kemme, 1997).

Studies in Netherlands show that the crops extract by midterm 50 kg of P_2O_5 by hectare, the overpass of these limits drives to an eutrophication and can give place to an excessive growth of undesired algae, aquatic vegetation that results in a massive fish mortality, biological oxygen demand, since they dissolve O_2 releasing disgusting odors and degrading the water quality, incapacitating it for fishing, recreation and consume, damaging the landscape (Jongbloed and Kemme, 1997; Parry, 1998; Sharpley *et al*., 1994, 2004). Since phosphorus dragged by surface runoff in agricultural fields is implicated in degradation of water quality in rivers and lakes (Leytem *et al*., 2004). This way the phosphorus along with nitrogen has transformed in minerals with environmental problems at a worldwide scale in the latest years.

The loss of P in farm soils in superficial flow or surface runoff occur under diverse conditions, generally one can assume the proportion between soil mass and water (dissolved electrolytes) mass in contact with it, time of contact and grade of mix of soil and water seem to be the most important factor that influence the loss of P in soils, concluding that the concentration of reactive phosphorus dissolved in extracted water 1:1 P1:1 is a useful index to predict the discharge of P form soil to water in different scenarios of P retaining and through an extent range of soils (Torrent and Delgado, 2001).

Phosphorus excretion reduction: There are diverse technologies that allow to reduce the quantities of P excreted to the environment through dejections. A first way and probably the most rentable at a whole country scale is adjust the consume of P to the real necessities of the animal. This key strategy bring with it three possible lines of action: the exhaustive study of the animal needs by productivity and physiological state with the subsequent revision of P levels in diets, the evaluation of the use of contained P in diverse raw material in function of evaluated species and modifications of the diet with the incorporation of additives capable of bettering the use of P. On this particular, it is worth to mention the influence over the use of P and the ration Ca:P on the diet, the inclusion of high levels of vitamin D3 or its analogous, the addition of phytases and probably, the acidification of compound feed (Rebollar and Mateos, 1999).

Phosphorus in the soil: The soil values of P and K were related significantly with the productive answer to N application and these relations explain the 6 and 7% of the variability in the productive answer of *Zea mays* L. corn fertilized with manure, the mayor answers tend to occur at lower values, a possible explanation of this relation is that high levels of P and K in soil are result of previous applications of animal manure and this applications also increase the rate of N mineralization in the soil, the lineal relation indicates that P values explain the 4% of the soil's NO_3 concentration variability and that values of K in soil explain the 7% of the variability, however, the values of P and K aren't significantly correlated with N applications in manure indicating an effect of previous applications (Hansen *et al*., 2004).

Some results show that manure applications to the land change the P from Al-and Fe-forms to products of Ca-P reaction. Responding for a relatively higher Mehlich-3, but low water extractable P. This change has implications to environmental P tests, since Mehlich-3 P has showed overestimating the potential loss of P in the fluids with high manure concentration, could be explained through the dissolution of water insoluble Ca-P minerals (Sharpley *et al*., 2004). Aggregate measuring in P Resin soil, water soluble phosphorus and the buffer capacity of P, when two aggregation sizes where mixed the water soluble P released by a fraction can be absorbed by the other, this P reabsorption can result in a decrease of expected P concentration in the solution in some superficial waters (Maguire *et al*., 2002).

CONCLUSION

The phosphorus level on feedstuff has a variable availability related to the gastric and enzymatic configuration of the animals. The lowest phosphorus absorption rate belongs to monogastrics and the highest to poligastrics due to the ruminal flora activity.

The low phosphorus absorption allows great quantities of this mineral in the manure which, quickly contaminate the close environment. However, the phytasa diet inclusion reduces the environment phosphorus contamination.

As well the growing of phosphorus resistant plants is a good approach to reduce the deleterious effect of that mineral in highly contaminated soils.

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