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# The reverse of the medal : feed additives in the environment

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ABSTRACT

The aim of the paper is the probable scenario of changes which can be observed in the soil under influence of feed additives used in animal farming which reach the soil with animal's manure. The feed additives (e.g. antibiotics) inactivate microbial community. It leads to increase of plant debris in soil and elements are not available for plants, their production (primary production) fall down. Reduction of bacteria could cause loss of food source for soil fauna (protozoans, nematodes, micro-arthropods etc.) and its reduction. The reduction of soil animals community causes reduction of the soil community biodiversity and destabilisation of soil ecosystem. Those processes can cause the degradation of the soil and decrease of its productivity.

KEY WORDS: feed additives, antibiotics, soil ecosystem, soil degradation

## INTRODUCTION

From the well-known model of the energy and matter distribution in an organism (Figure 1) one can see that animal feeding, like a medal, has the averse – food consumption and assimilation, and the reverse – rejection of non assimilated parts of food ratio (for details – see Petrusewicz and Mcfadyen, 1970; Klekowski and Duncan 1975; Klekowski, 1993).

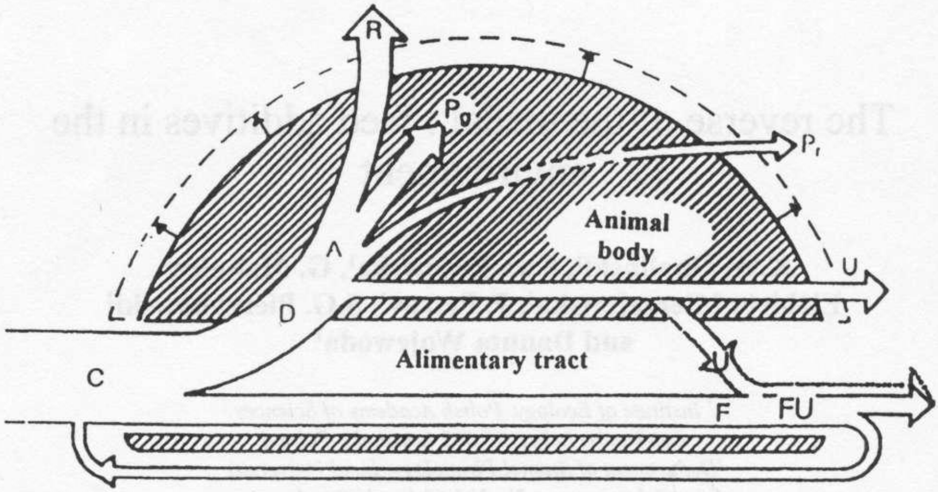


Figure 1. The scheme of food transformation in an animal. C – food consumption, D – digested food, A – assimilated food, R – respiration, Pg– production of body mass, Pr – production of offspring, U – urinary products, F – faeces, Crf – refecation (after Klekowski, 1993)

The stock-farmers and people working on the problem of intensification of the meat (milk, eggs etc.) production are interested only in the averse of the problem – food assimilation, body production. However for ecologists the problem starts on the reverse side. Animal rejecta come into the environment with all growth promoters which were added to the feedingstuff.

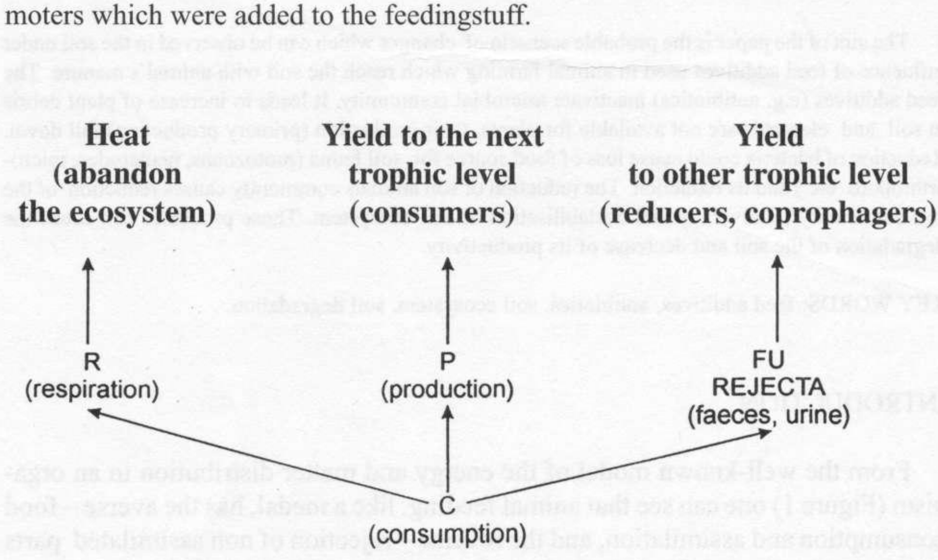


Figure 2. Matter balance in a species population level. Production of body mass (P) and rejecta (FU) are the yields to the next trophic levels

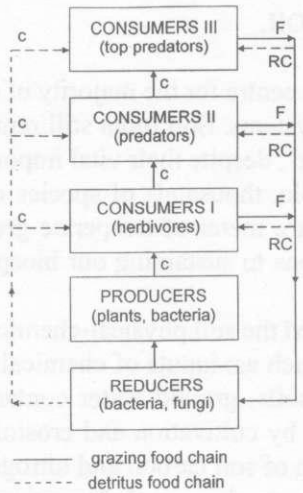


Figure 3. The scheme of grazing and detritus food chains in an ecosystem. C – consumption, F – faeces production, RF – refecation

What happens with those pharmaceutical products in the environment?

According to the scheme also well-known in ecology, animal faeces containing feed additives are the food supply for coprophagers and other decomposers (Figure 2; see also Odum 1971; Collier et al., 1973; Klekowski and Duncan, 1975), and those additives can come up along detritus food chain (Figure 3; for details see Odum 1971; Begon et al., 1996).

The detritus food chain take a course mainly in the soil. The information on the influence of feed additives on the soil ecosystem are rather scarce. According to Migliore et al. (1996) biocides from intensive farming can be one of sources of environmental chemical pollution. Those substances could affect soil microorganisms and thus disturb ecological cycles in the soil (van Gool, 1993). Antibacterial agents used as feed additives may contribute to the increase of antimicrobial resistance in bacteria that infect humans (Richter et al., 1996). In the other hand, Ellis and May (1986) suggest that avoparcin, a growth promoter for pigs, can be degraded by microbial processes in soil.

## THE AIM

The aim of this paper is to create the probable scenario of ecological changes, or generally – processes, which can be observed in the soil ecosystem under the pressure of drugs added to the animal food which reach the soil.

## SOME WORDS ABOUT THE SOIL

Soil is a critical and dynamic centre for the majority of ecosystem processes in both natural and managed ecosystems. Soil biota still remain the inscrutable life on the earth, a closed "black box", despite their vital importance to understanding ecosystem function. For example, thousands of species of microorganisms and invertebrates inhabit just a square meter of temperate grassland soil, organisms whose identities and contributions to sustaining our biosphere are largely undiscovered (Freckman, 1994).

Human pressure has destroyed the soil physical-chemical environment and the soil species through activities such as: inputs of chemicals from the atmosphere, disposal of waste products in soils, ground water contamination, and physical modification of removal of soil by cultivation and erosion. Soil degradation has also resulted in the mobilisation of soil carbon and nitrogen as greenhouse gases (i.e. $CO_2$ and $NO_x$) forcing climate changes. Information on the effect of these impacts on the loss of soil biodiversity and the loss of key functions (e.g., biogeochemical cycles of carbon, nitrogen, sulphur, potassium, phosphorus) in the biosphere is very fragmentary (Freckaman, 1994).

The biodiversity in soils is structured into food chains and webs which are important determinants of ecosystem function (Hendrix et al., 1986; Moore and de Ruiter, 1991; Heal et al., 1994 after Freckman, 1994). A few experiments have indicated that a loss of biodiversity can diminish the functioning of ecosystem processes (Verhoef and Brussaard, 1990). The fact that anthropogenic activities can decrease soil biodiversity is well-documented, particulary in the fauna of agroecosystems. Complimentary evidence from experiments has shown that increases in biodiversity can enhance plant growth, nutrient mineralization and resistance to stress (Elliot et al., 1979; Clarholm, 1989; Couteau et al., 1991; Lavelle et al., 1992). Even after human disturbance, soil biodiversity generally is greater than above-ground diversity. Species composition within soil food webs may change due to this disturbance, making the impact of species loss more difficult to determine (Malmer and Enckel, 1994; Trevors, 1998).

## THE FEED ADDITIVES ARE DEPOSITED INTO THE SOIL WITH ANIMAL'S MANURE AND WHAT HAPPENS?

We can say, after Socrates, that we know that we know nothing. A study of the published data on the impact of growth promoters added to the animal's food revealed that very little is known about activity of those agents in the environment – in the soil or in the water.

Very scarce literature information can be divided into some groups:

- antimicrobial drugs added to the food of animals and ended up in the soil with manure could affect microorganisms and thus disturb ecological balance in the soil (van Gool, 1993);
- the disturbance of the ecological balance of the soil is caused by reduction in bacterial populations and increase in fungal populations but not *vice versa* – when fungal populations were reduced, bacterial populations did not increase, because bacteria do not compete with fungi for substrate (Ingham et al., 1985). Generally, antibiotics (and other feed additives) can destroy the bacteria-fungi balance in the soil (Ingham et al., 1985, 1991; Collinas et al., 1994) and markedly depress microbial biomass (Landi et al., 1993);
- reduction of bacteria in soil affects changes of the soil nitrogen balance. The addition of antibiotics to the soil increased soil ammonia production (i.e. soil nitrogen mineralization) and soil respiration (Ingham et al., 1985; Landi et al., 1993);
- however on the other hand – addition of piggery manure to soil increase the amount of Cu in the soil which is correlated with increase of Cu-resistant bacteria. Moreover those bacteria exhibit more resistance to several antibiotics (Huysman et al., 1994);
- growth promoters may contribute to the increase of antimicrobial resistance in man, and it can be a major public health problem (Richter et al., 1996). The administration of antibiotics to animals can lead to the selection of a large number of resistant bacteria, some of which are patogenic for humans (Perez-Trallero and Ziggoraga, 1995; McDonald and Jarvis, 1997); there is definite shift to the increased number of strains of bacteria resistant to antibiotics applied in humane medicine (Szende, 1987).

As one can see, little is known about the biological and ecological role of the drugs applied in veterinary practice which enter the environment with animal faeces. But on the basis of the knowledge about soil ecology and processes we can try to built the scenario of the further consequences of application of those drugs into soil.

## SCENARIO OF THE FURTHER CHANGES IN THE SOIL SUBSYSTEM

Feed additives come into the soil. Part of microbial population is inactivated or killed. Since in every soil process composed sequences of soil organisms are involved, elimination of even one link of this chain (or web) can inhibit its course. For example, reduction of cellulolytic microorganisms leads to increase of plant debris and finally to changes in soil humidity , aeration, and temperature. As a result of the litter accumulation, the elements are not available for plants. Primary production falls down. Moreover in the same process humus contents is disturbed

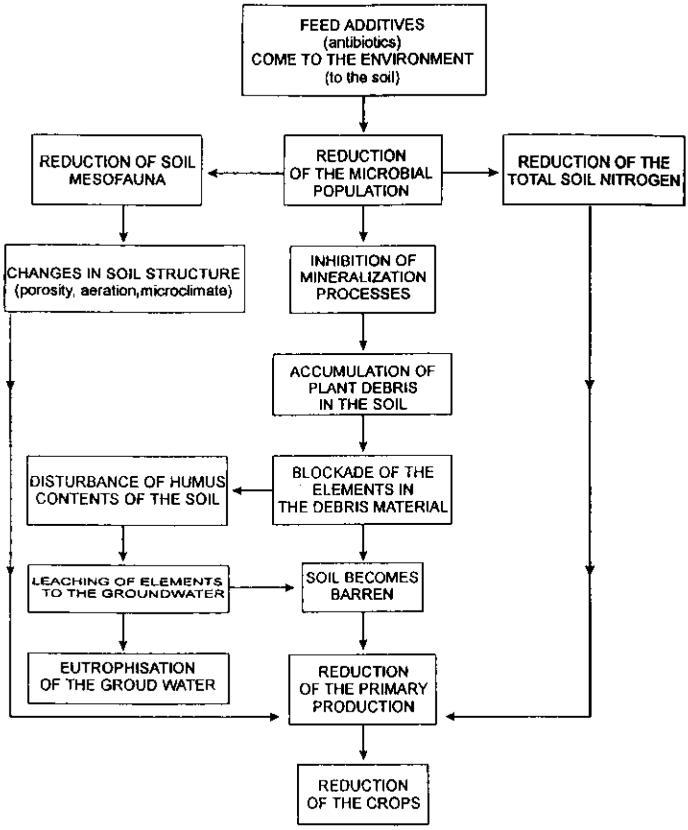


Figure 4. The scenario of changes in soil ecosystem under pressure of feed additives administrated to the food of animals and ended up in the soil with manure (see the text)

(plants and microbes exhaust nutrients) which is followed by leaching the nutrients from upper soil layer to the ground waters. Finally, in dependence on type of soil and management, the impoverishment of soil and water eutrophisation occurs. Although manuring should enrich arable soil, nutrients are lost.

Inactivation of some groups of bacteria affects other components of the soil food web. Microorganisms are the source of food for many soil organisms like Protozoa, Nematoda, and microanthropods. Decrease of some components of microbial population could cause loss of food sources for these animals and their populations could be reduced. For example:

– according to Caylor and Dreyfus (1975), each species of nematodes has its bacterial preferences, therefore lack of some bacteria can cause decrease of bacterivorous nematodes which are very abundant in manured soil (Dmowska and Kozłowska, 1988);

- reduction in numbers of soil invertebrates is unprofitable for soil function and even for soil properties, because those animals stimulate activity of soil microflora (Pussard, 1981);
- soil invertebrates play important role in the decomposition processes, for example – Acarina enhance the decomposition of dead organic matter through fragmentation – i.e. by increasing its surface area; microbial spore dispersal stimulate the microbial growth (Luxton, 1979; Fukuyama and Ito, 1992);
- Nematoda , the most abundant metazoans subsist on different living organisms and in turn contribute their biomass to small arthropods inhabiting soil;
- generally the presence of invertebrate fauna improves soil physical properties as porosity, aeration, and microclimate.

Inactivation of other groups of microorganisms, like symbiotic bacteria living in the alimentary tract of soil invertebrates – Diptera and Coleoptera larvae, earthworms, collembolans – is also important because they influence the condition of those animals, which play the vital role in decomposition of plant debris.

The microbial population can be regenerated fairly quickly after antibiotical shock, but the regeneration of animal population need much more time, e.g. months. The destruction of soil animals population causes reduction of the biodiversity of the soil community and finally – destabilisation the soil ecosystem.

The feed additives in spite of changes in soil structure and biology mentioned above could cause a decrease of the total nitrogen level (nitrogen leave the soil mainly as ammonia and nitrates). In consequence fertility falls down, primary production decreases.

On the other hand, the free living and symbiotic nitrogen fixing bacteria are resistant to antibiotics (Szende, 1987; Sindhu et al., 1989). Their resistance can soften negative effects of those drugs on soil productivity.

The processes presented above can cause the degradation of the soil which is slow and hard for direct observation, sometimes inreversible or reversible in fairly long time. The appearance of strains of bacteria resistant against antibiotics used in human medicine is the separate problem, very important for humans. But it is the other question.

## CONCLUSIONS

Is this "black scenario" observed *in situ*, in every day practice?

Due to high chemical and biological buffering potential of the soil ecosystem changes in soil productivity which we can be observed *in situ* are slow and occurs as a long, fluid process. For this reason it is vital to monitor changes in soils enriched with manure from animals feed with addition of growth promoters.

This scenario is still realised in the nature, in slow rate, and we can not see its results at the moment. May be because we do not search for it seriously? Or we do not like to see it?

For whom the bell tolls? For us ...

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