Microbial fertilizers from pig farm wastes

Les engrais microbiens issus des effluents d'élevage.

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Abstract

The process for the treatment of the waste waters from the pig farms has been developed. The process envisages obtaining the microbial biomass with an increased content of nitrogen, phosphorus, potassium and purified water. New microbiological methods for intensifying the aerotank operation, express methods for monitoring the activity of the microbial communities and the quality of the purified water are presented. The biomasse serves as a raw matter for producing a novel effective pelleted fertilizer Bamil. A pilot experimental industrial plant for producing experimental lots of 150 tons yearly has been constructed.

Bamil is used as a biofertilizer for vegetable, grain and green house crops. Its base comprises a stable association of the microbes promoting the plant growth. The content of Bamil is stable : nitrogen - 5% ; phosphorus - 1.8 %; potassium - 0.5%. It has positive effects of both the mineral fertilizers (known and controlled content and a low dose of application) and those organic (an increased biological activity of the soils and production of bumper crops of ecologically clean quality action during 2-3 years, supression of microflora inducing the plant diseases). Bamil ensures an increased yield of various agricultural crops : potato - by 10-15 t/ha increasing the starch content in the tubers by 4-5%, vitamin « C » - 1.5-2 fold increase ; perennial grasses hay by 4-7 t/ha ; spring wheat in an afteraction by 8-10 t/ha ; lettuce - a 4-fold increase ; tomatoes - a 3-fold increase.

Bamil actively degrades the soil oil contaminations and is successfully applied for recultivation of the soils.

Being an easily mineralized organic fertilizer Bamil activizes the microbiologic process and produces a positive effect on the nutritional conditions of the soil improving its physical and chemical properties, it actively produces influence on an increase in the humus content. Bamil is especially effective on the soils with a low content of humus.

It is produced in the form of dried pellets of the active microorganism biomass. A business plan has been worked out for setting up a plant for producting 10

thousand tons of biofertilizers per year. It has been shown that a yearly profit obtained by selling the feritlizers will amount to 1-1.2 mln $.

Keywords : microbial fertilizers, pig-farm wastes, aerotank, soil.

Résumé

On a élaboré une technologie de traitement microbiologique des effluents d'élevage porcin. Cette technologie suppose l'obtention de la biomasse microbienne avec une teneur élevée en azote, phosphore, potassium et eau clarifiée. On a présenté de nouveaux procédés d'intensification du fonctionnement des réacteurs d'aération, les méthodes de contrôle de l'activité des groupes microbiens et de la qualité de l'eau clarifiée. La biomasse sert comme matière première à l'obtention d'un nouvel engrais granulé efficace « bamil ». On a construit une installation industrielle pilote pour la production d'engrais « expérimentaux » (150 t/an). « bamil » est utilisé en qualité d'un engrais biologique pour les cultures maraîchères, céréales et en serre. C'est une association des microbes stimulant la germination des plantes qui forme sa base. La composition de « bamil » est stable : azote 5%, phosphore 1.8%, potassium 0.5%. Il a des qualités propres communes aux engrais chimiques (composition stable), aussi bien qu'aux engrais organiques (augmentation de l'activité biologique des sols et de hauts rendements des produits écologiques purs ; effet pendant 2-3 ans, suppression de la microflore provoquant les maladies des plantes). « bamil » assure l'augmentation du rendement de différentes cultures agricoles : de la pomme de terre à 10-15 t/ha, la teneur en amidon dans les tubercules étant augmentée à 4-5%, celle en vitamine « C » à 1.5-2 fois ; du foin des herbes vivaces à 4-7 t/ha ; du blé de printemps, effet postérieur, à 0.8 t/ha ; de la salade à 4 fois ; des tomates à 3 fois.

« bamil » décompose effectivement les contaminations pétrolières des sols et s'applique avec succès pour la recultivation des sols.

« bamil » étant un engrais facilement minéralisable stimule les processus microbiologiques et influence positivement la fertilité des sols, en améliorant les propriétés physiques et chimiques de ces derniers, il influence activement l'augmentation de la teneur en humus. Il est produit en granules sèches de biomasse des microorganismes actifs. On a élaboré un « business-plan » de la construction d'une usine à capacité de 10 000 tonnes d'engrais biologiques.

Mots-clés : fertilisants microbiens, déchets d'élevage porcin, cuve aérée, sol.

1. Introduction

For enhancing the soil fertility and obtaining the agricultural products of ecological quality it is necessary to develop the biotechnological methods for processing the

animal breeding wastes with the production of effective microbial fertilizers. Such technologies make it possible to solve two important ecological problems. One of them is associated with utilization of organic wastes and the second one with maintaining the soil fertility, improving the quality and the yield of agricultural products.

The microbial fertilizers possess the positive features both of the mineral fertilizers (known chemical composition; low application dose 1-2 t/ha; absence of the weed seeds, simple application procedure) and of the organic ones (increase in the yield of agricultural crops; enhancing the soil fertility; suppression of the microflora which causes the plant diseases; 2-3 year lasting effect), Table 1.

We have developed and patented the process for obtaining pure water and a microbial fertilizer called Bamil [1] from the pig-farm wastes. At the basis of the fertilizer there is an association of active microorganisms (activated sludge) having an increased content of nitrogen and phosphorus. Prevailing in the association there are nocardio- and corynebacteria of the genera Rhodococcus, Arthrobacter, Aureobacterium, Mycobacterium, and the gram-negative of the genera Alcaligenes, Pseudomonas the majority of which promote the plant growth (2). The biofertilizer Bamil is produced from the mixture of the microflora of the activated sludge and the sediment of the secondary settlers (1:1) which is transferred to the centrifuge in which the moisture content of the mass decreases from 97 down to 80%. Then the mixture is transferred to the granulator and after that - to the drier. The end product with the moisture content 10-15% is packed into the bags 20 kg each (Fig.1). Technical specification, a passport and a certificate have been developed for the biofertilizer.

By chemical parameters Bamil differs from other organic fertilizers by a high content percentage of nitrogen (5); phosphorus (1.8), potassium (0.8), calcium (3.4), magnesium (0.5), zinc (0.05), iron (1), manganese (0.8), copper (0.05), sulphur (0.5), the content of heavy metals is considerably lower than the limiting-admissible values.

Mineral Fertilizers	**Microbial Fertilizers**	**Organic Fertilizers**
Positive features • Increase in the yield of crops by 70-80% • Known chemical	**Combined positive action** • Increase in the yield of crops by 70-80% • Remediation of soil,	**Positive features** • Increase in the yield of crops by 70-80% • Remediation of soil,

composition • Low dose of application 1-2 t/ha • Absence of weed seeds • Simple application procedure	improvement of its fertility • Plant growth stimulator • Suppression of microflora inducing plant diseases • Positive effect during 2-3 years • Increase in the yield of crops by 70-80% • Known chemical composition • Low application dose 1-2 t/ha • Absence of weed seeds • Simple application procedure	• improvement of its fertility • Plant growth stimulator • Suppression of microflora inducing plant diseases • Positive effect during 2-3 years
Negative features • Pollution of the environment, ground waters • Increase in the nitrates content in plants • High cost • Lack of positive aftereffect	**Negative features** • Volatile compounds with a strong smell	**Negative features** • High application dose 60-80 t/ha • 1 t contains up to 12 mln weed seeds • Optimal distance of transportation is 3-4 km • Complicated application procedure • Nitrogen losses are up to 50% during 2 months

Table 1.
Advantages of microbial fertilizers

Microbial fertilizers from the livestock and poultry wastes possess the positive features both of mineral and organic fertilizers

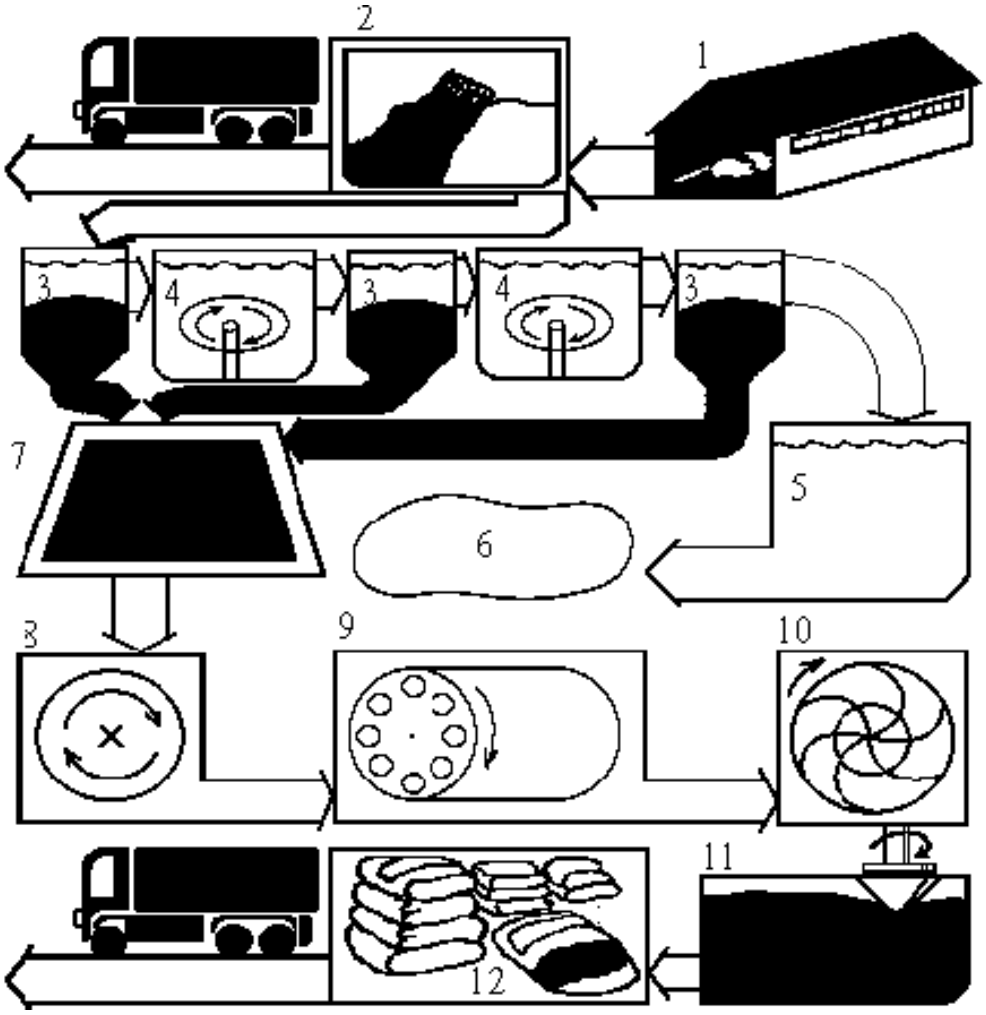

Figure.1.
The process scheme of the treatment of wastes from the pig-farm complexes (54-216 thousand pigs):

1-pigsty; 2-vibroscreen; 3-settler; 4-aerotank; 5-biopond;
6-water basin; 7-accumulator of sludges and deposits;
8-centrifuge; 9,10-drier-granulator; 11-bunker for storing Bamil;
12-packing line

2. Results

In 1986 - 1997 the trials of Bamil were conducted under greenhouse and field conditions on various crops: potato, tomato, pepper, wheat, lettuce, cabbage and others. Bamil stably enhanced the yield of potato by 10-15 t/ha, the hay of the perennial grasses - by 7 - 8, the wheat in an after effect - 0.8 - 1 t/ha and had a lasting after effect from 3 to 4 years. In sheltered grounds the yield of pepper increased by 25-70%; tomato - by 30%; lettuce - by 150-200%. Simultaneously, Bamil improved the agricultural product quality. Thus, the potato tubers showed a 6% increase in the starch content, Vitamin C had a 1.5-fold increase, the content of protein in the oats grains increased by 2-3%, in the wheat grains - by 1-1.4%. In the grown products the content of the nitrate nitrogen was considerably lower the admissible standards.

A stimulating effect of Bamil on the growth and development of plants was revealed. A considerable increase in the biological activity of the soil especially in the root zone was observed. The amount of active microorganisms-growth stimulators had a 2-3 fold increase.

The number of the soil infusoria (g.Oxitrichia, g.Colpoda, g.Cryptolophorus, g.Spathidinum) in variants with Bamil had a 5-8 fold increase as compared with the control variants.

Bamil easily mineralizes and increases the soil humus content, improves its physiological and chemical properties. Bamil is especially effective on the soils with a low humus content, particularly on soddy podzolic soils. Here the content of water soluble carbon has a 2-2.5 fold increase, $N\text{-}NO_3$ - a 8-10 fold increase; $N\text{-}NH_4$ - a 1.5-2.0 fold increase (Fig.2). Simultaneously, a sharp increase in the soil biological activity is observed: release of CO_2 becomes two times as great, the number of the soil bacteria participating in the cycle of the nitrogen containing compounds degradation increases: the ammonifiers have a 6-10 fold increase, those utilizing the nitrogen mineral compounds become 2-4 times as great, those utilizing easily accessible organic compounds have a 2-3 fold increase. The number of celulolytic microorganisms becomes greater by an order, the number of actinomycetes has a 1.5 fold increase. (Fig.3).

The study and analysis of the mechanism of the effect of the biofertilizer Bamil on the phytopathogenic microorganisms causing the plant diseases showed that in the biofertilizer the prevailing are aerobic bacteria which are capable of producing antibiotics. The microorganisms isolated from Bamil were studied by their antagonistic activity against a number of phytopathogenic fungi and bacteria which cause the plant diseases under the conditions of the Baltic Region. The results are presented in Table 2 from which it is clearly seen that the microflora of Bamil belongs to the antagonists to the number of phytopathogenic fungi and bacteria which cause such plant diseases as root and stem rot, grey and soft rot, vascular wilt of plants.

Greenhouse experiment Field experiment

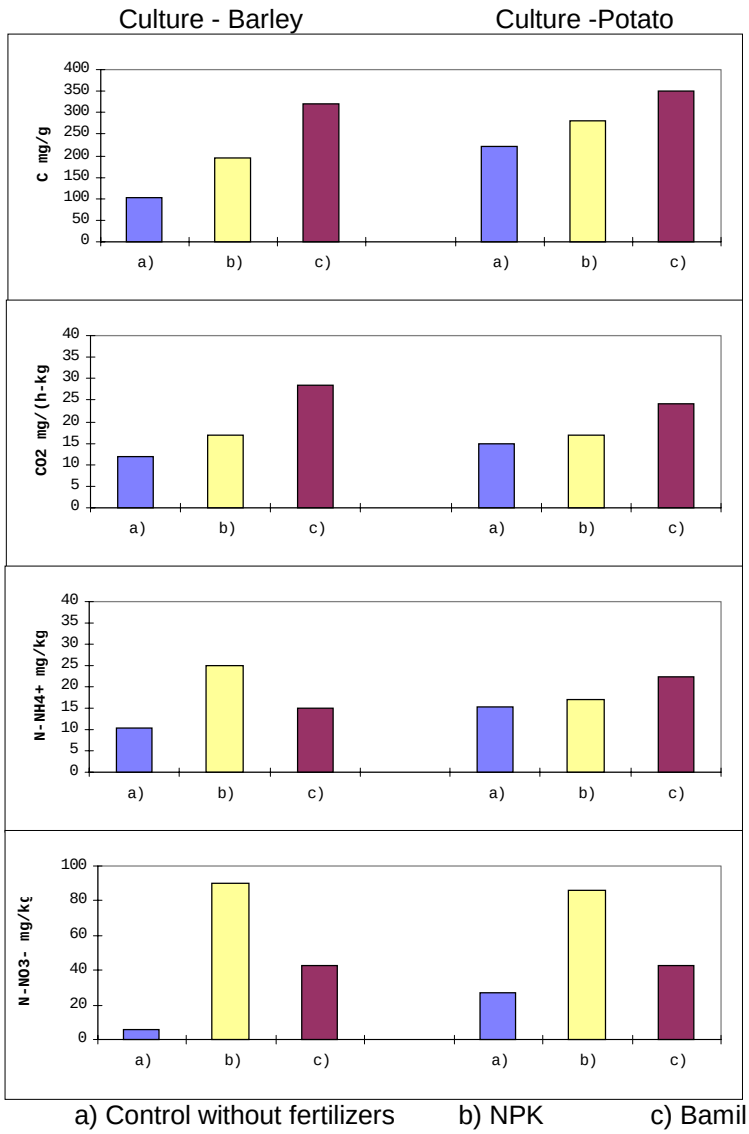

Figure 2
Effect of Bamil on agrochemical characteristics of podzolic soil. The doses of fertilizers in a pot experiment calculated as 0,1 g of acting substance of total nitrogen/kg of soil, in the field experiment N100, P80, K100, manure and Bamil are equivalent to this dose of NPK.

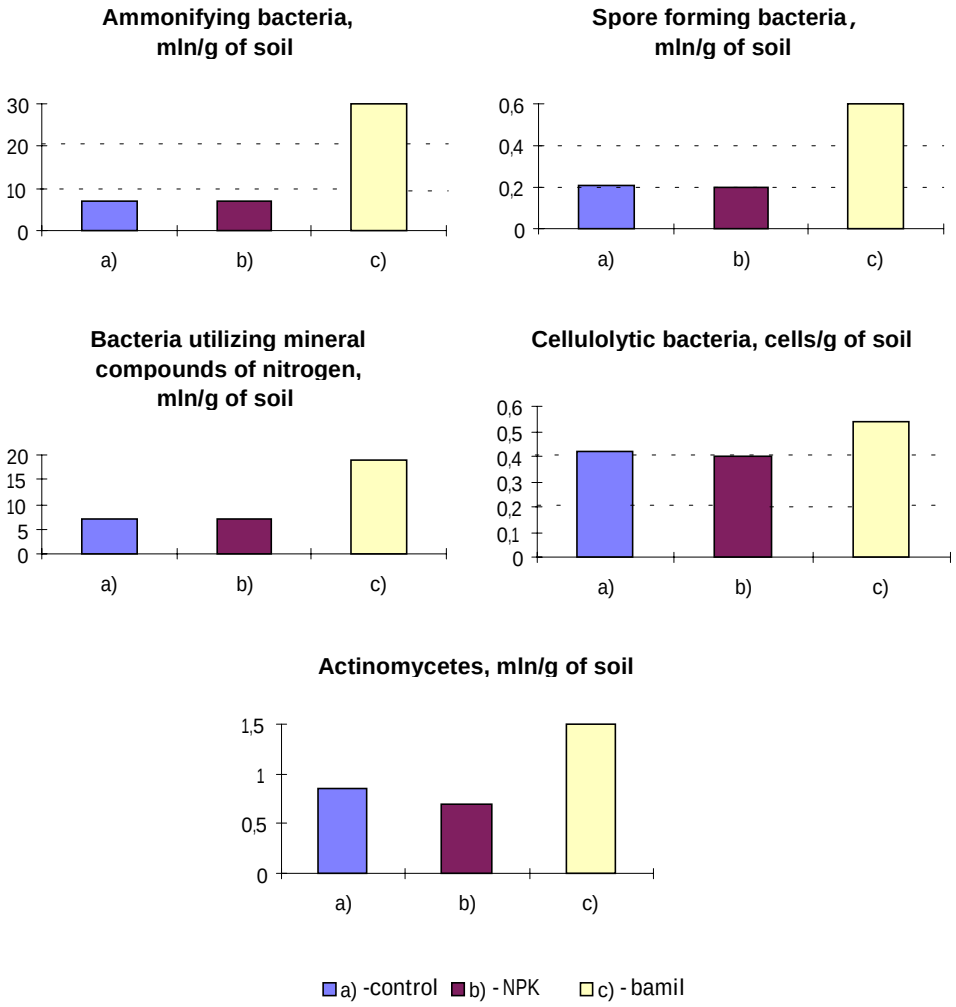

Figure 3
Effect of Bamil on the soil microflora (field experiment).

Test of the culture	N of the strains of microorganisms in Bamil

of phytopatho-genic fungi and bacteria	1	2	4	5	6	8	9	10	11	12	13	17	18	19	20	22	23	24	25	26
Erwinia carotovora C78								+												
E. carotovora P884		+						+								+				
Alternaria sp.24		+	+			+	+													
Botrytis cinerea 24		+		+		+		+	+	+			+		+	+				
Verticillium dahliae 289		+				+			+				+							
Fusarium oxysporum 98		+				+	+	+				+	+		+					
Fusarium oxysporum 99						+		+				+	+		+					

Table 2.

Antagonistic activity of microorganisms isolated from Bamil against a number of phytopathogenic fungi and bacteria causing the plant diseases under the conditions of the Baltic Region.

Proceeding from the literature data and our results we supposed a presence in Bamil of physiologically active compounds which stimulate the plant growth. The water extracts of Bamil were analyzed using the method of a highly effective liquid chromatography. It has been established that the water extract of Bamil may be divided into two fractions: low molecular (amino acids: tryptophan, tyrosine, phenylalanine) and high molecular (proteins containing tryptophan). Tryptophan is a predecessor of indoleacetic-3 acid (IAA) - auxin which is a plant growth stimulator. The results of the quantitative analysis of a free L-tryptophan in the examined samples of the fertilizers show that the content of L-tryptophan in Bamil constitutes 240 Mg/g, Bamil contains more tryptophan than the microbial fertilizers from the poultry dung - 72 Mg/g.

Of interest was to determine the effect of Bamil on the synthesis of IAA by the soil microflora. The object chosen was the soil with a 5% addition of Bamil. The soil was incubated for 6 days at 28 C. The control soil did not contain Bamil and was incubated under the same conditions. Extraction of IAA from the soil samples was done with a phosphate buffer with their following purification at a forcolumn BAKERBOND Octadecyl (C18). The methanol eluat from the forcolumn was evaporated at a rotor evaporator till it became dry and dissolved it in 0.5 ml of methanol. The amount of IAA in the soil samples was determined by an HPLC method at the apparatus JASCLC-900. For separation a reverse phase coulumn Li Chosorb RP-18 was used. As an eluent a mixture water-acetonitrile-acetic acid was used. The rate of the eluent supply was 0.9 ml/min, the temperature of the column - 34 C. No IAA was found in the soil without Bamil additive, the amount of IAA

calculated from the obtained chromatogrammes in the variant with Bamil was 46.3 ng/g which is sufficient for manifestation of the biological activity of the auxin.

Thus, application of Bamil to the soil promotes the biosynthesis of auxins by the soil microflora due to the presence of tryptophan in it. The revealed peculiarities of polyfunctional action of the biofertilizer Bamil enable us to suppose that the microbial fertilizers produced from the animal breeding wastes will take one of the chief places in a sustainable agriculture.

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3. References

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