ABSTRACT

Keywords: mathematical modeling, simulation, sewage sludge drying, organic carbon, nutrients, , soil fertility, environmental quality.

Use of sewage sludge is one of the most important challenges in wastewater management.

The sludge contains nutrients (especially N, P, K) and organic matter, which is an agronomic benefit. The use of sludge in agriculture has become an alternative to the use of waste from economic and practical considerations.

Without a safe sludge disposal method, real water protection concept will fail. Sustainable sludge handling can be defined as a method that meets the requirements of efficient recycling of resources without supply of substances harmful to humans or the environment. The aim of research conducted in this thesis is the development of techniques for using the sludge so as to be in line with EU directives, establish the modalities for the implementation of this sludge as fertilizer in the conditions obtaining healthy crop, conservation traits fertility soil and providing protection of the environment in general.

Digested sludge from the treatment plant Iasi has a neutral reaction and organic carbon content of 29-34%. Nitrate nitrogen concentration is low (0.16 to 0.42 ppm) and the ammonia nitrogen between 24 and 830 ppm. The total content of macronutrients (N, P, K, Ca, Mg) in the digested sludge is 1.37% total N, 1.19% total P, 4.45% K total content of Ca is high (3 12%) and organic Mg and S have normal levels, comparable to those from soils.

The fact that the sludge contains heavy metals allows use as fertilizer for cultivated soils. Bacterial and fungal microflora sludge has values similar to those of compost, size and composition of microbial populations were very close to those of soils.

Since the soils from Moldova, most of them located on slopes, are poor in organic matter and nutrients, these sludges, used correctly, can make up a good part of mineral nutrients and may also contribute to improve the content matter Organic soil.

In these circumstances, determining solutions for efficient processing and use under conditions of sludge in agriculture and that, more accurate use of sludge restrictive measures to ensure environmental protection are of special importance.

The paper, without an exhaustive, aims to contribute to the elucidation of issues on improving treatment processes sludge from sewage plants for use in agriculture, while maintaining soil fertility and environmental quality ambient whole.

The results show practical applicability and represents the value and originality arguments on the need to recover sludge from treatment plants of urban wastewater as fertilizer on agricultural land.

The doctoral thesis includes a volume of 159 pages and is divided into two parts and six chapters.

Part I (27% of extension work) contains general considerations on policies relating to the management of sludge The member states of the European Union and particularities management strategy sludge in our country, analysis of the natural area of reference and an x-ray day study of the issues addressed at national and international level.

Chapter I is about 7% of the work and includes assessments on the possible use of sewage sludge in agriculture as one of their clearance methods as a form of enhancing their content in organic matter and nutrients. Based on bibliographic documentation, they exposed some considerations regarding the possibilities of reducing the pollutant effect of sludge and recovery of nutrients it contains. Thus, it is considered necessary that sludge be treated properly, apply only to land price in the doses and the seeding determined, to a certain range of cultures recommended and ensure adequate control of environmental factors. It insists on the need to manage differentiated sludge on soil types, land and cultivated plant to prevent negative impacts on crop, soil fertility and environmental quality.

Chapter II - The includes a volume of approximately 11% of the work, analytical presentation of the environmental components of the farm Ezăreni aa University of Agricultural Sciences and Veterinary Medicine "Ion Ionescu de la Brad" University in which were conducted experiments that aimed to investigate the effect of sludge on crop and main soil properties.

Chapter III - century, with the share of about 9% of extension thesis refers to studies and research - conducted in Romania and other countries - on wastewater treatment and handling of sludge to meet the conditions of It is used as fertilizer on crops.

In the second part of the thesis on 105 pages representing 67% of the paper are presented the personal contributions in the field of study pursued.

Chapter IV - century (about 5% of the thesis) highlights the objectives of the study and investigation methods used to carry out observations and measurements.

From a conceptual standpoint, research theme adopted approaches in a new way, modern methods of treating sludge from urban wastewater treatment plants and how to exploit the sludge as fertilizer on agricultural land under conservation of soil fertility and environment as a whole.

Specifically, the research was aimed at achieving the following objectives:

- Establish new methods of treating sludge from urban wastewater treatment plants to ensure efficient drying conditions economically using solar energy accumulated inside a greenhouse tunnel construction type.

- Determining the sludge and assessment in accordance with EU Directives.

- Study of sludge application on agrochemical characteristics (organic matter content, pH value, availability of N, P, K and microbiological properties of the soil).

- Determination of upper safety limits sludge application to land, so as to avoid negative effects (affecting soil quality, crops and the environment in general).

The analytical methods used for the proposed research topics were considered novelties in the field and have been adapted to national and international research policy of sustainable development, through an interdisciplinary approach to the topic.

Theoretical study of the drying was performed using a mathematical model based on laws and principles known model describing the progress made during or after certain mutual dependencies, under the action of known factors.

Hot air convection drying simultaneously achieves a heat and mass transfer between the air and the product subjected to drying. The principle of black body radiation sludge largely absorbed from the sun and its temperature increases.

Convection drying process is complex, requiring the development of sub-models depending on the purpose, available data and level of abstraction.

The mathematical model is essential to optimize the drying of the sludge, it underpinning the simulation CFD (Computational Fluid Dymanics). The proposed sludge drying include assumptions; Fundamental parameters and variables of the drying process; correlated variables equations establish links between non-steady state; restrictions on certain variables.

To substantiate methods of processing sludge drying process gases was simulated CFD (computational fluid dynamics computer)) by three steps necessary:

- Pre-processing (definition 3D model geometry and meshing thereof);

- Processing (creating algorithm that is based on the mathematical model and impose conditions limit);

- CFD simulation analysis (color graphic representation of the fields of speed, temperature, humidity and sludge subjected to drying).

CFD simulation was performed with ANSYS software (FLUENT and GAMBIT) holding the most complex mathematical models fluid flow and heat transfer of existing commercial programs today.

Characterization of chemical and mineralogical sludge from WWTP Iasi done with existing equipment in the Laboratory of Materials Science, Faculty of Mechanical Engineering of Iasi based on analyzes SEM / EDX.

Studying the design of the driers sludge implemented in the country and in Europe and the technology of wastewater treatment in WWTP Dancu - Iaşi and considerations of efficiency

and technical economic and environmental protection was proposed constructive solution for drying plant to accelerate Sludge, ensuring that the sludge to a state of humidity of 15-25%.

The main system components are type tunnel greenhouse, ventilation, air mixing and aerating respectively nămolulului electrical equipment and automation equipment.

Work to increase the capacity of the drying and odor avoid the formation of sludge must be turned regularly. Pushing and return sludge involves labor-intensive and time. Therefore, performing these operations was provided by screw conveyors driven by motors with gearbox supplied with electricity from a photovoltaic acquired in a battery, power augers calculated to spin every few minutes. It was designed also auger angle and type of construction so as to provide more return and less sludge moving it. Also the shape and dimensions of the auger will need to ensure minimum effort and bending over it. This will auger 6 of 6 meters each socket support to minimize bending effort that appears.

The design of the conservatory was drying tunnel and computer-assisted simulation using CFD that is based on a complex mathematical model of heat and mass transfer that takes into account all key process parameters, allowing optimal shape of the plant.

Through repeated simulations was reduced greenhouse height and positioning the fan, the air inlet vents in the greenhouse, respectively exhaust air outlet slots so that air to circulate to the 10 vats mud surface as evenly as possible.

It can be seen from the distribution of temperature and humidity on the surface of the slurry in the boundary layer as well as the distribution of the lines of current in the soil.

Analysis of the results indicates an optimal moist air from exhaust emissions and optimum mass transfer between the boundary layer and air emissions. Parameters of speed, temperature and humidity of the air at the surface thereof nomolului anticipates the development of moisture on the entire length of the tank. To a slurry inlet temperature of 22 ° C and a relative humidity of 65% after parcugerea the length of the drying apparatus to obtain a final temperature of 43 ° C and a relative humidity of 23% within 2 hours and 10 minutes. These parameters are obtained under the conditions of the input air temperature in the interior of the greenhouse gases

and varies between 23 ° C and 35˚C humidity between 45% and 28-30% in the same period of time.

This difference in temperature between the environment greenhouses and sludge subjected to drying can be explained due to heat transfer radiative irradiation of long wavelength which heats more black surface sludge, it having time to accumulate a larger amount of heat due to rate highly Small (VN = 0.025 m / s) forward to the discharge of emissions.

Simplifying assumptions made in the mathematical model and simulation CFD loss not lead to accurate final results. This can be seen from the three-dimensional geometric model where not provided şnecurii transport sludge from the tanks, but considering their effect by introducing sludge simulation as a vâscoplastic fluid moving at a low rate. In fact by placing the screws in the installation of drying compared with the CFD simulation, the additional operation can be obtained by stirring the slurry moisture content reduced by a few percent at the end of drying the dried sludge.

Morphological analysis showed blackish color samples of sludge. SEM images show the existence of angular particles. In addition, the SEM images reveal a high degree of heterogeneity of texture and particle size. In general, the sludge particles have an irregular shape with a diameter of up to 40 μm.

Chemical analyzes showed the sludge composition are dominant C (organic matter) 24.6% 20.9% Si, Ca 13.1%, 12.7% Fe, 7.8% Al and O 7.2%. The nutrient content of 2.5-4% is N, 2.5-3% and 1.3-2.3% K P. Important is that not detected the presence of heavy metals.

XRD analyzes carried out on samples of sludge highlights the amorphous nature of matter and the presence of crystal structures because of its organic and inorganic matter.

The efficiency of the use of sludge was evidenced by production increases achieved through the application of sludge applied to the dosing but took into account the influence it exerts on improving soil fertility.

The average yield obtained in the last 3 years, compared to the untreated control, applying doses of 30 t / ha sludge were 1236 kg / ha (35%) of maize, 590 kg / ha (42%) at Sunflower Sun and 1386 kg / ha (83%) on soybean.

From the analysis of soil samples taken from the areas under maize, for example, soil that has been microbiota quantitative variation of the colony forming units (CFU) of between 16.1 x 105 CFU / g soil for version control and 33.6 x 105 CFU / g soil on which version sludge applied at a rate of 30 t / ha.

Regarding the ratio of the number and composition of the main groups of microorganisms are significant differences between the studied variants. The results show that sludge from sewage stimulates the growth and development microfungilor and bacteria, where corn with 326.8% and 8.0%.

The bacterial strains isolated from soils planted with corn are the principal where Gram negative (G-). Thus, to the control of the total number of microorganisms, the percentage of bacteria G is 73.0%. Application of Sludge from sewage dose of 30 t / ha caused a reduction in the number of Gram positive (G +) from 26.8% to 2.3%, while a significant increase G- bacteria to 97.0%.

Version control fungal spectrum of genres is complemented by *Fusarium, Penicillium, Trichoderma, Rhizopus, Alternaria* and *Cladosporium*. If variant fertilized with sludge isolated genres number was reduced to five detaching genus *Penicillium*, followed at a distance especially species of the genera *Fusarium, Aspergillus* and *Verticillium*.

In response to the application of sludge, soil solution concentration growth has been accompanied by changing spectrum of fungal evident in the case of the genus *Penicillium* species. In all cases under study including sunflower cultivated soils was observed that after application of sludge dose of 30 t / ha spectrum changed significantly in favor fungal genera *Aspergillus* and / or *Penicillium* spp in favor of *Fusarium*.

Thesis ends with the conclusions and recommendations resulting from studies and observations on ways to improve treatment processes sludge from sewage wastewater and the favorable effect of the application of sludge as a fertilizer to increase agricultural production maintaining soil fertility and prevent environmental degradation in general.