

## METHOD OF FERTILIZATION OF ENERGY WILLOW PLANTATION USING SEWAGE SLUDGE

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### ABSTRACT

Sewage sludge deriving from biofiltration of municipal waste abound in soil processed organic substances and mineral fertilization components which may be used for fertilization of energy willow plantations. In the article the potential of natural utilization of sewage sludge and the patented device for injection dosage of sludge has been presented. The device enables putting into soil mineral and organic fertilizers with loose consistency and their immediate covering by soil in order to reduce unpleasant smell and limit loss of volatile components of fertilizer.

**Key words:** fertilization, sewage sludge, energy willow.

### INTRODUCTION

Communal sludge created in sewage treatment plants may be utilized, in processed and unprocessed form, in agriculture, provided that it is stable and conforms with sanitary requirements and levels of heavy metals contained in them are not exceeded. The term communal sludge encompasses sediments obtained from septic tanks, other communal sewage treatment installations and sewage whose composition is similar to communal sewage [19]. The emergence of large volumes of sewage sludge is inherent to sewage treatment process. It is estimated that 1 million tons of sludge is created annually in Poland, which constitutes 2% of the total volume of treated sewage waste and contains a half of the total load of pollutants originating from raw sewage reaching treatment plants [1]. Communal sewage sludge may be utilized in soils whose reaction is higher than pH 5–6 and the level of heavy metals contained in the sludge does not exceed levels defined in the regulation of the Minister of Envi-

ronment [15]. In recent years, the level of heavy metals in sludge, which must be extracted from industrial wastewater before being released into the sewage system, has decreased.

The utilization of sewage sludge obtained from communal sewage treatment plants and from food industry in order to fertilize the soil is considered as the most economic method of the waste utilization. Sludge originating from communal sewage, agricultural treatment plants and agriculture and food industry is a rich source of nutrients for plants and exerts a positive influence upon soil forming. Moreover, when introduced into the topsoil, sludge enriches the soil and activates it biologically [18].

The process of soil fertilization by means of sewage sludge may be realized on the surface of the soil by universal spreaders used for spreading granular fertilizers or by manure spreaders. Such method of fertilization may be inconvenient (in case of sewage sludge in particular) due to onerous smell and the loss of volatile fertilizing components. The proposed device for inject-

ing a dosage of fertilizers, sewage sludge in particular, enables the introduction of loose mineral and organic fertilizers into the soil to the depth of 0,05–0,25 m. The trend of limiting or altogether eliminating the use of mineral fertilizer in farming in favor of organic fertilizers leads to the introduction of sewage sludge obtained from sewage treatment plants apart from widely used manure and liquid manure.

Sewage sludge must undergo particular technological procedures such as, liming, composting, hydrophytic drainage, mineralization and drying so that it can conform with norms pertaining to its usage or storage. Among all methods of sanitation and biological stabilization, organic mass composting seems the simplest and the cheapest [7, 17]. The forecast structure of transforming technologies in Poland in 2010 is presented in Fig. 1.

These forecasts indicate that there exists a growing trend as regards sewage sludge originating from communal sewage treatment plants in Poland (Fig. 2). In 2007, close to 800 thousand

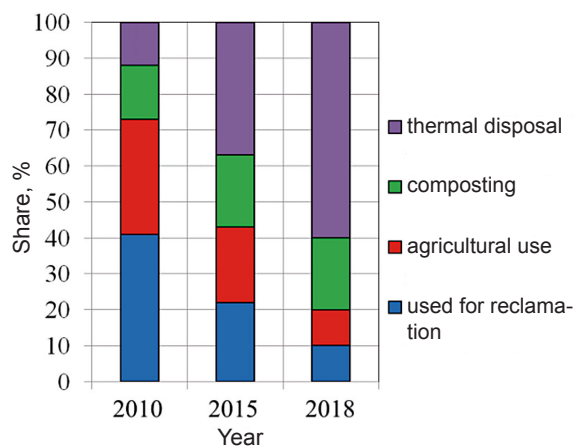


Fig. 1. Forecast structure of transforming technology of sewage sludge in Poland [8]

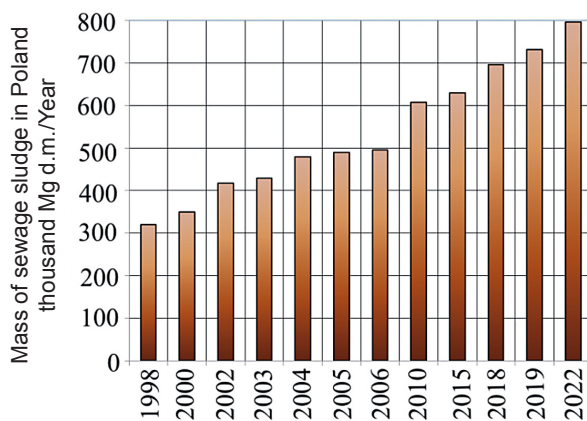


Fig. 2. Historical and forecast weight of sludge produced in Poland [9]

Mg of dry mass of old sludge were stored in treatment plants. Every year, almost 30% of these are still stored outside the plants [9].

## THE USE OF SEWAGE SLUDGE IN NATURE

The proper use of sewage and communal sewage sludge in households and agriculture ensures environmental safety and human and animal health. Sewage and sewage sludge must undergo initial processing before being utilized in energy crops plantations. In the EU, the agricultural use of sludge is regulated by the Nitrates Directive [4], the Sewage Sludge Directive [3] and proper national regulations [15, 19]. At present, works are carried out in order to introduce a considerable decrease in the level of heavy metals contained in the sludge. As a consequence, this may limit the agricultural use of sludge in the long-term. In addition, ban on storing sewage sludge, effective after 1<sup>st</sup> January 2013 [5], entails the search for new methods of the waste utilization.

One of the methods of utilization, which makes use of fertilizing properties of sludge, is its implementation in agriculture [14]. Agricultural utilization is understood as [16]:

- fertilizing soil and plants,
- reclamation of degraded soil and soilless ground,
- consolidation of soilless ground exposed to water and wind erosion,
- compost production for the above purposes,
- cultivation of non-consumption plants and the production of fodder.

The majority of soils in Poland belong to low valuation classes, thus their fertilization by means of sewage sludge seems vital [13]. Sewage sludge influences chemical and physicochemical properties of the soil and yield of cultivated crops. Agricultural utilization of sewage sludge is limited by the contents of toxic substances, heavy metals in particular, and the presence of viruses and bacteria [6].

Sewage sludge can also be used in forestry and agriculture in the production of wood and seedlings. Fast-growing energy crops which have large growth dynamics and high productivity can be cultivated on sludge or sludge-land surface containing excessive amounts of heavy metals. Non-consumption and non-fodder application of these plants makes the level of heavy metal and mineral components (nitrogen, phosphorus, potassium) negligible in terms of use value.

As regards rich cultivation of poplar and willow the following types of sludge can be utilized:

- liquid for constant supply of nutrients and water,
- earthy for fertilization of the topsoil and reclamation of land,
- greasy for molding the surface covering mineral land.

In case of fertilizing energy willow with sludge, the growth is proportional to the dose of sludge. No considerable relationship between the volume of the dose and the contents of heavy metals in the crop was determined [10]. Agricultural usage of sewage sludge is a cheap method of its utilization. Moreover, it enriches the soil with substances contained in the sludge [20].

### THE METHOD AND DEVICE FOR INJECTING DOSAGES OF SOLID FERTILIZERS

Fast-growing, perennial energy crops (of various structure and root systems) require the appropriate level of nutrients to grow, which cannot be sufficiently supplied to the soil while establishing their plantation. Energy crop plantations are fertilized with mineral fertilizers by means of commonly known machines called spreaders. The efficiency of enriching the plantation depends upon the proper dosage of fertilizers, depth of fertilization and immediate covering of the fertilizer with a layer of soil (spreaders do not provide means for doing so). A device for introducing fluid under a layer of soil and meadows provides means for that, but only partially [12]. In accordance with the above mentioned idea, the device is comprised of coulters which cut grooves in the fertilized soil. Coulters are coupled with a series of lines dosing liquid fertilizer from a tank mounted on wheeled undercarriage. The fertilizer is drawn from the tank by means of gravity or pressure. In case of fertilizing meadows, after the fertilizer has been injected into to soil, grooves are flattened by means of pressure rollers mounted behind the aforementioned coulters. In case of fertilizing soils, such grooves are removed by means of listers mounted behind coulters.

Utilizing currently used devices for fertilizing perennial plantations does not ensure optimal character of the process, especially when it comes to introducing fertilizers to the appropriate depth and its immediate covering with a layer of soil.

The process is particularly important when properly prepared communal sludge is intended for use, as its utilization requires the fertilizer to be immediately covered with soil [15, 19].

The device for injecting dosages of a fertilizer, sewage sludge in particular [11], allows for introducing loose solid mineral and organic fertilizers into the soil to the required depth and simultaneous covering of these with a layer of soil, which decreases odor factor and the loss of volatile fertilizing components. The fertilizer is supplied to the area of root mass without damaging it, which facilitates the acquisition of nutrients. The fact that one process realizes fertilizing and transportation of the fertilizer, its introduction to the soil to the required depth and its covering with a suitable layer of soil is noteworthy.

The device, as a separate module, may be also attached to typical, currently used spreaders without the necessity of technical adaptations. The device's design process was started with the creation of a spatial parametric construction (Fig. 3), including kinematic ties between individual parts of the machine, with the use of Autodesk Inventor software. This process enabled the tracking of possible collisions between moving parts of the construction. The design of the construction assumes that the device for injecting dosages of loose fertilizers to the soil is mounted on a spreader and is equipped with a hydraulic system enabling its positioning against the field. The device is equipped with a series of working sections injecting the fertilizer spaced every 0,7m which corresponds to the typical system of planting energy willow.

The device for injecting dosages of loose organic and mineral fertilizers (Fig. 4) to the soil is attached to a spreader. The device is equipped with a frame mount (1), feeding beams (2) with coulters (3). Riding ploughs (4) are located be-

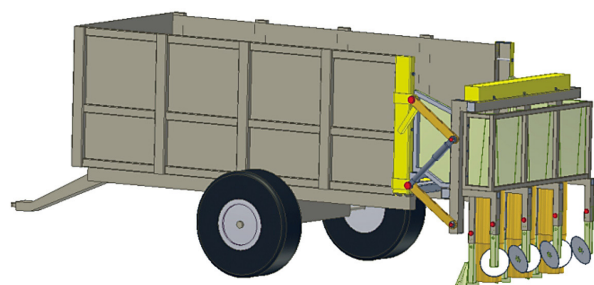
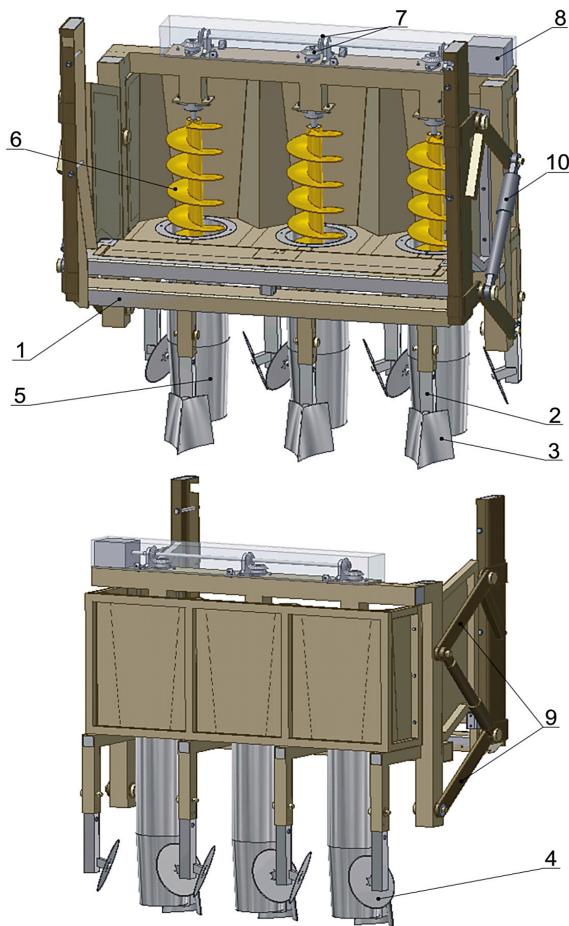


Fig. 3. Concept of joining of attachment with manure spreader



**Fig. 4.** Device for injection dosage into soil of loose organic and mineral fertilizers: 1 - frame, 2 - feeding beam, 3 - coulter, 4 - ridging plough, 5 - cylindrical housing, 6 - feeding screw, 7 - bevel gears, 8 - hydraulic engine, 9 - hydraulic cylinder, 10 - arms

hind these. Cylindrical housings (5) and feeding screws (6) working inside them are coupled with the frame. In their top section, above the working area, feeding screws have got bevel gears (7) which transfer power from a hydraulic engine (8). Each of the screws may be alternatively equipped with its own hydraulic engine powered via a coupling from the spreader's hydraulic engine. Feeding beams and coulters constitute elements joined telescopically and their positioning against each other is set stepwise by a mechanical blockade. The position of coulters against beams may also be set non-stepwise by a hydraulic system. In order to put the device into a hauling position, arms (9) and hydraulic cylinder (10) are used. The depth of grooves for fertilizing is set by adjusting the position of the feeding beam (2). The fertilizer in the storage chamber is transported to the feeding area by means of a floor conveyor. The fertilizer is fed from the feeding area to the

grooves in soil by coulters by means of feeding screws. Grooves are then filled by riding ploughs located behind coulters.

## CONCLUSION

Expanding cultivation of industrial and energy crops endangers the traditional cultivations of food crops. One of the methods of expanding energy crop cultivations is utilizing fallow lands, wastelands, degraded or agriculturally unexploited areas. This process is connected with the use of sewage sludge for fertilizing purposes. Agricultural use of sludge originating from the biological treatment of sewage requires stabilization and sterilization. Such treatment of sludge eliminates all bacteriological dangers ensuing from its use as a fertilizer. Sanitary risks associated with utilizing sewage sludge in the cultivation of energy crops is low due to the industrial use of the biomass and exclusion of pathogens from the trophic circulation of humans and animals.

The parametric spatial model of the device designed with Autodesk Inventor software allowed for a kinematic analysis of working mechanisms. In order to define relations between working components a wide spectrum of geometric and motion bindings was used. At present, design documentation and the prototype of an adapter are under development.

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