Bio-Disposal Waste Improve the Biological Activities of Agricultural Land

Hosam E.A.F. Bayoumi Hamuda[1], Lyudmila Symochko[2]

[1]Institute of Environmental Protection Engineering, Rejtő Sándor Faculty of Light Industry and Environmental Protection Engineering, Óbuda University, Doberdó út 6, H-1034 Budapest, Hungary, E-mail: bayoumi.hosam@rkk.uni-obuda.hu; [2]Faculty Biology, Uzhhorod National University, Uzhhorod, Ukraine

***Abstract**: The agricultural activities and practices have an important influence on the soil biological activities and biodiversity. The growth in global population, increasing urbanization and specialization led to produce larger quantities of food to cover the increasing in global population. Conversion of bio-disposal waste materials to bio-products is the main goal today to meet this increasing in world population and decreasing in the rate of agricultural land areas because of climatic changes. Globally, more than 200 billion metric tons of bio-disposal wastewater sludge (BDWS) is generated every year from agriculture, sewage water treatment plants and other sources. With the global facing the global climate change, countries are now looking for alternative sources of energy to minimize greenhouse gases emissions. The main objective of this research work is to identify and assess environmentally sound technologies for converting organic waste disposal biomass into raw materials for promoting the biological activities and biodiversity in the soil. An increase in organic waste materials has positive influences on soil microbial properties and enzymatic activities that serve as good indicators of improvement of agricultural soil. Also, it showed a positive relationship between bio-disposal waste application dose and microbial activities, such as respiration, mineralization, enzymatic activities and microbial structure community and biomass. However, the subject of agroecosystem is very complex and need more research to understand the interaction between the plant, the rhizospheric environment, and nutrient bioavailability. It is important to emphasise that moving towards the balance between agricultural, environmental and economic aspects of BDWS utilization in agro-environment are the most desirable approach for the future. Globally, "healthy soil for healthy life", more food production, protection and enhance the natural environment without damaging the natural resources are needed.*

***Keywords:** agricultural land, , biological activities, bio-disposal waste, microbial and enzymatic parameters*

1 Introduction

Despite the substantial amount of crop residues and manure produced in farms, it is becoming increasingly difficult to recycle nutrients, even within agricultural systems [1, 2]. Today, about 7 billion humans rely on biodiversity for its goods and services. The global population doubled since 1950 and the UN forecasts a population of 9.2 billion for the year 2050. The demands on natural resources are growing even faster, because the global economy has increased 5 times in the last 50 years. Conversion of organic nitrogen (N), phosphorus (P) and sulphur (S) to available mineral forms of ammonium, phosphate and sulphate occurs through the microbial activities and the rate of conversion is influenced by many factors affecting the microbial activities such as temperature, moisture, nutrient content and pH in the soil. The maintenance of soil fertility depends on the activity of the soil microbial biomass. A small fraction of soil OM (1-3%) is a fundamental importance in the biocycles of all major plant nutrients. Soil microbial biomass is the living part of soil organic matter (SOM) which acts as soil indicator and is responsible for the decomposition and mineralization of organic matter (OM) in the soil. There are two options for improving soil management: direct and indirect interventions. Direct method can be done by inoculating seeds, roots or soil with plant growth promoting rhizomicrobiota. Indirect method through managing soil bioprocesses by manipulating the factors that control biotic activity rather than the organisms themselves. Sewage sludge (SS) is a by-product generated from various biological, chemical and physical treatment processes that may create environmental concerns in its disposal due to the presence of soil contaminants [9]. Sewage sludge contains useful quantities of organic material of C, N, P, and S for improving soil quality. It is one of the sustainable practices to convert SS into useful agricultural product because it is rich in OM, micro- and macronutrients, which are essential for plants growth and soil organisms to live. Kihanda et al. [3] found that mineral fertilisers provided the same rates of N and P as in 5 t ha^{-1} manure and initially, gave the same yield as manure, declining after 9 years to about 80%. Dordas et al. [4] indicated that liquid cattle manure can be used to replace inorganic fertilizers for maize growth and production. Composts prepared from biowaste have a positive effect on the biological, physical and chemical properties of the soil [5, 6]. The results suggested that composting of SS with optimal proportion of cattle manure and saw dust, especially in C/N 30, can produce stable compost within 20 days of composting [7]. Also, higher reductions in CO_2 evolution and O_2 uptake rate observed in C/N 30 showed the stability, resulting in the total biodegradable ingredients to be stabilized [8].

Total microbial activity is a good general measure of OM turnover in natural environment since generally more than 90% of the energy flow passes through the microbial decomposers. The is an evidence that heavy metals introduced by SS to soil giving higher metal concentrations several times than the limits provided by EU. These cause an accumulation of SOM higher than the untreated soil control [10]. Zinc is required for growth; Ni was required for growth and expression of hydrogenase activity. Cu has an essential role in many enzymes and at least 30 Cu-containing enzymes are known all of which function as redox catalyses or O_2 carriers. However, above certain concentration and over a narrow concentration range, their status can change from an essential to a toxic.

Soil enzymes have been suggested as potential indicator or monitoring tools to assess soil quality and health also can effectively reflect the biostatus of the soil. Soil enzymes can be used as indicators of soil contamination because of their bioavailability and specificity. Fluorescein diacetate (FDA) is a substrate for determining the overall activity of decomposers. Non-specific esterases, proteases, and lipases, which have been shown to hydrolyse FDA, are involved in the decomposition of many types of tissue. The ability to hydrolyse FDA thus seems widespread especially among the major decomposers, bacteria and fungi. A good correlation was found between FDA hydrolysis and respiration, and the decomposers activities in different soil environmental conditions, which were probably, reflect the amounts of SOM. Soil dehydrogenases is a group of intracellular enzymes present in living soil microbes, regulating the metabolic reactions involved in oxidative energy transfer [11]. Dehydrogenase activity depends on the metabolic state of soil microorganisms which can be used as an indicator of microbial activity in soil amended with SS containing high amounts of heavy metals, while phosphatase will be unaffected or decreased. β-Glucosidase activity reflects the state of the OM and the processes occurring therein. Many reports e.g., García et al. [12] had found that soil enzymatic activities are enhanced by the addition of organic amendments. de Caire et al. [13] mentioned that there is evidence that urease activity in soils can be increased by the addition of OM that promotes microbial activity. Little attention has been paid to S. Availability of organic and inorganic soil S to plants and microbes can both be controlled through enzyme activities. Aryl-sulphatase is commonly detected S-transforming enzymes in soil. Aryl-sulphatase catalyses the organic S, which leads to the release of plant available inorganic S.

The search for bio-alternatives to improve and maintain yields is a high priority and needs to understand the effect of different practices on soil biota, their functions, processes, and their influence on plant nutrition and soil stability. The soil microbial biomass is the living part of SOM, which comprises the total mass of microorganisms that live in soil. The bioactivity in a soil is usually evaluated by measuring CO_2-release. It was found that addition of SS containing high amount of Zn to the soil increase the CO_2 evolution. Microbial parameters appear to be very useful in monitoring soil pollution by the environmental wastes, but no single parameter can be used universally. Combining microbial activity and population counts appears to provide more sensitive indication of soil quality than either activity or population alone. The following investigations will give some information about how soil microorganisms are able to convert the waste material to useful and increase the quality of soil fertility.

2 Materials and Methods

The soil samples were collected from the top 20 cm of chernozem meadow from the non-cultivated and untreated area from Szeged, Hungary. The soil samples were divided into two sub-samples: control soil and soil amended with communal bio-disposal wastewater sludge (BDWS) originated from the plant of wastewater treatment in Hódmezővásárhely, Hungary at 15, 30, 45 and 45% (w/w) rates. Some physicochemical properties of used soil and BDWS samples are in Table (1).

Table 1

The physicochemical properties of used soil and communal wastewater sludge samples

Parameters	Chernozem meadow soil	Communal BDWS
Clay and slit content (Li), %	51.7	n.d.
$pH_{(KCl)}$	6.02	7.8
Dry matter content, %	n.d.	42.9
Organic carbon content, %	2.87	20.4
Humus content, %	3.55	n.d.
Total N, mg/kg	334.7	43311
NO_3-N, mg/kg	39	n.d.
NH_4-N, mg/kg	4.5	n.d.
Mg, mg/kg	257	11860
Na, mg/kg	53	1441
AL-P_2O_5, mg/kg	378	20104
AL-K_2O, mg/kg	428	2908
Zn, mg/kg	1.1	1068
Mn, mg/kg	61	351.2
Fe, mg/kg	1094	13610

n.d.: Not determined, AL: Ammonium lactate soluble P and K

The following evaluations were carried out to study the effects of BDWS on soil biological activities after 15 weeks incubation in greenhouse at 26±2°C. Because the soil samples had been stored at 4°C, soil sub-samples were pre-incubated as previously described to allow the microbial activity to restore and stabilise.

Soil pH was measured in 1 M KCl suspensions (1:2.5 w/v) with a glass electrode. Soil moisture was measured gravimetrically according to Mishra [14]. Determination of Na^+, K^+, Ca^{2+} and Mg^{2+} in soil was carried out according to the Hungarian Standard MSZ 20135/1999 [15]. Determination of Fe^{2+}, Mn^{2+} and Zn^{2+} content in soil was detected according to the Hungarian Standard MSZ 21470-50/1998 [16]. Total organic carbon (TOC) content was determined by oxidation with potassium dichromate ($K_2Cr_2O_7$) in a concentrated sulphuric (H_2SO_4) medium and excess dichromate evaluated using Mohr's salt [$(NH_4)_2Fe(SO_4)_2$] according to Walkley & Black [17]. Total N content (TNC) in soil was determined by Kjeldahl digestion–distillation procedure [18]. Phosphorus mineralization: were determined according to Olsen & Sommers [19]. Soil samples were extracted in dilute NH_4F-HCl at the beginning and end of incubation period and the extracted P was estimated colorimetrically using the ammonium molybdate-stannous chloride (blue colour method). Mineralized inorganic P was extracted with 0.5 M $NaHCO_3$ and was analysed by the ammonium molybdate–ascorbic acid method described in biomass P measurement. Available extractable S was measured after the extraction with 0.01 M $CaCl_2$ and analysed according to Subba Rao [20]. The SO_4-S extracts were measured by converting them to barium sulfate by the addition $BaCl_2.2H_2O$ crystals; and the turbidity was measured at 340 nm on a UV-VIS spectrophotometer. Available S in soil sub-sample is expressed as SO_4-S in mg/kg. To determine the soil respiration rates, CO_2-released was measured according to Stotzky [21] and expressed by mg CO_2-C/kg dry soil.

Quantitative enumerations of mesophilic culturable populations of aerobic heterotrophs bacteria, filamentous fungi and actinobacteria were expressed by colony forming units (CFU) per gram dry soil. The populations were measured in 10 g of sieved soil was added to 90 ml of sterile saline solution (0.85% NaCl) in a 250-ml flask, and the suspension was shaken at 150 rpm for 30 min. Ten-fold serial dilutions were made and 1 ml of 10^{-4}, 10^{-5}, 10^{-6} and 10^{-7} dilution was used to inoculate Petri dishes of different cultural media. Plates were incubated at 28°C for 2 and 7 days for bacterial and fungal cultivation, respectively. Bacteria were determined on nutrient agar medium supplemented by filter-sterilized cycloheximide (100 μg/ml final concentrations) after autoclaving to prevent fungal growth. Fungal population was estimated on Rose Bengal-Streptomycin Agar [22] and modified potato dextrose agar (MPDA) supplemented with streptomycin (30 μg/ml) to inhibit bacterial growth according to Alef & Nannipieri [23]. Actinobacteria were counted on Starch Casein Agar medium of Küster & Williams [24] supplemented by cycloheximide (100 μg/ml) and modified by addition of nystatin and nalidixic acid which were used as antifungal and antimicrobial agent respectively in plates [25]. The plates were inverted and incubated for 7 days at 28°C. The results are reported as log10 of bacterial, fungal or actinobacteria CFU/g of dry soil. Detection of phosphate-solubilizing microorganisms: One ml of homogenous soil sub-sample suspension of low dilution (10^5, 10^6 and 10^7) was plated on the surface of the agar plate containing a medium described by Pikovskaya [26] and according to the procedure of Goldstein [27]. After incubation for 5 days at 28°C, colonies surrounding with clear zones were counted. Colonies showing solubilisation zones over 0.5 mm in diameter were counted. Detection of cellulose-decomposing microorganisms: Microbial populations utilize cellulose were detected on carboxymethylcellulose (CMC) medium according to Hendricks et al. [28]. The CMC plates were flooded with Gram's iodine which formed a bluish-black complex with cellulose but not with hydrolysed cellulose, giving a sharp and distinct zone around the cellulase-producing microbial colonies within 3 to 5 minutes. According to Kasana et al. [29] this is more rapid and efficient method than Congo red. The clear zone formed by isolates is used as indicator for cellulase activity.

Determination of soil microbial biomass: The most common technique used to estimate microbial biomass C, N, P and S were measured by the chloroform fumigation-extraction method. The MBC (C_{mic}), MBN (N_{mic}), MBP (P_{mic}) and MBS (S_{mic}) were measured by ethanol-free chloroform fumigation–extraction method. Briefly, 30 g of control and treated soil for each sample was fumigated with ethanol-free chloroform for 24 h at 28°C after one week incubation at 45% WHC. Simultaneously, another unfumigated set was prepared and incubated under the similar conditions. After complete removal of $CHCl_3$, OC and N from fumigated and non-fumigated soil sub-samples were extracted with 0.5 M K_2SO_4 with a soil: extractant ratio of 1:5 (w/v), inorganic P was extracted with 0.5 M $NaHCO_3$ (pH 8.5) with a soil:extractant ratio of 1:20 (w/v). Phosphate was measured by photospectrometry at 882 nm as described by Jöergenson et al. [30]. Also, S was extracted with 0.01 M $CaCl_2$ for 30 min on a rotating shaker [20]. MBC was calculated as: MBC = E_C/k_{EC}, where E_C = (OC extracted from fumigated soils) − (OC extracted from non-fumigated soils) and k_{EC} = 0.38 [31]. MBN was calculated as: MBN = E_N/k_{EN}, where E_N = (total N extracted from fumigated soils) − (total N extracted from non-fumigated soils) and k_{EN} = 0.54 [32]. MBP was calculated as: MBP = E_P/k_{EP}, where E_P = (total P extracted from fumigated soils) − (total P extracted from non-fumigated soils) and k_{EP} = 0.40 [33]. MBS was calculated as: MBS = E_S/k_{ES}, where E_S = (total S extracted from fumigated soils) − (total S extracted from non-fumigated soils) and k_{ES} = 0.35 [34].

Determination of enzymatic potential activities: Hydrolysis of FDA (3’, 6’-diacetyl-fluorescein) was evaluated according to the methods of Schnürer & Rosswall [35]. Dehydrogenase was determined by the reduction of 2-p-iodo-3-nitrophenyl-5-phenyl-tetrazolium chloride to iodonitrophenyl-formazan according to García et al. [36]. Urease and N-α-benzoyl-l-argininamide hydrolysing protease were determined following the method of Nannipieri et al. [37]. Urease and protease activities are expressed as mg NH4/kg dry soil/h. Acid phosphatase was determined by spectrophotometry at 398 nm [38]. The enzyme activity is expressed as mg PNP/kg dry soil/h. β-glucosidase was determined using p-nitrophenyl-β-D-glucopyranoside as substrate. The amount of PNP was determined in a spectrophotometer at 398 nm [38]. Aryl-sulphatase activity was measured colorimetrically according to at 420 nm [39] and is expressed as mg PNP/kg dry soil/h.

3 Results and Discussion

Healthy and productive soils are central to achieving a number of the 17 sustainable development goals adopted by the UN General Assembly this year. After two years of intensive work, 2015 has been declared the International Year of Soils (IYS) by the 68^{th} UN General Assembly (A/RES/68/232). The IYS aims to be a platform for raising awareness of the importance of soils for food security and essential eco-system functions. The UN General Assembly has declared 5th of December 2015 the International Year of Soils to raise awareness of the life-supporting functions of soil. Therefore, the application of BDWS to soil can increase OM, pH of acidic soils [40], and soil microbial and enzymatic activities [10] in the soil. The present investigations confirm the recent results mentioned above. The importance of the reuse of SS in agriculture is derived from its high nutrient content that can improve the soil characteristics crop production. Table 2 shows that the application of BDWS to the control chernozem meadow soil provided a good environmental medium for not only plant growth but also for investigated soil micoorganisms by increasing the pH and moisture content over the controls. The increases in soil moisture content will reduce the amount of water used in irrigation and the pH ranged between 6.19 and 6.71 creating a favourable medium for promoting plant growth.

Table 2
Application of communal bio-disposal wastewater sludge changes the pH and moisture content of chernozem meadow control soil samples.

Soil system	Various BDWS rates (%)	$pH_{(KCl)}$	Moisture content (%)
Control soil	0	6.02	100
Soil amended with BDWS rates	15	6.19	118.1
	30	6.37	132.76
	45	6.50	152.5
	60	6.71	165.4

Figure 1a and 1b illustrate the there is a positive effect of different application rates of the BDWS on the availability of Na, K, Mg and Ca in the investigated soil. These results are in an agreement with Prasanna et al. [45] who pointed out those organic amendments are benefit for plant growth by increasing soil moisture WHC, improving soil texture, and providing plant nutrients such as N and P. The addition of BDWS to soil acts as nutrient reservoir.

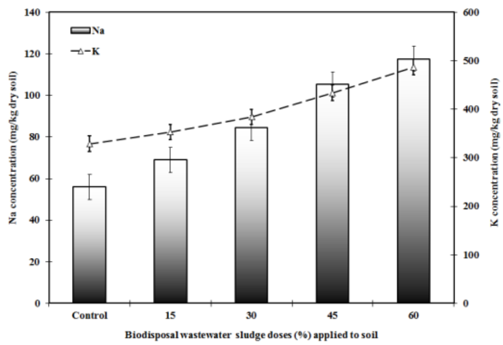

Figure 1a

Application of communal bio-disposal wastewater sludge affects the sodium and potassium concentrations in chernozem meadow soil

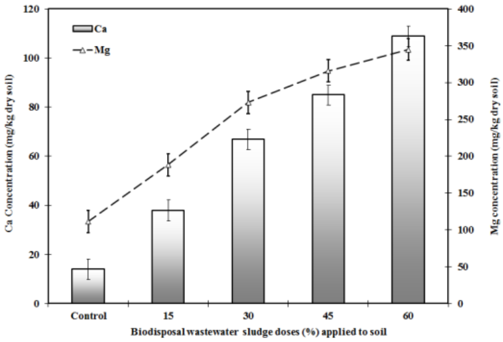

Figure 1b

Application of communal bio-disposal wastewater sludge affects the calcium and magnesium concentrations in chernozem meadow soil

These nutrients released to the soil medium throughout the mineralization. The results showed higher contents of essential elements (Fe, Mn and Zn) in BDWS treated soil in comparison with untreated control soil (Figure 2a and 2b). Our results indicated that the significantly higher of Fe, Mn and Zn, in the investigated soil samples may also due to the higher content and type of BDWS use.

Our results clarified that BDWS enhanced the OM and biological characteristics e.g., the OC content and soil respiration were found to be higher in the BDWS treated soil in comparison with the biodynamically properties of the control soil.

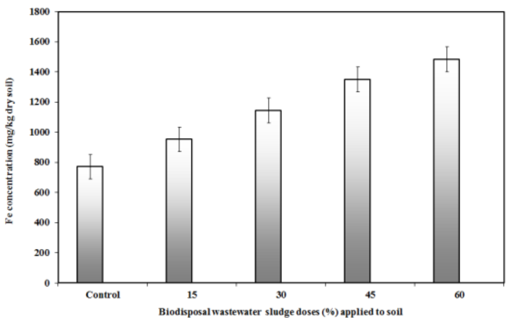

Figure 2a

Application of communal bio-disposal wastewater sludge affects the iron concentration in chernozem meadow soil

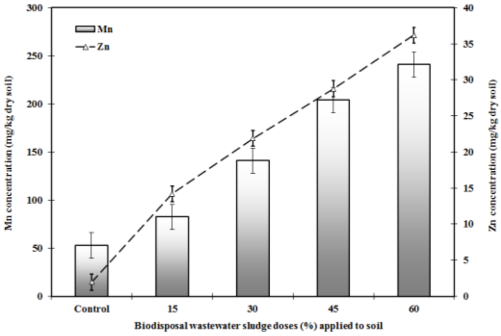

Figure 2b

Application of communal bio-disposal wastewater sludge affects the zinc and manganese concentrations in chernozem meadow soil

The higher content of C, N, P and S indicates that OM can maintain the nutrients supplied by BDWS in amended soil better than the control soil. In general, soil treated with BDWS had better soil properties than untreated control soil. The BDWS amended soil had TOC, TNC, available P and S content higher concentration than in the control soil sample. Organic fertilizer is also known as a slow release nutrient source, so the nutrients can be effectively used for plant uptake, preventing nutrient losses from soil. Soil pH, OC, total N, available P and exchangeable Na, K and Ca increased in soil amended with SS in comparison to control soil. Sewage sludge amendment led significantly to increase in Pb, Cr, Cd, Cu, Zn and Ni concentrations of soil [46]. Due to our experimental work, we agreed with these results, but we found soil samples received BDWS had increased their pH values from 6.02 in control sample to 6.19 (15%), and the highest was in soil samples treated with 60% BDWS (Table 2).

Microorganisms play a major role on decomposition of several organic compounds frequently used in agriculture, which directly affect the synthesis and decomposition of SOM [47]. The results indicated that the increasing rate of application of BDWS increased the population dynamics of aerobic bacterial counts, filamentous fungi and actinobacteria as well as the phosphate-solubilising and cellulose-decomposing microorganisms as it is shown in Figure 3a, 3b and 3c, respectively. These results indicated that the effects on the content and activity of soil microorganisms was significantly positive, and indirectly increased nutrient recycling in the agroecosystem. The main microbial enzymes involved in the mineralization of SOM are cellulase, protease, urease and phosphatase [48]. Cellulase decomposers hydrolysed cellulose compounds present in fresh plant residues that are continuously deposited above soil [49].

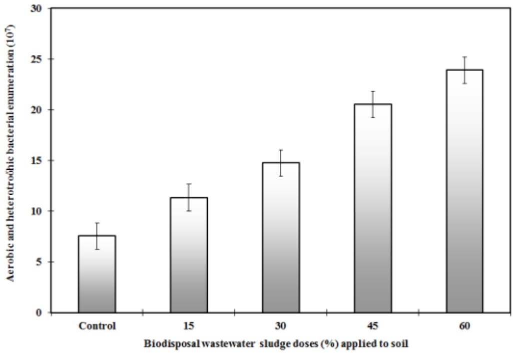

Figure 3a

Application of communal bio-disposal wastewater sludge influence the population of aerobic and heterotrophic bacteria in chernozem meadow soil

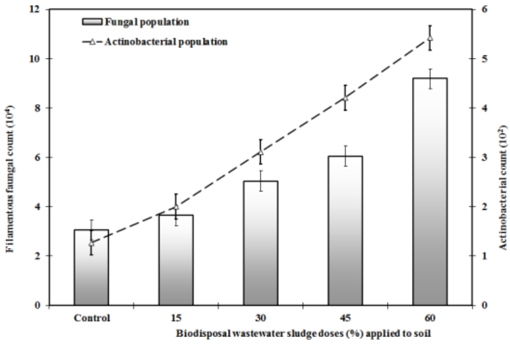

Figure 3b

Application of communal bio-disposal wastewater sludge influence the population of actinobacteria and filamentous fungi in chernozem meadow soil

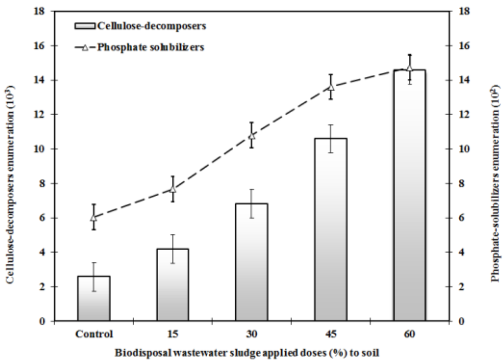

Figure 3c

Application of communal bio-disposal wastewater sludge influences the population of cellulose-decomposers and phosphate-solubilisers in chernozem meadow soil

Figure 4 shows an increases in the potential activities of FDA and dehydrogenase occurred with the application of BDWS. Our results are agreed with Shentu et al. [50] that soil biota is a significant component of soil quality as microorganisms play a vital role in soil ecosystem functioning related to soil fertility and primary production through OM decomposition and nutrient recycling. Dehydrogenase activity is directly linked with living cells associated with microbial oxido-reduction processes [51], which are important for OM degradation and transformation. Since, dehydrogenase activity is not active as extracellular enzymes in soil, it is considered to be a good indicator of overall microbial activity [36, 52].

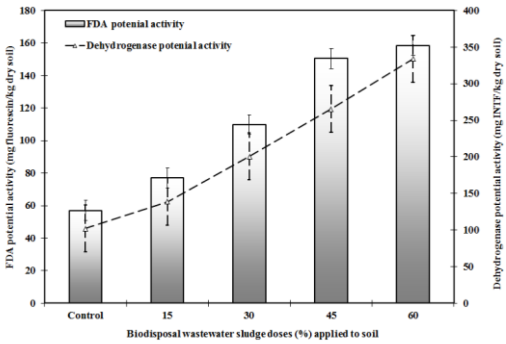

Figure 4

Application of communal bio-disposal wastewater sludge influences the potential activity of fluorescein and dehydrogenase in chernozem meadow soil

Usually, larger differences were observed in the soil of higher BDWS rate, for soil MBC, TOC and enzyme activities. Higher microbial activity was observed in the treated soil systems (Figure 5) than control soil samples. Figure 5 demonstrates that the quantities of MBC and TOC are depending on the amounts of OM in the soil. The estimation of microbial biomass can provide useful information on the changes in soil biological properties [53]. The strongest and most widely used calibration equations for quantifying microbial biomass are based on soil samples with a very wide range of biomass values [27, 54]. Figure 6 indicates the amount of CO_2-released and potential activity of β-glucosidase in BDWS treated soil were higher (as the rate of OM increased) than the control soil. Moeskops et al. [55] reported significant correlation of β-glucosidase activity and SOC content with significantly higher β-glucosidase activity in organically managed soils. It has been shown that microbial activity and biomass is higher in fields with organic amendments than fields with conventional fertilizers [56]. Furthermore, the microbial biomass reflects the contribution of soil microorganisms as both a source and a sink of C in soil ecosystem [57]. Soil microbial biomass, both source and sink of available nutrients plays a critical role in nutrient transformation. As a consequence, our results are agreed that the microbiological properties and the soil enzymatic activities have been suggested as potential indicators of soil quality because of their essential role in soil biology, ease of measurement and rapid response to changes in soil management [58].

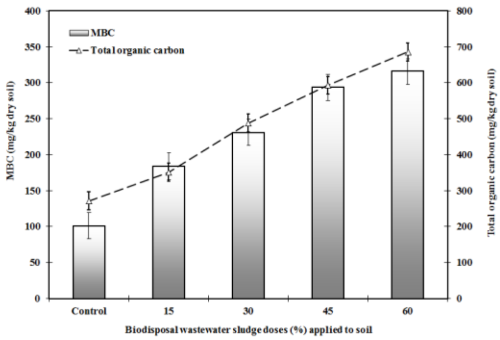

Figure 5

Application of communal bio-disposal wastewater sludge influences the microbial biomass carbon and total organic carbon in chernozem meadow soil

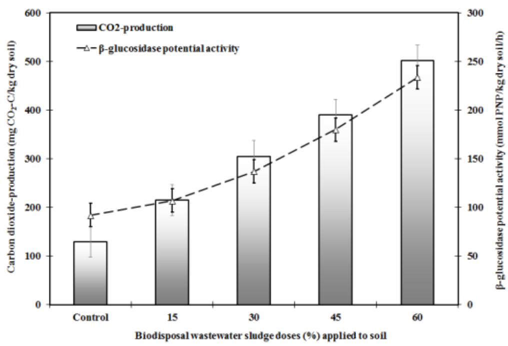

Figure 6

Application of communal bio-disposal wastewater sludge influences the carbon dioxide production and the potential activity of β-glucosidase in chernozem meadow soil

Our results showed that the application of BDWS increased the quantities of MBN, TNC and the potential activities of urease and protease, and these stimulation effects were increased by increasing the application rates of BDWS (Figures 7 and 8, respectively) in comparison with control soil samples.

Our results are in an agreement with the recent studies [59, 60], that soil is a highly complex biological system which is subject to dynamic changes under the effect of biotic and abiotic factors. The use of microbiological and biochemical properties of soil for the estimation of changes taking place in soil environment as a result of e.g., application BDWS is fully justified. Nitrogen fertilization is the most important management strategy for the improvement of agricultural crops. Urea is the most widely used source of organic N fertilizer in the world, which is easily hydrolysed to NH_4^+ and CO_2 by urease [61]. Organic N also affects directly the distribution and action of proteolytic enzymes in soils [62].

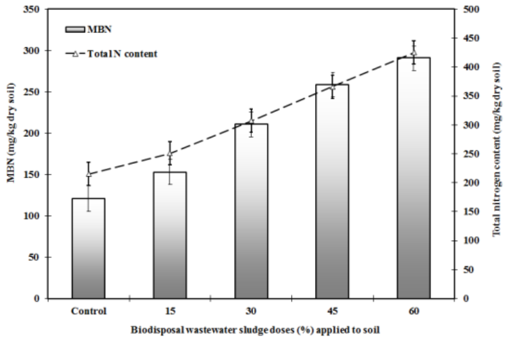

Figure 7

Application of communal bio-disposal wastewater sludge influences the microbial biomass nitrogen and total nitrogen content in chernozem meadow soil

Figures 9 and 10 illustrate the effects of BDWS on the MBP, TIP, PO_4-P and potential activity of phosphatase under different treatments. It is clears that the addition of BDWS increases the P content in treated soil more the control soil.

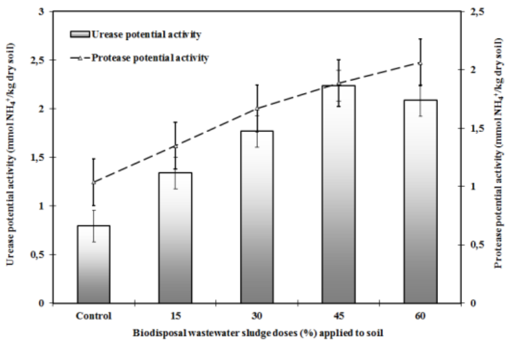

Figure 8

Application of communal bio-disposal wastewater sludge influences the potential activity of urease and protease in chernozem meadow soil

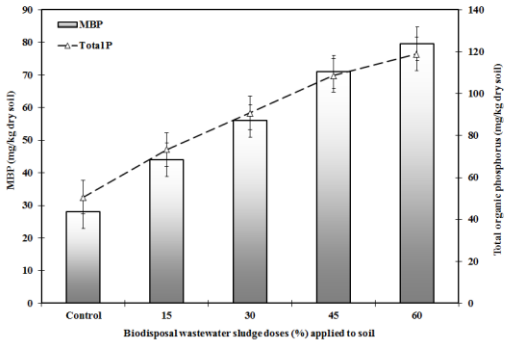

Figure 9

Application of communal bio-disposal wastewater sludge influences the microbial biomass phosphorous and total phosphorous content in chernozem meadow soil

The stimulation of the P content was influenced by the increasing the application rate. Figure 11 represents the gradually increases in the dynamics of soil microbes in the term of MBS and the amount of TOS.

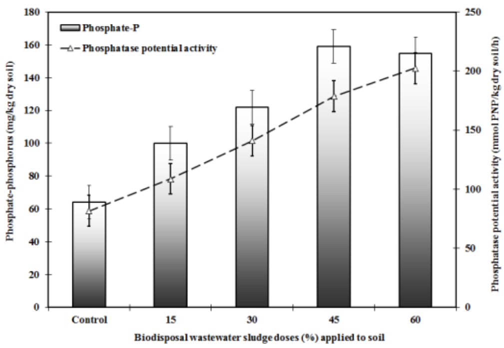

Figure 10

Application of communal bio-disposal wastewater sludge influences the total phosphate-phosphorus and potential activity of phosphatase in chernozem meadow soil

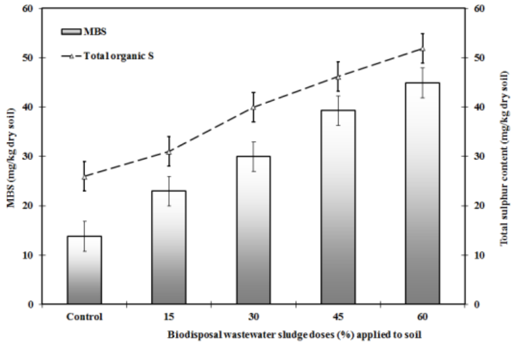

Figure 11

Application of communal bio-disposal wastewater sludge influences the microbial biomass sulphur and total sulphur content in chernozem meadow soil

Figure 12 shows the relationship between the application rate of the BDWS and the SO_4-S as well as the potential activity of aryl-sulphatase

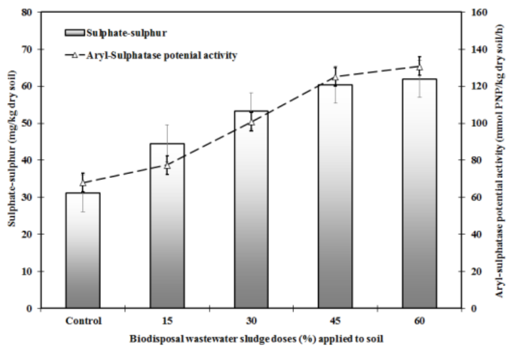

Figure 12

Application of communal bio-disposal wastewater sludge influences the total sulphate-sulphur and potential activity of aryl-sulphatase in chernozem meadow soil

Microbial S values showed direct relationships with both microbial C and with total soil organic S. This result is in agreed with Banerjee & Chapman [30]. The results indicated that the enzymatic activities tended to be higher in soil treated with composted BDWS than in control samples. Although, our conclusion is in agreement with Vepsäläinen [63] in which soil enzyme activities are commonly correlated with each other, it is advisable in soil quality studies to measure a pattern of several enzyme activities simultaneously. Also, we are agreed with Roldán et al. [64] that soil enzyme activity can be used as an indicator of soil quality for assessing the sustainability of agricultural ecosystems.

4 Conclusion

A greenhouse pot experiment is described for studying the changes in soil biodynamics after the application of BDWS. A substantial increase in the quantities of soil microbial biomasses and enzymatic activities take place in the mineralization of OM present in the BDWS applied to the soil samples. The biochemical indices in the present research can provide a reliable and useful indication of soil biological quality of soil fertility after application of BDWS.

The result demonstrated that BDWS have a great potential to enhance soil OM, nutrient availability, microbial activity, MB and enzyme production. Soil biochemical and microbiological indicators of soil quality were generally higher in BDWS systems compared to control soil. High of soil enzymatic activities and MBC as affected by OM input in BDWS systems emphasize the important role of element recycling processes supported by an abundant and active soil biological community. The result demonstrated that the biological activities in different soil treated with different rates of BDWS were directly proportional with the amounts of fluorescein produced and CO_2 release. Therefore, the significant correlation between the CO_2-release, FDA hydrolytic activities and dehydrogenase activity is occurred. Combining microbial activity and population measurements appears to provide more sensitive indications of soil quality by adding communal BDWS.

In most cases, the research study highlights that a portion of C, N, P and S were increased in soil amended with higher rates of BDWS. Microbial interactions in the BDWS treated soil are the determinants of soil fertility and environmental health, our understanding of these interactions has implications for sustainable soil management. Soil host a lot of the world's biodiversity and these are the main key in the C, N, P and S cycles and help us to mitigate and adapt to climate change.

5 References

[1] Bayoumi Hamuda H.E.A.F. and Patkó István: Relationship between environmental impacts and modern agriculture. Óbuda University e-Bulletin, 2010, 1 (1): 87-98.

[2] Bayoumi Hamuda H.E.A.F. and Patkó István: Strategy for improve the global food production. Óbuda University e-Bulletin, 2011, 1 (1): 57-74.

[3] Kihanda M.F., Warren P.G. and Micheni N.A.: Effect of manure application on crop yield and soil chemical properties in a long-term field trial of semi-arid Kenya. Nutrient Cycling in Agroecosystems, 2006, 76 (2): 341-354.

[4] Dordas A.C., Lithourgidis S.A., Matsi Theodora and Barbayiannis N.: Application of liquid cattle manure and inorganic fertilizers affect dry

matter, nitrogen accumulation, and partitioning in maize. Nutrient Cycling in Agroecosystems, 2008, 80 (3): 283-296.

[5] Elfoughi Alaelddin, Benedek Sz., Bayoumi Hamuda H.E.A.F. and Füleky Gy.: Komposzttrágyázás hatásának vizsgálata a talaj tápelem-szolgáltató képességére. Agrokémia és Talajtan, 2010, 59: 315-328.

[6] Elfoughi A. Alaeddin, Benedek Sz., Abusriwil M.H.L., Bayoumi Hamuda H.E.A.F., Füleky Gy.: Effects of compost application on nutrient supply and heavy metal sorption of soil. Carpathian J. Earth and Environ. Sci., 2012, 7 (4): 189-196.

[7] Song U. and Lee J.E.: Ecophysiological responses of plants after sewage sludge compost applications. J. Plant Biology, 2010, 53 (4): 259-267.

[8] Nayak K.A. and Kalamdhad S.A.: Sewage sludge composting in a rotary drum reactor: stability and kinetic analysis. Int J Recycl. Org. Waste Agricult., 2015, DOI 10.1007/s40093-015-0104-4

[9] Singh R.P. and Agrawal M.: Potential benefits and risks of land application of sewage sludge. Waste Manag., 2008, 28 (2): 347-358.

[10] Bayoumi Hamuda H.E.A.F. and Ligetvári F.: Impacts of municipal sewage sludge on dynamics of organic matter and biological activities in clay loam brown forest soil. J. Residual Science & Technology, 2011, 8: 143-149.

[11] Smith L.J. and Papendick R.I.: Soil organic matter dynamics and crop residue management. In: Metting, B. (ed.). Soil Microbial Ecology. 1993, New York, Marcel Dekker.

[12] García C., Hernandez T., Albaladejo J., Castillo V., Roldán A.: Revegetation in semiarid zones, Influence of terracing and organic refuse on microbial activity. Soil Sci. Soc. Am. J., 1998, 62: 670-678.

[13] De Caire G.Z., de Cano M.S., Palma R.M. and de Mulé C.Z.: Changes in soil enzyme activities following additions of cyanobacterial biomass and exopolysaccharide. Soil Biol. Biochem., 2000, 32: 1985-1987.

[14] Mishra R.: Ecology Work Book. 1968, Oxford IBH, New Delhi, India.

[15] MSZ 20135: Determination of the soluble nutrient element content of the soil. Hungarian Standards Institution, Budapest (in Hungarian) 1999:

[16] MSZ 21470-50: Environmental Soil Analyses. Determination of the total and available toxic elements, heavy metals and chromium(VI) concentrations. Hungarian Standard Institution, Budapest (in Hungarian) 1998.

[17] Walkley A. and Black I.A.: An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci., 1934, 37: 29-38.

[18] Keeney D.R. and Nelson D.W.: Nitrogen-inorganic forms. In: Page L.A., Miller H.R. (Eds). Methods of Soil Analysis. Part 2. 2nd ed. Agron. Monogr. 9. ASA and SSSA, Madison, WI, 1982 pp. 643-698.

[19] Olsen S.R. and Sommers L.E.: Phosphorus. In: Methods of soil analysis, part 2. Chemical and microbiological properties. Page L.A., Miller H.R., Keeney R.D. (Eds.) pp. 403-430. Agron. Mongr. 2nd ed. 1982, pp.: 1159. American Society of Agronomy, Madison, Wisconsin, USA..

[20] Subba Rao A.: Analysis of soils for available major nutrients. In Methods of Analysis of Soil, Plants, Waters and Fertilisers (Tandon S. L.H., Ed.). Fertiliser Development Consultation Organisation, New Delhi, India, 1993, pp. 28-30.

[21] Stotzky G.: Microbial respiration. In: Black C.A., Evans D.D., White J.L., Ensminger L.E. and Clark F.E. (Eds). Methods of soil analysis. Am. Soc. Agron. Madison, Wis, 1965 pp. 1550-1570.

[22] Martin J.P.: Use of acid, rose bengal and streptomycin in the plate method for estimating soil fungi. Soil Sci., 1950, 69: 215-232.

[23] Alef K. and Nannipieri P.: Methods in applied soil microbiology and biochemistry. Academic Press, London, U.K. 1995.

[24] Küster E. and Williams S.T.: Selection of media for isolation of Streptomycetes. Nature, London, 1964, 202: 928-929.

[25] Williams S.T. and Davies L.F.: Use of antibiotics for selective isolation and enumeration of actinomycetes in soil. J. Gene. Microbiol., 1965, 38: 251-262.

[26] Pikovskaya, R.I.: Mobilization of phosphorus in soil in connection with vital activity of some microbial species. Mikrobiologiya, 1948, 17: 362-370.

[27] Goldstein, A.H.: Bacterial solubilization of mineral phosphates: historical perspective and future prospects. Am. J. Altern. Agric., 1986, 1: 51-57.

[28] Hendricks C.W., Doyle J.D. and Hugley B.: A new solid medium for enumerating cellulose-utilizing bacteria in soil. Appl. Environ. Microbiol., 1995, 61: 2016-2019.

[29] Kasana R.C., Salwan R., Dhar H., Dutt S. and Gulati A.A.: Rapid and easy method for the detection of microbial cellulases on agar plates using Gram’s iodine. Curr. Microbiol., 2008, 57 (5): 503-507.

[30] Jöergensen R.G., Kübler H., Meyer B. and Wolters V.: Microbial biomass phosphorus in soils of beech (Fagus sylvatica L.) forests. Biol. Fertil. Soils, 1995, 19: 215-219.

[31] Vance E.D., Brookes P.C. and Jenkinson D.S.: An extraction method for measuring microbial biomass C. Soil Biol. Biochem., 1987, 19: 703-707. [doi: 10.1016/0038-0717(87)90052-6]

[32] Brookes P.C., Landman A. and Pruden G.: Chloroform fumigation and the release of soil nitrogen: A rapid direct extraction method to measure microbial biomass nitrogen in soil. Soil Biol. Biochem., 1985, 17 (6): 837-842. [doi:10.1016/0038-0717(85)90144-0]

[33] Öhlinger R.: Biomass-C by Fumigation-Extraction Technique. In: Schinner F., Kandeler E., Öhlinger R., Margsin R. (Eds.) Methods in Soil Biology, Springer, Berlin, 1996 pp. 54-56.

[34] Banerjee M.R. and Chapman S.J.: The significance of microbial biomass sulphur in soil. Biol. Fertil. Soils, 1996, 22: 116-125.

[35] Schnürer J. and Rosswall T.: Fluorescein diacetate hydrolysis as a measure of total microbial activity in soil and litter. Appl. Environ. Microbiol., 1982, 43: 1256-1261.

[36] García C., Hernandez, T. and Cost F.: Potential use of dehydrogenase activity as an index of microbial activity in degraded soils. Commun. Soil Sci. Plant Anal., 1997, 28: 123-134.

[37] Nannipieri P., Ceccanti B., Cervelli S., Matarese E.: Extraction of phosphatase, urease, protease, organic carbon and nitrogen from soil. Soil Sci. Soc. Am. J., 1980, 44: 1011-1016.

[38] Tabatabai M.A. and Bermned J.M.: Factors affecting soil aryl-sulphate activity. Soil Sci. Soc. Am. Proc., 1969, 34: 427-429.

[39] Tabatabai M.A. and Bermned J.M.: Use of P-nitrophenol phosphate in assay of soil phosphatase activity. Soil Biol. Biochem., 1970, 1: 301-307.

[40] Maynard A.A.: Cumulative effect of annual additions of MSW compost on the yield of field-grown tomatoefs. Compost Sci. Util., 1995, 3: 47-54.

[45] Prasanna R., Jaiswal P., Singh Y.V. and Singh P.K.: Influence of biofertilizers and organic amendments on nitrogenase activity and phototrophic biomass of soil under wheat. Acta Agron. Hung., 2008, 56 (2): 149-159.

[46] Singh P.R. and Agrawal M.: Effects of sewage sludge amendment on heavy metal accumulation and consequent responses of Beta vulgaris plants. Chemosphere, 2007, 67 (11: 2229-2240.

[47] Carney K.M. and Matson P.A.: Plant communities, soil microorganisms, and soil carbon cycling: does altering the world belowground matter to ecosystem functioning? Ecosystem, 2005, 8: 928-940.

[48] Kunito T., Saeki K., Goto, S., Hayashi H., Oyaizu H. and Matsumoto S.: Copper and zinc fractions affecting microorganisms in long-term sludge-amended soils. Bioresource Technol., 79, 2001 pp. 135-146.

[49] Dilly O. and Nannipieri P.: Response of ATP content, respiration rate and enzyme activities in arable and a forest soil to nutrient additions. Biol. Fertil. Soils, 2001, 34: 34-64.

[50] Shentu Jia-li, He Zhen-li, Yang Xiao-e. and Li Ting-qiang: Microbial activity and community diversity in a variable charge soil as affected by cadmium exposure levels and time. J. Zhejiang Univ. Sci. B, 2008, 9 (3): 250-260.

[51] Stepniewska Z., Wolinska A. and Lipinska R.: Effect of fonofos on soil dehydrogenase activity. Int. Agrophys., 2007, 21: 101-105.

[52] Quilchano C. and Maranon T.: Dehydrogenase activity in Mediterranean forest soils. Biol. Fertil. Soils, 2002, 35: 102-107.

[53] Jordan D., Kremer R.J., Bergfield W.A., Kim K.Y. and Cacnio V.N.: Evaluation of microbial methods as potential indicators of soil quality in historical agricultural fields. Biol. Fertil. Soils, 1995, 19: 297-302. [doi: 10.1007/BF00336098]

[54] Vance E.D., Brookes P.C. and Jenkinson D.: Microbial biomass measurements in forest soils: determination of Kc values and tests of hypothesis to explain the failure of the chloroform fumigation-incubation method in acid soils. Soil Biol. Biochem., 1987, 19: 381-387.

[55] Moeskops B., Sukristiyonubowo B.D., Sleutel S., Herawaty L., Husen E., Saraswati R., Setyorini D. and De Neve S.: Soil microbial communities and activities under intensive organic and conventional vegetable farming in West Java, Indonesia. Appl. Soil Ecol., 2010, 45: 112-120.

[56] Drinkwater L.E., Letourneau K.D., Workneh F., van Bruggen C.H.A., and Shennan C.: Fundamental difference between conventional and organic tomato agroecosystems in California. Ecol. Appl., 1995, 5: 1098-1112.

[57] Baaru M.W., Mungendi D.N., Bationo A., Verchot L. and Waceke W.: Soil microbial biomass carbon and nitrogen as influenced by organic and inorganic inputs at Kabete, Kenya. In: Bationo A. (Ed.) Advances in Integrated Soil Fertility Management in Sub-Saharan Africa: Challenges and Opportunities, 2007 pp. 827-832.

[58] Kandeler E., Tscherko D. and Spiegel H.: Long-term monitoring of microbial biomass, N mineralisation and enzyme activities of a chernozem under different tillage management. Biol. Fertil. Soils, 1999, 28: 343-351.

[59] Janvier C., Villeneuve F., Alabouvette C., Edel-Hermann V., Mateille T. and Steinberg, C.: Soil health through soil disease suppression: Which

strategy from descriptors to indicators? Soil Biol. Biochem., 2007, 39: 1-23.

[60] Jezierska-Tys S. and Frqc M.: Microbiological indices of soil quality fertilized with dairy sewage sludge. Int. Agrophysics, 2008, 22: 215-219.

[61] Masciandaro G., Ceccanti B. and Garacía C.: Anaerobic digestion of straw and piggery wastewater. II. Optimalization of the process. Agrochimica, 1994, 38: 195-203.

[62] Insam H.: Developments in soil microbiology since the mid 1960s. Geoderma, 2001, 100:. 389-402.

[63] Vepsäläinen M.: Functional biodiversity in boreal soils: Enzyme activity pattern measurement method development and applicability studies. Monographs of the Boreal Environment Research 2012, No. 41: 59. Edita Prima Ltd. Helsinki ISBN 978-952-11-4084-6

[64] Roldán A., Salinas-García R.J., Alguacil M.M., Díaz E. and Caravaca, F.: Soil enzyme activities suggest advantages of conservation tillage practices in sorghum cultivation under subtropical conditions. Geoderma, 2005, 129: 178-185.