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Proposed treatment applicable scenario for the treatment of domestic sewage sludge which is produced from a sewage treatment plant under warm climates conditions

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ABSTRACT

Characterization and operation description of municipal wastewaters has been the subject, or the indispensable starting point, of many studies. The present paper (as there is a very limited work on the subject) deals with the operation, description, and characterization of the domestic sewage sludge (DSS) as well as a proposed applicable scenario (composting) is presented with a feasibility study. The area presented with a long period of warm and high temperature conditions (>27˚C, and during summer >32˚C). The sludge, almost 4,200 t/y, does not present significant concentration of heavy metals. However, the sewage sludge contains high concentration of organics and phosphorus, and with further treatment like composting may be used in agriculture purposes. DSS is presented with no significant ($p < 0.05$) concentration of heavy metals but it is presented with low concentration of humics, lignin, cellulose, and the germination index (G.I.) are too low. A co-composting of sewage sludge with pure organic which is produced from hotels green waste is presented as applicable scenario. The feasibility study indicated a total capital investment up to 600,000€ while the yearly operation cost will be up to 50,000€.

Keywords: Wastewater treatment plant; Sludge characteristics; Composting; Green waste; Feasibility study

1. Introduction

Increasing urbanization and industrialization has culminated in a dramatic growth in the volume of municipal wastewater produced worldwide. This wastewater contains all the substances that enter the human metabolism, such as food, beverages, pharmaceuticals, a great variety of household chemicals, and the substances discharged from trade and industry to the sewer system [1–3]. The Council Directive 91/271/EEC of 21 May 1991 [4] concerning

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urban wastewater treatment (also known as The European Water Act) establishes restrictive threshold concentrations in the wastewater emissions and its implementation is leading to a rapid multiplication of wastewater treatment plants (abbreviated WWTPs) across Europe. WWTPs produced significant values of sewage sludge, which, is the concentrated bioactive residue of mostly organic clay-sized particles derived from wastewater treatment processes. The consolidation and hydraulic characteristics of the dewatered sludge material are of major importance with regard to its long-term behavior in landfills (sludge monofills, municipal landfills, or sludge lagoons), currently the principal means of disposal in the European Community. In many countries, there is an almost complete reliance on landfilling since the spreading of sewage sludge material on land is banned and incineration may not be an option. The sludge landfill and its engineered capping system are subject to considerable settlement that must be assessed at the design stage. In practice, sewage sludge shows unpredictable consolidation behavior that can be attributed to a number of causes [2,3]. In general, sludge treatment systems involve high costs, ranging from 20 to 60% of the total operating cost of WWTPs [5,6]. This is particularly critical in the case of WWTPs of small rural communities, which, in practice, may then transport raw sludge to larger WWTPs instead of implementing their own sludge treatment line [7]. Sludge management includes land application, incineration, landfill, composting, gasification, ocean dumping, etc. [8]. The present paper (as there is a very limited work on the subject) deals with the characterization of the domestic sewage sludge (DSS), under warm climate conditions, and also a proposed applicable and feasible treatment scenario is presented (using open composting system).

1.1. Area description

As already presented in other studies [2,3,9] in the greater eastern area of Cyprus are the Municipality of Paralimni and Ayia Napa. Those municipalities with permanency population almost 22,000 citizens (19,000 and 3,000, respectively) consist of the main economical lung of the island due to the fact that in this area there are the largest hotel resorts. During the winter, the population is estimated to be 22,000 citizens but from the beginning of April since October are estimated to be 75,000 with the tourist per day. With almost 2,000,000 tourists per year who visit Cyprus, from all around the world, and especially the European Union, the two Municipalities has the ability to quest almost the 35–40% per year of the total tourist that they visit the Island [2,3,9]. There is no major water-consuming industry in the project area, and according to the available development plants the situation will remain the same in the future. In the nearby area, there are mainly tourist activities like hotels, restaurants, bars, pubs, night clubs, and water parks. There are 115 hotels and apartments in the Municipality of Paralimni, and 185 hotels and apartments in the Municipality of Ayia Napa, according to the Cyprus Tourist Organization [2].

Also, in the area there are almost 6,000–6,500 houses, one water park the biggest in the Mediterranean (120,000 m^2 approximately), eight petrol stations and 12 cars cleaning services, approximately 15 machinist's craftsmanship, small industries like bakeries, confectioneries, car wash, food suppliers, supermarkets, and schools, six clinical laboratories, two private clinics, and one public hospital, football fields and athletic activities, two chicken farms (approximately 30,000 chicken/y), two big laundries, one concrete plant and some small industrial activities which do not produce liquid waste are the main activities of the area. The water consumption arising from small-scale industries is included in per capital/per bed consumption figures with the daily visitors in the tourist area. Intrusion of storm water/groundwater into the sewer system is omitted as the sewers will be installed above the groundwater table and the possible storm water leakage would occur during the low tourist season when water consumption is low. Total population served is 120,000 including residents, tourist, and labor force in tourism. The number of tourist beds used as the dimensioning basis is 44,000 in Paralimni and 36,000 in Ayia Napa [2,3,9]. The estimated total wastewater flow is up to 28,000 $m^3 d^{-1}$ during the high season and up to 18,000 $m^3 d^{-1}$ during the low season. The average flow (yearly average) is estimated to be about 20,000 $m^3 d^{-1}$.

1.2. Sludge handling current situation

Sludge is separated from wastewater in secondary clarifiers. Secondary sludge (excess sludge from biological process) is pumped from the return sludge stream into primary clarifiers. Excess sludge is taken from two of the four basins. Back wash water from sand filters is pumped to primary clarifiers. Sludge sediment in primary clarifiers is pumped into two gravity thickeners. Pumping is controlled with timers. The thickeners are equipped with torque measurement. Thickened sludge is pumped with two pumps to belt filter presses to dewater. Pumps are controlled from the level of the wet zone of belt filter presses. Polymer is dosed prior to dewatering. Each of the two sludge lines controls a respective polymer pump. Preparation and dosing of polymer solution takes place automatically. Effluent after sand filters is used for polymer dissolving and diluting as well as for the washing of belt filter presses with showers. Dewatered sludge falls from the presses on a conveyor screw at the end of each equipment. Dewatered sludge is stabilized now with lime (CaO). CaO is dosed to form lime silo with dry feeder. Mixing of sludge and CaO occurs in a conveyor screw. Stabilized sludge is transferred by means of a belt conveyor to the landfill site. Over flows from the thickeners and filtrates (rejects) from sludge dewatering are collected into a well and pumped back to the wastewater process (to sand removal). The total yearly amount is about 4,200 ± 200 t [2,3,9].

1.3. State of the Art

Composting is under consideration in many municipalities throughout the world because it has several advantages over current disposal strategies. Firstly, composting can reduce the waste volume by 40–50% and thus require less landfill space for disposal [8,10–13]. Secondly, pathogens can be killed by the heat generated during the thermophilic phase [8,10–13]. Finally, composting has been well established and currently it is used to provide a final product which can act as a soil conditioner or fertilizer. Compost contains major plant nutrients such as N, P, and K, micro nutrients such as Cu, Fe, and Zn, and humic substances which improve the physical properties of soils such as aeration and saturation capacity. Co-composting of sewage sludge with other raw materials has been investigated in the past. Sludge with zeolites for the removal of heavy metals [8,12,14–16], sludge with organic fraction of municipal solid waste [8,10,11], sludge with waste paper and sludge with sawdust [13] in order to increase the humic substances, sludge with zeolites and organic fraction [11], sludge with green waste [17], sewage sludge, barks, and green waste [18] have been investigated in the past by many researchers providing applicable solution to those wastes.

2. Materials and methods

A sufficient amount of the sludge samples collected once in a week (25 kg sample per day) served as two homogenized examined samples per month (26 homogenized samples per year) for the last seven years and were analyzed for several parameters as presented in Tables 1–3. All parameters are determined according to Standards Methods [12,19–23]. Statistical analysis was performed using standard deviation formulas from Microsoft Excel 2010.

3. Results and discussion

3.1. Sludge physicochemical analysis and literature review

Table 1 presents the physicochemical characteristics of sludge from 2004 to the end of 2011 while Table 2 presents the metals concentration in sludge the last seven years. The water content was 70.2%. The pH values of dry sludge sample were about 7. The EC was about 3,000 mS/cm. The total phosphorous content was found in high levels due to the fact that the main load of the treated wastes was municipal. The E4/E6 ratio shows the characterization of humic materials. As the E4/E6 ratio is below 5, the samples are characterized as Humic Acid (whereas if the ratio is above 5 the sample is characterized as Fulvic Acid), [21]. The C/N ratio is considered to be very low for the production of high-quality final compost. The organic matter is about 50% of the volatile suspended solid (VSS) while the Total organic carbon (TOC) is about 30%. VSS is at 72%, sludge volume index (SVI) varies from 104.23 to 131.06, the mixed liquor volatile suspended solid (MLVSS) from 3.65 to 3.92 mg/l, and the mixed liquor suspended solid (MLSS) range from 432.11 to 476.11 g/l (Table 3). A minimum of 14 d was required for optimum MLSS and MLVSS reductions. The longer the retention time, the higher the reductions achieved. For domestic sludges, a high reduction in settled sludge volume was observed between 14 and 21 d. Therefore, the best retention time appears to be about 17 d, just after the improvement in settle ability; at this time, the filterability was still reasonable. The SVI may be monitored each day, and the supernatant removed as soon as the sludge settle ability reaches optimum. However, the retention time should not be longer than 21 d because of the risk of foam production and the decrease in filterability [24].

Comparing the results presented in Table 2 with other studies [12,14,15] and the directive 86/278/EC [25] the concentrations of the examined metals in sludge are too low due to the fact that the sewage treatment plant (STP) does not receive any heavy wastes and the examined metals are in the limits of the specific directive for the safe discharge of the sludge. Psittalias' wastewater treatment plant (municipal and industrial waste) which is the biggest in the greater area of Athens (Greece) the heavy metals

Table 1
Physicochemical characteristic variations of DSS the last seven years

Parameters	2005	2006	2007	2008	2009	2010	2011
Moisture%	85.91 ± 3.01	81.12 ± 4.25	77.32 ± 2.45	83.10 ± 2.13	78.12 ± 3.12	75.36 ± 2.85	74.36 ± 3.25
pH	7.23 ± 0.37	7.55 ± 0.25	7.22 ± 0.35	7.14 ± 0.21	7.19 ± 0.28	7.23 ± 0.28	7.19 ± 0.25
EC mS/cm (25℃)	3,058 ± 138	2,779 ± 201	3,004 ± 176	3,423 ± 198	2,790 ± 166	2,954 ± 146	2,990 ± 206
Total phosphorous (mg/g)	55.12 ± 28.91	62.09 ± 19.25	58.96 ± 24.62	71.05 ± 34.51	67.25 ± 21.12	70.21 ± 26.15	69.87 ± 22.62
Organic matter% (VSS)	55.12 ± 5.12	49.63 ± 4.33	50.12 ± 6.18	49.63 ± 4.66	52.39 ± 6.09	51.23 ± 4.89	55.98 ± 6.12
TOC%	30.31 ± 3.16	27.29 ± 2.81	27.56 ± 5.42	27.30 ± 4.02	28.81 ± 3.19	26.89 ± 5.01	29.56 ± 4.74
Ash%	23.16 ± 6.41	24.79 ± 7.52	28.32 ± 5.97	26.99 ± 4.08	27.55 ± 5.08	26.32 ± 4.85	24.99 ± 5.56
Total Kjeldahl nitrogen%	6.40 ± 3.42	7.45 ± 2.06	7.25 ± 2.51	6.24 ± 1.11	6.42 ± 1.69	6.18 ± 1.76	5.99 ± 2.08
Humic substances%	2.67 ± 0.77	3.55 ± 0.55	3.98 ± 0.57	4.07 ± 0.33	4.65 ± 0.23	4.57 ± 0.51	4.09 ± 0.69
Humic acid (mg/g)	0.78 ± 0.13	0.81 ± 0.11	1.01 ± 0.12	1.15 ± 0.74	0.89 ± 0.26	1.16 ± 0.33	0.99 ± 0.58
Fulvic acid (mg/g)	15.23 ± 5.12	22.52 ± 12.31	13.69 ± 9.95	14.56 ± 4.89	17.66 ± 7.52	26.91 ± 9.19	31.23 ± 11.89
E4/E6	1.89 ± 0.08	1.41 ± 0.07	1.66 ± 0.09	1.59 ± 0.06	1.49 ± 0.07	1.38 ± 0.09	1.12 ± 0.11
Lignin (mg/g)	0.25 ± 0.06	0.36 ± 0.09	0.22 ± 0.05	0.31 ± 0.04	0.42 ± 0.09	0.38 ± 0.10	0.35 ± 0.08
Cellulose (mg/g)	9.58 ± 1.23	12.69 ± 3.42	11.55 ± 2.69	13.33 ± 3.11	10.59 ± 2.55	8.96 ± 3.59	11.23 ± 2.59
G. I	24 ± 7	44 ± 8	39 ± 5	37 ± 11	41 ± 9	38 ± 11	44 ± 8
Grow Index%	32 ± 5	39 ± 9	42 ± 5	25 ± 10	36 ± 8	32 ± 9	29 ± 10
Cl^- (mg/g)	2.87 ± 0.58	3.14 ± 0.95	3.55 ± 0.63	2.99 ± 0.88	3.79 ± 0.46	3.06 ± 0.68	2.85 ± 0.51
$N–NH_4^+$ (mg/g d w)	0.125 ± 0.008	0.203 ± 0.012	0.195 ± 0.022	0.236 ± 0.033	0.158 ± 0.055	0.356 ± 0.068	0.299 ± 0.092
$N–NO_3^+$ (mg/g d w)	0.356 ± 0.089	0.402 ± 0.108	0.360 ± 0.127	0.286 ± 0.106	0.358 ± 0.149	0.401 ± 0.205	0.363 ± 0.187
C/N	5.06 ± 2.31	7.21 ± 3.29	5.91 ± 1.87	8.12 ± 2.87	9.21 ± 4.45	11.61 ± 3.98	12.56 ± 4.03
Fats and oils (mg/g)	2,230 ± 324	2,015 ± 295	1,560 ± 198	1,720 ± 23	1,340 ± 125	2020 ± 186	2,105 ± 209

Note: All value in dry matter except moisture. n.d: not detected.

concentration on sludge [12,21] is (in mg/g dry bases): 0.002 for Cd, 0.563 for Co, 0.552 for Cr, 0.258 for Cu, 5.089 for Fe, 0.150 for Mn, 0.041 for Ni, 0.326 for Pb, and 1.739 for Zn. Zorpas et al. [25] mentioned that the concentration of metals in mg/g dry base from Komotinis STP (Greece, mainly municipal waste) was 0.044 for Cr, 0.040 for Cu, 7.760 for Fe, 0.218 for Mn, 0.750 for Mg, 0.864 for Zn, 0.050 for Ni, 0.139 for Pb, 14.50 for Ca, and 2.36 for K, 1.16 for Na. Also, the same researcher [26] mentioned that the metal concentration in mg/g dry base in sewage sludge from the Metorphosis STP in Athens (Greece mainly municipal waste) is 0.210 for Cr, 0.282 for Cu, 11.048 for Fe, 0.141 for Ni, 0.275 for Pb, and 1.193 for Zn. During 1993, Savvides [26] mentioned that the sewage sludge from the STP of Limassol (Cyprus, treat only municipal waste) in mg/g dry samples was 0.090 for Cr, 0.060 for Cu, 5.56 for Fe, 1.760 for Ni, 0.050 for Pb, and 0.40 for Zn. Watteau and Villemin [18] indicated that the concentrations of metals from sewage sludge were 9.95 mg/kg for Fe, 223 mg/kg for Cu, 1,369 mg/kg from Zn, and 129 mg/kg for Pb.

The European Commission has said repeatedly that the "Directive on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture" (86/278/EEC) [25] has been very successful in that there have been no cases of adverse effect where it has been applied. The EC encourages the use of sewage sludge in agriculture because it conserves organic matter and completes nutrient cycles. Recycling of phosphate is regarded as especially important because the phosphate industry predicts that at the current rate of extraction, the economic reserves will be exhausted in 100 or at most 250 years. The problems dealing with sewage sludge are complex because it is largely constituted of those substances responsible for the offensive character of untreated wastewater [27]. Besides the potentially hazardous materials, however, sludge also contains valuable materials. To identify potential alternatives for a sustainable treatment, it is useful to evaluate the composition of the sludge. This composition can be roughly characterized by five groups of components, which are present in the sludge: (a) nontoxic organic C compounds, Kjeldahl-N, phosphorus containing

Table 2
Metals concentration in sludge

Metals (mg/kg dry base)	July 2003	July 2004	July 2005	July 2006	March 2007	April 2008	August 2008	August 2009	May 2010	November 2010	March 2011	June 2011	86/278/EOK for land disposal or in agricultural
Copper (Cu)	190.2	193.7	149.0	151.1	125.1	179.4	136.5	141.9	142.6	123.9	241.6	205.4	
Iron (Fe)	8,890	7,031	6,900	7,210	4,829	4,241	6,039	7,900	7,550	8,012	7,984	8,105	1,000–1,750
Manganese(Mn)	195.9	178.4	183.7	167.3	204.7	102.1	144.9	177.3	201.5	188.6	197.4	214.9	
Zinc (Zn)	345.1	355.7	390.2	384.1	407.5	356.3	309.4	287.6	411.3	305.9	661.2	561.3	
Nickel (Ni)	17.91	15.39	20.82	17.91	16.79	16.96	14.05	15.55	9.12	17.2	14.8	21.4	2,500–4,000
Boron (B)	91.6	88.4	75.5	90.4	77.98	63.6	67.9	88.9	77.9	99.3	141.3	103.4	
Cobalt (Co)	0.071	0.060	0.052	0.092	0.065	0.018	0.068	0.043	0.051	0.048	0.039	0.063	
Lead (Pb)	115.5	93.1	98.7	87.5	80.4	65.5	74.6	82.0	69.14	106.7	96.9	129.8	
Chromium (Cr)	13.01	11.32	15.92	17.01	20.71	17.81	16.08	11.01	10.03	12.1	7.16	8.98	750–1,200
Cadmium (Cd)	0.712	0.991	0.690	0.796	0.882	1.019	0.908	0.775	0.205	1.09	2.26	1.87	100–500
Calcium (Ca)	19,234	20,018	23,434	26,100	21,948	24,141	27,201	26,987	32,145	29,527	284,160	30,148	20–40
Sodium (Na)	3,020	3,315	2,688	3,001	2,698	2,734	2,996	3,030	3,125	2,987	3,019	2,874	
Potassium (K)	12,001	8,789	10,345	11,007	10,493	12,759	10,870	9,982	8,745	9,983	10,024	11,476	
Magnesium(Mg)	9,991	10,234	8,903	11,212	10,873	11,864	9,825	10,034	11,245	10,987	9,874	11,299	
Arsenic (As)	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	
Mercury (Hg)	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	
Cianium (CN)	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	

Note: Significant different at $p < 0.05$, n.d: not detected.

Table 3
MLSS, MLVSS, SVI, and VSS variation

Month—Year	September-06–August-07 (Average)	September-07–August-08 (Average)	September-08–August-09 (Average)	September-09–August-10 (Average)	September-10–August-12 (Average)
MLSS (g/l)	457.34 ± 92.12	432.11 ± 159.56	476.54 ± 71.79	469.87 ± 83.61	474.67 ± 69.78
MLVSS (mg/l)	3.76 ± 0.64	3.92 ± 0.79	3.65 ± 0.33	3.71 ± 0.56	3.88 ± 0.47
SVI	120.12 ± 17.16	104.23 ± 21.22	131.06 ± 14.87	128.6 ± 19.32	127.9 ± 17.98
VSS%	71.68 ± 4.12	73.01 ± 4.63	72.45 ± 5.25	73.05 ± 3.11	72.01 ± 2.98
Monthly yearly flow (m^3)	212,167 ± 106,689	213,594 ± 103,814	218,986 ± 98,474	225,174 ± 87,415	236,911 ± 91,025

components, (b) toxic pollutants: heavy metals, such as Zn, Pb, Cu, Cr, Ni, Cd, Hg, and As (varying from more than 1,000 ppm to less than 1 ppm); PCBs, PAHs, dioxins, pesticides, endocrine disrupters, linearalkyl-sulfonates, and nonyl-phenols. (c) Pathogens and other microbiological pollutants; (d) inorganic compounds such as silicates, aluminates, calcium, and magnesium containing compounds; (e) water varying from a few 0.01% to more than 95%.

3.2. Proposed treatment scenario

The area has almost 300 hotels. Those hotels produce huge quantities of green waste and yard waste apart from the other waste (organic, recyclables, liquid, and solid waste) as they have gardens and large site of fields. Until now the only applicable method for the treatment of the waste is the disposal at the landfill site or to use them as feedstock for some farms. It is estimated that each hotel produces sewage sludge somewhere of 20 ± 5 t. The proposed scenario includes the co-composting of the 4,200 ± 200 t sewage sludge with green waste (grass, garden waste). Grass exhibits a relatively slow decomposition rate due to the high content of recalcitrant decomposable compounds such as cellulose and lignin. Therefore, sewage sludge is composed with relatively high N content and would complement grass with relatively high C content for co-composting. After composting treatment, dewatering sludge can be served as soil amendments, and be used in agriculture and forestry soil maintenance and improvement of pasture restoration. The using of dewatering sludge as organic fertilizer, not only can improve the yield and quality of crop but also can increase the organic nutrient content in soil, thus improving the physical properties of soil [28].

As the area is presented with a long period of warm and high temperature conditions (>27˚C, and during summer >32˚C), the sludge can be physical sundry and the co-composting system will include a windrow system with a mechanical aeration. The unit can be in the same area of the STP plant as is in the middle of the two municipalities. Thus could help both municipalities to reduce the constructions, transportation, and operation cost. Also, this proposed treatment scenario could be very useful in order to minimize the gate fee, that both municipalities pay in order to transfer their waste to the Central Unit of Solid Waste Management based in Koshis area (which is about 70 km away) as the green waste abuts to the collected system of household waste. The two municipalities spend huge amount to buy fertilizer in order to redesign their parks, their fields, and their roads so the produced fertilizer can be used for those proposed.

This practice not only solves the disposal problem of sewage sludge and green waste of the area, but also achieves the sustainable material recycling. Therefore, the sludge and garden waste co-composting have important strategic significance on environment protection and resources conservation.

Table 4 presents some of the main economic data for this solution. It is estimated that a total budget of 600,000–700,000€ could build up the specific unit as most of necessary buildings are already exist. The total capital investment is up to 450,000€, while the Sorting building and assess is up to 70,000€.

With the site prepared, infrastructure in place, and equipment requisitioned, attention must also be paid to the cost and logistics of the operation. The cost can be divided into five categories: equipment time, equipment maintenance, repair and replacement of parts, labor, and depreciation of assets. The operation includes receiving the sourced material, pre-processing (hand sorting of biggest wood and chipping green waste), forming windrows, tuning and watering windrows, monitoring the process, stockpiling the compost product, and troubleshooting (litter maintenance and adjusting the process elements). The total operational cost is estimated up to 50,000€.

Table 4
Economic data regarding the proposed scenario

Description	Cost in €	Comments
Area requirements for windrow system with mechanical aeration		At least 1,000 m^2
Capital Investment and site planning (CP)		
Aerator	80,000 (1 unit)	Self-contained loader attachment
Wood chipper/shredder/cutting machine for the bigger parts of the woods	50,000 (1 unit, 120 + hp commercial)	
Depot (pole barn facility)	150,000	At least 500 m^2
Tools and safety equipment	20,000	
Wind screen fence	5,000	
Other equipment like lorries, mixers	100,000	
Electromechanically parts (study and installations)	50,000	
Total CP	455,000	
Sorting building and access (SBA)		
Construction of surface from precast cast concrete	60,000	
Formation of the construction area	10,000	
Total SBA	70,000	
Overheads (10% of SBA and CP)	52,500	
Total CP + SBA + Overheads	577,500	
Operation cost (OC)		
Equipment: loader (with bucket or aeration)	Almost zero	(up to 20 h, or 2.5 d/week)
Labor (aerator and loader)	80 (4,160)	8 h (1 d/week)
Labor (chipper)	200 (10,400)	24 working h (2 d/week)
Operation supervisor	300 (15,600)	3 d/week
Maintenances	8,500	Up to 200 h per year
Parts(aerators or chippers, etc.)	5,000	
Overheads (10%)	4,500	
Total yearly OC	48,100	
Sludge collection	Zero cost as already is cover by the STP budget	
Green waste collection and transmit to the STP area	Zero cost as already those waste are collected with the other waste and disposed to landfilled site	Requires only to organized the collective days
Control room	Zero cost as can be used the existing control rooms of the STP	
Laboratory	Zero cost as already exist in the STP	

About the composting operations, the largest area will be open-sloped land, where the actual windrow will be established and turned. A chain link fence, serving as windscreen litter catch, will be constructed along the downwind side of the operations area. Inputs will be stocked in this area for the week. Once weekly, the bucket and loader will be used to create one or two new fresh windrow with stocked material. A buck wall at the real corner of the building will facilitate the bucket and loader in picking up the stocked material. These windrows will be approximately 2–2.5 m wide and up to 1.8–2.2 m high allowing them to be aerated. Spray bar will be used at the aerator rotor head, injecting (spraying) the water as the material is turned. The windrows will be turned at least once a week. As the temperature is critical parameter for composting as well as an indicator of the composting process, the operation supervisor will walk the operation area, measuring internal temperatures of the piles.

4. Conclusion

Urban wastewater systems, having sewer system, wastewater treatment plant, and receiving water as their main elements, can be found throughout the world. The present paper deals with the characterization of the DSS as well as a proposed treatment scenario are presented. Land filling is the main disposal route for sewage sludge at present in Cyprus. On the other hand, land filling generates potential environmental hazards, including the production of odor and methane gas, as well as contamination of groundwater by leachate.

The sludge almost 4,200 t/y is not presented with significant consecration of heave metals. However, the sewage sludge contains high concentration of organics and phosphorus and with father treatment like composting may be used in agriculture purposes. DSS presented with no significant ($p < 0.05$) concentration of heavy metals but presented with low concentration of humics, lignin, cellulose, and the Gemination Index (G.I.) are too low. For that reason the co-composting of sewage sludge with the green waste that is produced from the hotels that exist in the area seems very promising. This practice not only solves the disposal problem of sewage sludge and green waste of the area, but also achieves the sustainable material recycling. Therefore, the sludge and garden waste co-composting have important strategic significance on environment protection and resources conservation.

The total estimated cost for this solution will be up to 600,000€. This cost includes constructions, electronics, and typical equipment such as mixers, tacks, cutting machines, etc. This cost included the implementation of a windrow system with mechanical aerations. Operation cost for such a unit is up to 50,000€/year.

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