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TREATMENT OF SOME WASTES FOR THEIR UTILIZATION IN CULTIVATION AND ENVIRONMENTAL PROTECTION

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ABSTRACT

This investigation was conducted at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate and divided into two sections. The aim of the first section (during summer season 2003) is to study some chemical and biological characteristics of sewage sludge and treating of sewage sludge with drying beds, hydrate lime and composting with plant residues (rice straw, corn stalks and cotton stalks).The second section amis to study the effect of their application on some soil chemical properties and wheat yield under pot experiments during 2003-2004 winter growing season.

The important findings could be summarized as follows:-

- Improving sewage sludge by using drying beds, chemically by addition of 5% lime and biologically by composting with plant residue caused reduction in the soluble heavy metals contents and killing all pathogens (Fecal, strepto coliform) and *Salmonella & Shigella* .
- Application of different composting materials to the soil increased the EC values. The highest EC value (6.8 dSm^{-1}) was observed in case of 4% lime compost followed by 4% cotton compost(3.5 dSm^{-1}) .The highest pH value was also obtained in case of lime compost followed by cotton compost, corn compost, rice compost and sewage sludge compost, but all pH values were lesser than the control (8.81).The application of composting materials also increased the values of macro, micro-nutrients(N, P, K, Mn, Zn & Cu) and heavy metals (Pb, Cd & Ni) in soil after cultivation compared with control. The highest increase in trace elements was obtained with the soil treated by sewage sludge followed by the soil treated by plant residues.
- In wheat grains, the macro and micro elements content were influenced by different composted materials. The increase in NPK content in wheat grains could be arranged as following sequence: sewage sludge treatment > lime compost > plant residues compost. Similar results were obtained with wheat straw.
- Physiological parameters (total carbohydrate and protein in grains, and total chlorophyll in leaves) of wheat plant with all treatments were increased according to the following sequence: soil treated with sewage sludge > soil treated with lime compost > different compost materials (rice straw, corn stalks and cotton stalks).
- Values of plant height, , number of grains / spike, 100 grain weight, straw and grain yields were significantly increased in response to sewage sludge treatments compared with control. The highest growth parameters and yield components of wheat plants were obtained with 4% sewage sludge compost.
- Results show that, the uptake of the Egyptian adult per day of trace elements in wheat grains was in accordance with the critical levels of WHO (1996). Therefore, it could be concluded that concentration of all elements are within the normal range and not exceed the WHO limits.

INTRODUCTION

Due to the over increases of the Egyptian population(70 X 10^6) and development and urbanization of rural areas, as well as increasing in activities of the agriculture and industry , huge amounts of dry sludge as well as many million tones of crop residues are currently produced in Egypt (EPA, 1990). The disposal and / or recycling of sewage sludge is a problem facing municipalities throughout the world. Sewage sludge is very rich with easily decomposable organic matter and nutrient elements. Unfortunately, it contains a variety of trace consumers and pathogenic bacteria, potentially harmful to the plants and consumers. Safety utilization of sewage sludge must be carried out for a beneficial use to the crop without causing environmental problems associated with accumulation of trace elements and/or pathogenic bacteria in soil. For the safe use of sewage sludge in agriculture, it must be treated either with composting with plant residues or chemical treatment with lime. Lime is considered as sludge conditioner, dewatering and disinfectant agent depending on lime dose addition (Jeffery *et al.,* 1990).

The short term composting of sewage sludge with agricultural wastes is an appropriate alternative for straw management and sludge improvement. This type of compost after proper maturation acts as a soil conditioner and rich organic manure improves the biophysical conditions of the soil and helps to maintain the plant nutrients in available forms. Keeping this aim in view, the present investigation was planned to through the light on the following items:-

1- Evaluation of sewage sludge generated from Kafr El-Sheikh Waste Sanitary Station for the agricultural use.
2- Study the change of some chemical properties during composting period of sewage sludge with different plant residues (rice straw, corn stalks and cotton stalks).
3- Evaluate the effect of treated sewage sludge and compost on:
   a- Some chemical properties of tested soil.
   b- Yield and yield component as well as mineral content of wheat crop.

MATERIALS AND METHODS

This investigation was conducted at Sakha Agricultural Research Station during 2003 and 2004 years and divided into two sections. The first section aims to assess the chemical and biological characteristics of biosolid (sewage sludge) generated from Kafr El-Sheikh Waste Sanitary Station and treated sewage sludge by lime and plant residues during composting periods. The second section aims to studying the effects of these materials on wheat yield and some chemical properties of tested soil under pot experiments during 2003-2004 winter growing season.

The composite sample of aerobically digested sewage sludge (SS) collected from Kafr El –Sheikh sanitary Station. Some chemical and biological characteristics of used sewage sludge are given in Table 1 and Table 2.

Table 1: Chemical characteristics of sewage sludge of Kafr El-Sheikh Sanitary Station.

Variables		Values
pH(1:10 amendment/ water)		6.0
EC(1: 10 water- extract) dSm^{-1}		2.4
Cations (meq L^{-1})	**Na^+**	18.0
	K^+	1.5
	Ca^{++}	30.0
	Mg^{++}	15.0
Anions (meq L^{-1})	**CO^{--}_3**	0.7
	HCO^-_3	3.8
	Cl^-	17.0
	SO_4^{-}	43.0
Total macronutrients (%)		
	N	2.40
	P	1.64
	K	0.47
Organic matter (%)		55.1
Organic carbon (%)		32.0
C/N ratio		13.0
Available microelements, ppm (mg kg-1)		
	Mn	115.0
	Zn	344.0
	Cu	39.0
	Pb	25.7
	Ni	14.0
	Cd	0.7

Table 2: Biological characteristics of sewage sludge.

Biological characteristic	**Values**
Total coliform	2.75×10^5 / 100ml
Fecal coliform	4.5×10^5 MPN gm^{-1}
FS(CMPN x 100)	1.6×10^7 / 100cm3
Salmonella and Shigella	1.5×10^3 MPN gm^{-1}

MPN : most probable number

Plant residues (rice straw, corn stalks and cotton stalks) were collected from Kafr El-Sheikh Governorate. The plant residues were air dried, and then chopped for mixing with sewage sludge to form compost. Some chemical properties of used organic residues and lime are given in Table 3.

Sewage sludge drying beds:

Sewage sludge was placed on sand beds for air drying in sunlight for 6 months. Air drying requires dry and relatively warm weather for greatest efficiency.

Composted preparation:

- Samples of crop residues rice straw, corn stalks and cotton stalks were collected from Sakha Farm, spread to dry in air and finally chopped into about 2-4cm segments.
- Aerobic decomposition method was used in this study.
- Alternative layers from rice straw and sludge with each other to construct the pile. The same method was used for corn stalks and cotton stalks, so three piles were done. Another pile from sewage sludge treated by lime was done. The plant residues and lime were added at the rate of 10% and 5% by weight respectively, to the used sewage sludge.
- Some activation substances were added to active the biological decomposition.
- Optimum moisture content (50-60%) was maintained in three piles by moistening every week. For a reaction occur, the composted materials was turned over and pressed again every two weeks.
- Three samples of compost were taken during composting after 2, 4 and 6 months for chemical analyses.

Table (3): Chemical characteristics of plant residues and lime.

components	Rice straw	Corn stalks	Cotton stalks	Lime
Total organic carbon, %	29.04	29.21	25.85	-
Organic matter %	50.07	49.51.	44.57	-
Total nitrogen%	0.78	0.59	0.58	0.02
C /N ratio	37.23	57.96	52.54	-
Total phosphorous %	0.11	0.01	0.10	0.24
Total potassium %	1.47	2.09	1.79	0.27
Available Microelements,mgkg-1				
Cu	3.10	3.30	6.20	2.30
Zn	4.60	6.20	6.90	75.60
Pb	2.60	2.80	2.04	1.50
Cd	2.04	2.73	3.06	0.65
Ni	3.44	3.06	2.60	1.85

Soil of the experiment work:

Soil samples were collected from surface layers (0-30cm) of Sakha Agriculture Research Farm, Kafr El-Sheikh. Soil samples were air dried, crushed and passes through a 2 mm sieve and analyzed for chemical and physical characteristics (Table 4).

The soil analyses were attained according to the standard methods by Page (1982), and Richards (1954).

Experimental treatments were carried out as follows:

1- Application of recommended dose of NPK (control).
2- Application of sewage sludge to the soil at the rates of 1, 2 and 4%.
3- Application of rice compost (rice straw+ SS) to the soil at the rates of 1, 2 and 4%.

4- Application of corn compost (corn stalks + SS) to the soil at the rates of 1, 2 and 4%.
5- Application of cotton compost (cotton stalks+ SS) to the soil at the rates of 1, 2 and 4%.
6- Application of lime compost (lime+ SS) to the soil at the rates of 1, 2 and 4%.

Table (4): Some Chemical and physical properties of the experimental soil.

Variables	Values
PH(1:2.5 soil / water)	8.10
EC(soil Paste extract) ,dS m^{-1}	2.70
Cations, meq L^{-1} Na+	15.50
K^+	0.16
Ca^{++}	7.75
Mg^{++}	3.67
Anions (meq L^{-1} CO_3^{--}	-
HCO_3^-	1.75
Cl^-	9.30
SO_4^{--}	16.03
Available macro-nutrients, mg kg^{-1}	
N	31.00
P	9.70
K	320.00
Available micro-elements, mg kg^{-1}	
Mn	27.30
Zn	8.75
Cu	9.92
Pb	2.00
Ni	1.77
Cd	0.38
Bulk density, g cm^{-3}	1.26
SP (saturation percentage) %	77.90
Particle size distribution: Sand, %	21.55
Silt, %	23.23
Clay %	55.22
Texture class	Clayey

The presentation of the experiment planning is listed in Table (5).

Pot experiment design:

Five kilograms of studied soil were placed in each pot (30 cm in diameter and 40 cm high), 9 pots for each treatment according to the kind of organic wastes and 6 sub groups according to the application rates of sewage sludge and mixing ratios i.e. 1%, 2%and 4%.The tested treatments arranged randomly and statistical analysis factorial design was carried out according to Cochran and Cox (1960).

Wheat variety Sakha 8 was sown on 22nd November 2003 and after two weeks, each pot was thinned to 10 plants. The crop was harvested on 5thMay, 2004. The recommended doses of N, P and K fertilizer were added to the pots which treated with mineral fertilizers as follow:

Nitrogen fertilizer was applied as urea (46%N) at the rate of 75kg N / fed in two equal doses, the first dose before the post planting irrigation and the second dose before second irrigation.

Phosphorus fertilizer in the form of calcium super phosphate (15.5% p_2O_5) was added at 100kg P_2O_5/ fed. in one dose before planting.

Potassium fertilizer in the form of potassium sulphate (48%K_2O) at 50 kg K_2O / fed. was added in two equal portions at the same times of adding nitrogen fertilizer.

Table (5): presentation of the experiment treatments

Treatment	Abbreviation
Control(NPK, recommended)	C
Sewage sludge	SS
At rate 1%	SS 1%
At rate 2%	SS 2%
At rate 4%	SS 4%
Rice sewage sludge compost	RC. comp.
At rate 1%	RC. comp. 1%
At rate 2%	RC. comp. 2%
At rate 4%	RC. comp. 4%
Corn sewage sludge compost	CO. comp.
At rate 1%	CO. comp. 1%
At rate 2%	CO. comp. 2%
At rate 4%	CO. comp. 4%
Cotton sewage sludge compost	CT. comp.
At rate 1%	CT. comp. 1%
At rate 2%	CT. comp. 2%
At rate 4%	CT. comp. 4%
Lime treated sewage sludge compost	L. comp.
At rate 1%	L. comp. 1%
At rate 2%	L. comp. 2%
AT rate 4%	L. comp. 4%

Soil moisture was maintained around filed capacity. After maturity wheat plants were harvested and separated into grains and straw. The grains were dried at 70^{o}C and grounded to pass through a 20- mesh screen and kept for chemical analysis.

Growth, yield and yield components of wheat crop:

The agronomic studied parameters were: grain yield (g pot^{-1}), straw yield (g pot^{-1}), total dry matter (g pot^{-1}), 100 grain weight (g pot^{-1}), height of plant and number of grains spike^{-1}.

Representative dried samples of grains and straw yield were fine grounded and analyzed to determine N, P and K, micro nutrients contents, some heavy metals (Pb, Cd, Ni), protein and carbohydrates as well as total chlorophyll in leaves of plants.

At the end of experiment, the soil samples were thoroughly mixed for each treatment, air dried and kept for chemical analysis to determine soil pH, EC, soluble cation (Ca^{++},Mg^{++},Na^{+},K^{+})and soluble anions (SO_4^{-},CO^{--}_3, HCO_3^{-}

,Cl^-),macro-nutrients(N, P and K), micro-nutrients (Cu,Mn,and Zn) and heavy metals(pb, Cd and Ni).

Salinity, pH, soluble ions .available N, P and K, organic matter, Available trace elements of soil and sewage sludge were determined according to Page,(1982).

Plant residues (rice straw, corn stalks and cotton stalks) and wheat plant (grains and straw) were dried at 70^0C for 24 hours O.2 g of these oven dried samples (grains, straw) were wet digested in 5ml of H2SO4$_+$ 1 ml $HCLO_4$ (5:1) mixture according to the methods described by Chapman and Pratt (1961) .The different elements were measured according to Page, (1982).

Total nitrogen was determined for seeds and straw of wheat by modified kjeldahl method (Cottenie *et al.*, 1982). Determination of total phosphorus content of plant seeds and straw were carried out in digested materials calorimetrically (Snell and Snell, 1976). The total potassium was measured by flam photometric (Jackson, 1967). The trace elements and heavy metals were determined using atomic absorption (GBC Avanta g).

Culture media and procedures for bacterial counting (total coliform, fecal coliform and salmonella &Shigella) were prepared and determined according to Swaroop (1951) and Difco Manual, (1977).

Physiological characteristics of wheat plant:

Leaf chlorophyll content was measured using a portable meter according to Benedict and Swidler (1961).

Total carbohydrates:

Total carbohydrate was determined according to Doubias *et al.* (1956).

Nitrogen and total protein:

Nitrogen content was determined by modified Kjeldahl method using automatic kjeldahl model kejetic Auto Sampler System 1035 analyzer. The nitrogen content was multiplied by factor of 5.75 for wheat plant to obtain the protein content (A.O.A.C., 1980).

RESULTS AND DISCUSSION

1- Evaluation of sewage sludge generated from Kafr El-Sheikh Waste Water Sanitary Station for the agricultural use:

1-1 Heavy metals:

Data in Table (1) show that the overall values for available heavy metals in sewage sludge were 115mg/kg for Mn, 344mg/kg for Zn, 39 mg/kg for Cu, 25.7mg/kg for pb, 14 mg/kg for Ni and 0.7 mg/kg for Cd. For safety use of sewage sludge in agriculture guideline for permissible limits of heavy metals have been introduced in Egypt which were derived from maximum pollutant concentrations in sewage sludge as suggested by the Environment Protection Agency (EPA),commonly called (503 regulations).The EPA concentrations(ppm) were Cd=39, Cu=1500,pb=300, Ni=420 and Zn= 2800 (EPA, 1990).Comparing the concentration of heavy metal in sewage sludge used in current study with the limits of EPA, it can be stated that all heavy metals in sewage sludge were below the EPA limits by several orders of magnitude.

1-2 Pathogen:

Pathogenicity was one of the major concerns from use of sewage sludge. The most characteristics potential health hazards of biosolid was the wide range of pathogenic microbes carried in sewage. Wastewater sludge was known to contain pathogens bacteria, viruses, parasites and helminthes. According to EPA, (1993), the final rule contains specific pathogen reduction criteria

for sewage before it can be applied to agriculture land. The Egyptian degree for safety use of sewage sludge related to pathogens depends on standards of EPA.

Sewage sludge was designated as class A where use was allowed without restrictions. Criteria for class A sewage sludge includes fecal coliform density (in term of most probable number, MPN) of less than 1000MPN/g of total solids, or density of Salmonella bacteria less than 3MPN/4g of total solids. The class B pathogen standard was less than 2 million fecal coliform per gram of sludge.

Data presented in Table (2) show that fecal coliform density in the initial sewage sludge produced from Kafr EL-Sheikh Sanitary Station were $4.5x10^5$ MPN/gm of total solid and density of Salmonella and Shigella were $1.5x10^3$

MPN/gm of total solids. Comparing these data with the limits of pathogens suggested by EPA, it can be concluded that, sewage sludge used in the current study does not meet the EPA criteria for class A or class B. Therefore, to use this sludge in agriculture, it must be treated to minimize pathogen content. In this respect, Rezk (2003) stated that, the class B pathogen standard can be achieved by aerobic digestion, air drying, composting and lime stabilization. The results of different types of bacterial investigation in sewage sludge from Kafr El- Sheikh plant as affected by drying bed for six months show that no bacteria were detected after 2 , 4 and 6 months .

2- Change of some chemical properties during composting of sewage sludge and different plant residues (rice straw, corn stalks and cotton stalks):

Data presented in Tables (6) and (7) show that, organic matter contents of the three composts were decreased with composting time. The reduction was rapid during the first stage of composting. Organic matter contents continued to decrease, their reduction were 17.8, 15.5 and 11.7% for rice straw, corn stalks, and cotton stalks, respectively at the end of the composting period (180 days). Similarly, the carbon content was decreased by 21.7, 15.5 and 1.7% for rice, corn and cotton compost, respectively

Table (6): variation in some chemical properties of compost (SS and different plant residues) at different periods.

Compost type	Time (days)	pH	O.M. %	C %	Total N %	C/N ratio	Available P %	Available K %
Rice straw	0	5.0	63.63	36.91	1.30	28.40	0.33	0.22
	60	5.5	55.92	32.43	1.38	23.50	0.42	0.28
	90	5.5	53.11	30.80	1.68	18.33	0.46	0.33
	120	6.0	52.12	30.23	1.72	17.58	0.48	0.38
	180	7.0	49.82	28.90	1.72	16.80	0.48	0.41
Corn stalks	0	4.0	61.20	35.50	0.98	36.22	0.21	0.18
	60	5.0	57.40	33.29	1.12	29.72	0.30	0.23
	90	6.0	55.12	31.97	1.33	24.04	0.35	0.29
	120	6.0	53.91	31.27	1.56	20.04	0.40	0.32
	180	7.0	51.71	29.99	1.67	17.96	0.40	0.34
Cotton stalks	0	4.o	60.29	34.97	0.84	41.60	0.22	0.20
	60	4.5	57.89	33.58	1.01	33.25	0.30	0.25
	90	5.0	56.20	32.60	1.12	29.11	0.32	0.30
	120	6.o	54.10	31.38	1.34	23.42	0.39	0.34
	180	7.0	53.20	30.86	1.44	21.43	0.41	0.37
Lime	0	5.0	55.10	33.00	2.17	15.21	1.88	0.22
	180	10.0	50.20	28.50	0.96	29.69	0.36	0.40

Table (7): Chemical properties of different kinds of composts after compost period (180 days).

Compost type	pH	Total N %	Available macro , micro nutrients and heavy metals							
			P %	K %	Mn ppm	Zn ppm	Cu ppm	Pb ppm	Ni ppm	Cd ppm
Sewage sludge (SS)	6.00	2.47	1.64	0.47	115.00	344..00	39.00	25.70	14.00	0.70
Rice straw compost (RC.comp.)	7.00	1.72	0.48	0.41	59.00	172.00	17.50	11.00	7.00	0.52
Corn stalks compost (CO. comp.)	7.00	1.67	0.40	0.34	60.00	174.00	18.00	14.00	8.00	0.60
Cotton stalks compost (CT. comp.)	7.00	1.44	0.41	0.37	55.00	175.00	20.00	12.00	6.00	0.65
Lime compost (L. comp.)	10.00	0.96	0.36	0.40	40.00	120.00	9.00	6.00	5.00	0.30

On the other hand nitrogen content showed corresponding increases by 32, 70 and 71% for rice, corn and cotton compost, respectively. The final values of C/N ratio were 16.80, 17.96 and 21.43 respectively at the end of composting period. The reduction in C/N ratio was 40.8, 50.4 and 48.5% for rice, corn and cotton compost, respectively. The phosphorous content increased by 45.0 , 90.5 and 86.o% for rice, corn and cotton compost, and potassium content by 86.4, 88.9 and 85.0% for rice, corn and cotton compost, respectively at the end of composting period. Variation in chemical properties of lime compost at the end of composting time indicated that their contents were decreased by 8.9% for organic matter, 55.8%for nitrogen, 13.7% for carbon content and 80.9% for phosphorous. The results also showed that the increase in C/N ratio was 95.2% and 81.8% for potassium content at the end of lime composting period (Table 6).

The reduction in organic matter was attributed mostly to decomposition of easily degradable compounds in composts of plant residues such as protein, cellulose and hemicellulose, which were utilized by microorganisms as carbon and nitrogen sources. The reduction in C/N ratio may be due the gaseous loss of carbon as CO_2, a little amount of nitrogen lost as ammonia gas. However, the loss of carbon to CO_2 exceed the loss of N as NH_3 resulting in reduction of C/N ratio. This reduction in C/N ratio is in accordance with results obtained by Moharram *et al.* (1989).

Table 6 shows that P and K contents were slightly increased in composting materials. It may be attributed to bio-degradation of organic material released available P and K (Rynk *et al.*, 1992). Concerning lime compost, the results in Table 6 shoe that there were a clear losses in nitrogen content where the value of nitrogen was decreased by about 55% due to lime application. These losses in nitrogen may be due to ammonia release as affected by increase in pH. Liming the sludge caused reduction in its organic matter by 8.9%. This may be due to the acceleration of organic matter decomposition by added lime. These results were in agreement with Tayel *et al.*, (2002) who found that liming sludge decreased its organic matter content and soluble phosphorus content and heavy metals as Pb and Ni.

The initial pH values of composting usually recorded slight decrease during the first 2 or 3 days of aerobic composting due to the formation of some acids, then it tend to raise up to 8-9 towards the end of the process for organic plant residues compost. This rise in pH value led to precipitation of heavy metals (Table 7).

The present data show that pathogenic microorganisms such as Salmonella and Shigella, total coliform and fecal coliform disappear after two month from the composting. This may be due to their utilization by microorganisms through composting process or due to rising the temperature during composting process which reach 45-70^{o} C causing killing of all the pathogens as suggested by Jimenez and Garcia (1989), who found that the absence of some indicator pathogen microorganisms such as Salmonella which gradually disappears as nutrients were exhausted during the progress of maturation.

3- Effect of sewage sludge and compost on some chemical properties of tested soil after cultivation:

3-1 The effect on pH and EC values:

The obtained data in Table (8) show that, the EC values were increased in response to treatment of the soil with sewage sludge and compost. The values were higher in sewage sludge treatment than in compost treatment. The increases of EC were 22, 25 and

29% in case of 4% addition of rice compost, corn compost and cotton compost, respectively.

Table (8): Effect of sewage sludge and compost on some chemical properties of experimental soil.

treatments	EC dS/m	Soluble cations and anions,meq L^{-1}								PH	O.M %
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3	HCO_3	Cl^{-}	SO_4^{2-}		
Control											
	2.70	5.94	3.24	17.9	0.3	0	3.5	11.34	12.5	8.81	1.5
SS											
1%	3.61	7.97	4.33	24.4	0.40	0	3.0	15.16	18.2	7.81	1.9
2%	4.33	9.53	5.20	29.4	0.45	0	3.2	18.19	22.3	7.77	2.3
4%	5.84	12.1	7.48	38.6	0.60	0	4.0	24.21	30.5	7.60	2.8
RC-comp.											
1%	2.9	5.97	3.50	19.7	0.33	0	3.5	12.44	12.0	7.88	1.7
2%	3.0	6.00	3.70	20.0	0.38	0	3.7	13.10	14.0	7.86	1.9
4%	3.3	7.30	4.20	20.7	0.40	0	3.9	14.00	15.3	7.64	2.1
CO-comp.											
1%	2.99	6.00	3.70	19.0	0.34	0	3.6	12.7	12.7	7.90	1.75
2%	3.10	6.20	4.00	21.0	0.40	0	3.8	13.0	13.8	7.81	1.93
4%	3.40	7.10	4.80	22.0	0.41	0	4.0	14.0	16.1	7.71	2.20
CT-comp.											
1%	3.0	6.20	3.56	20.0	0.33	0	3.0	12.0	15.0	7.91	1.80
2%	3.3	6.45	4.80	20.8	0.39	0	3.2	13.7	16.0	7.88	1.95
4%	3.5	7.70	5.20	21.3	0.40	0	3.5	14.0	18.0	7.74	2.43
L-comp.											
1%	3.9	11.00	4.40	24.5	0.40	0	3.7	16.0	19.3	8.42	1.60
2%	4.5	13.00	5.20	27.0	0.48	0	4.0	19.0	22.0	8.60	1.90
4%	6.8	17.50	8.50	39.5	0.70	0	4.3	26.0	38.0	8.70	2.10

It could be observed that the highest values of EC were recorded in case of 4% addition of sewage sludge. This increase may be due to the high salt content in the used sludge (Table 1), as well as, the microbial mineralization of sewage sludge, which led to the release of the nutrients.

The reduction in the pH value of soil treated with sewage sludge compared with control may be due to nitrification (Mineralization) and production of organic acids (Koriem, 1993). Therefore, application of compost of plant residues resulted in reducing soil pH considerably, which considered as the most useful soil chemical property. Such reduction was affected by amount of added organic wastes. The values of pH were markedly reduced in all treatments. Treatment by lime showed a little decrease if compared to control, but it was higher than the values of pH in soil treated by sewage sludge only. This may be attributed to the release of ammonia (Bruce, 1984, Jeffery *et al.* 1990).

3-2 Effects on Soil Organic matter (O.M):

Data in Table (8) show that the values of organic matter for the tested soil were increased in response to different treatments. It could be arranged in the following sequence: plant residues compost > sewage sludge treatment > lime compost. This could be attributed to the presence of sewage sludge (its organic matter is high), which presented in all treatments. The differences in the obtained values could be attributed to the amount and type of the added materials**.**

3-3 Effect on macro, micro nutrients and heavy metals.

Data tabulated in Table (9) show increase in N, P and K in response to all treatments in comparison with the control. It could be observed that the increasing of SS level caused successive increase in macro and micro-elements contents. The highest value was observed in case of 4% sewage sludge treatment. The different increases could be arranged in the following sequence: sewage sludge treatment > plant residues compost > lime compost. The higher increases in different element contents were obtained by sewage sludge alone. It could be attributed to the reduction in pH value of the tested soil, which increases the level of the extractable metals.

The micronutrients (Mn, Zn and Cu) in tested soil have the same trend as macro-nutrients (Table 9).

3-4 Effect of sewage sludge and compost on heavy metals content of the used soil:

Data presented in Table (9) show clear increases in heavy metals content (Pb, Cd and Ni) in treated soil.

Table (9): Effect of sewage sludge (SS) and compost on element content of experimental soil after cultivation.

Treatments	Available elements (ppm)								
	N	P	K	Mn	Zn	Cu	Pb	Cd	Ni
C									
	16.2	9.1	320	26.68	8.72	9.23	0.62	0.35	o.40
SS									
1%	19.2	11.0	332	32.4	11.3	12.0	0.70	0.45	0.50
2%	21.4	14.0	350	36.3	14.9	14.5	0.82	0.60	0.61
4%	26.1	17.0	360	41.8	16.2	17.0	1.10	0.68	0.70
RC-compost									
1%	18.0	10.0	327	28.0	9.2	10.0	0.65	0.41	0.48
2%	19.0	11.9	339	30.0	10.0	12.0	0.71	0.51	0.58
4%	24.0	13.2	348	30.5	1.0	13.5	0.79	0.60	0.65
CO-compost									
1%	17.5	9.9	325	29.2	9.3	10.5	0.65	0.41	0.48
2%	18.0	11.0	330	32.0	1.2	12.0	0.71	0.51	0.58
4%	22.0	13.4	340	32.5	12.3	13.5	0.79	0.60	0.65
CT-compost									
1%	17.5	10.3	327	27.5	10.0	10.9	0.69	0.43	0.44
2%	17.9	12.0	335	29.0	12.5	12.3	0.70	0.52	0.56
4%	20.5	14.0	342	30.3	13.5	14.5	0.78	0.63	0.63
L-compost									
1%	18.0	10.4	328	27.3	9.0	9.7	0.63	0.38	0.43
2%	19.2	12.5	340	28.8	9.8	11.3	0.67	0.47	0.55
4%	24.2	15.0	349	30.0	10.5	12.0	0.71	0.55	0.60
Critical levels					300.0	100.0	100.0	3.00	50.00

***Critical levels according to Mingel and Kerkby (1987).**

The rise of heavy metals contents in response to the different treatments could be arranged in the following sequence: sewage sludge > organic residues compost > lime. The percentage of increase of heavy metals with 4% sewage sludge was 77%, 94% and 75% for Pb, Cd and Ni respectively. This led to reduction in pH as well as redox potential and consequently increases the availability of determined trace elements. These results are in good accordance with those obtained by Dixon *et al.* (1995), and Ma *et al.* (1997). Lime compost shows the lowest values of increase in heavy metal contents. This may be due to less amount of organic matter, the amounts of macronutrients and extractable heavy metals were less in lime compost than the other treatment. The percentages of increase in case of 4% lime compost were 14, 57 and 50% for Pb, Cd and Ni, respectively.

4- Effect of sewage sludge and compost on elemental composition of wheat grains and straw:

A perusal of Table 10 show increases in all studied elements content in wheat plant in response to the different treatments compared to the control (without any treatment) .Soil treated with sewage sludge gave the highest value of NPK in wheat grains. The increase in NPK content in wheat grains as affected by different treatments could be arranged as follows: sewage sludge> lime compost> plant residues. The percentage of increase in NPK in case of 4% sewage sludge was 64%, 55%, 53% respectively. It could be observed that, the increase in microelements (Mn, Zn and Cu) and heavy metals (Pb, Cd and Ni) could be arranged in the following sequence: sewage sludge treatment > plant residues compost > lime compost. The percentage of increase in available heavy metals in wheat grains in case of 4% sewage sludge were 70, 150, 93% for Pb, Cd and Ni respectively.

Table (10): Effect of sewage sludge (SS) and compost on element content in wheat grain.

Treatments	Elements								
	N (%)	P (%)	K (%)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Pb (ppm)	Cd (ppm)	Ni (ppm)
	C								
	1.4	0.45	o.49	16.20	35.42	12.o	0.41	0.10	0.31
	SS								
1%	1.9	0.50	0.60	19.23	50.20	14.2	0.45	0.15	0.40
2%	2.1	o.61	0.67	21.11	65.00	16.0	0.61	0.18	0.51
4%	2.3	0.70	0.75	24.00	70.60	19.0	0.70	0.25	0.60
	RC-comp.								
1%	1.70	0.48	0.53	17.70	43.00	13.0	0.43	0.13	0.35
2%	1.95	0.50	0.57	20.00	50.00	13.9	0.45	0.14	0.47
4%	2.oo	0.62	0.60	21.50	54.30	14.8	0.47	0.17	0.43
	CO-comp.								
1%	1.65	0.48	0.56	18.00	45.00	13.3	0.44	0.13	0.36
2%	1.73	0.49	0.60	20.20	51.00	14.2	0.48	0.15	0.43
4%	1.98	0.52	0.65	22.00	55.00	15.0	0.61	0.18	0.50
	CT-comp.								
1%	1.60	0.47	0.55	17.50	46.00	13.6	0.43	0.17	0.34
2%	1.70	0.48	0.59	19.80	55.00	14.9	0.47	0.16	0.40
4%	1.88	0.60	0.62	21.00	62.00	15.7	0.60	0.21	0.44
	L-comp.								
1%	1.72	0.49	0.57	17.30	39.00	12.7	0.42	0.11	0.32
2%	1.98	0.52	0.60	19.00	48.00	13.3	0.44	0.13	0.39
4%	2.00	0.63	0.66	19.80	50.00	14.2	0.48	0.16	0.43
Critical levels				200	200	20	20	10	20

***Critical levels according to Mingel and Kerkaby (1987).**

The percentage of increase in available heavy metals content in wheat grains with 4% lime compost were 17, 60, 38%for Pb, Cd and Ni, respectively. On the other hand, wheat straw showed the same trend (Table 11).

The superiority of sewage sludge over others may be due to the narrow C/N ratio. The values of micronutrients (Mn, Zn, and Cu) and heavy metals (Pb, Cd and Ni) in soil treated with compost were less than those of soil treated with sewage sludge alone. Such decrease was proportional to the reduced sewage sludge amount in the compost used and at the same time increasing the organic residues in their mixtures with sewage sludge. Also, this reduction may be due to the dilution effect of these organic residues and the raising potential effect of these wastes in soil pH.

Table (11): Effect of sewage sludge (SS) and compost on element content in wheat straw.

Treatments	Elements								
	N (%)	P (%)	K (%)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Pb (ppm)	Cd (ppm)	Ni (ppm)
	C								
	0.41	0.39	0.35	18.0	44.2	5.6	0.83	0.31	0,71
	SS								
1%	0.60	0.44	0.39	18.6	55.0	8.5	0.95	0.40	0.89
2%	0.75	0.48	0.42	19.8	62.0	10.2	1.10	0.51	1.00
4%	0.80	0.69	0.55	22.0	75.0	12.3	1.40	0.60	1.20
	RC-comp.								
1%	0.55	0.42	0.37	18.5	47.3	7.5	0.89	0.36	0.81
2%	0.70	0.43	0.39	18.9	50.0	9.4	0.92	0.41	0.85
4%	0.80	0.50	0.45	19.5	55.5	11.1	0.98	0.48	0.92
	CO-comp.								
1%	0.50	0.41	0.35	18.6	49.0	7.6	0.91	0.37	0.88
2%	0.66	0.42	0.37	19.5	53.0	9.7	1.00	0.43	0.90
4%	0.70	0.45	0.41	20.5	58.0	11.2	1.10	0.50	1.00
	CT-comp.								
1%	0.48	0.43	0.36	18.4	50.0	8.0	0.90	0.38	0.80
2%	0.65	0.45	0.39	18.5	56.0	9.9	0.95	0.45	0.89
4%	0.69	0.51	0.43	19.2	62.0	11.3	1.00	0.52	0.91
	L-comp.								
1%	0.55	0.44	0.38	18.0	47.0	7.3	0.85	0.53	0.76
2%	0.71	0.45	0.40	18.4	49.0	9.0	0.80	0.39	0.80
4%	0.82	0.56	0.50	19.1	53.0	10.5	0.96	0.46	0.90
Critical levels					**500**	**100**	**30**	**1.0**	**60**

Critical levels according to Mingel and Kerkaby (1987).

5. Effect of sewage sludge and composts on physiological parameters of wheat:

The physiological parameters in Table 12 show that, total carbohydrates of grain, total chlorophyll in leaves and total protein in grains were increased in response to the different treatments if compared with control. The increase in different measured physiological parameters could be arranged as follows: sewage sludge treatment > lime compost treatment > plant residues compost treatment.

Table (12): Effect of sewage sludge and compost on some physiological parameters of wheat plant.

Parameters / Treatments	Total Carbohydrates in grains mg/g	Total chlorophyll in leaves mg/g fresh weight	Total protein in grains %
	C		
	64.49±2	31.3± 1	8.05
	SS		
1%	70.94±3	35.5±2	10.91
2%	80.32±2	36.0±1	12.08
4%	83.00±2	38.0±2	13.25
	RC-comp.		
1%	66.2±2	33.7±2	9.75
2%	72.1±2	35.5±1	11.21
4%	76.9±2	36.0±2	11.50
	CO-comp.		
1%	**66.7±1**	**34.0±1**	**9.48**
2%	**73.7±1**	**36.0±1**	**9.94**
4%	**75.0±2**	**37.0±2**	**11.41**
	CT-comp.		
1%	67.2±1	34.6±2	9.20
2%	69.9±2	36.2±1	9.78
4%	72.2±1	37.0±1	10.81
	L-comp.		
1%	70.2±2	35.0±2	10.03
2%	80.1±1	37.0±1	11.41
4%	75.0±2	36.5±1	11.27

Mean ± standard deviation

In case of 4% lime compost treatment, the values of the physiological parameters showed small reduction if compared by 2%lime compost treatment. Thus, the increases of carbohydrates were 8%, 24 and 16% in case of 1, 2 and 4%lime compost treatment, respectively. The increases of total chlorophyll were 11, 18 and 16% and the increase of total protein percentages were 24, 41 and 40% in case of 1, 2 and 4% lime compost treatment, respectively.

This increase could be attributed to the activity increase of photosynthesis and nitrogen metabolism. The protein content of grain treated with 4% lime compost was reduced, it may be due to the salinity affect protein synthesis by including Na / K imbalance in leaves which was probably a factor for reduction of the protein content, because Na cannot replace K in its function in protein biosynthesis (Gibson *et al.*, 1984).

6- Effect of different treatments on growth parameters of wheat:

Data in Table 13 shows that plant height exhibited significant increases over the control as a result of sewage sludge application.

The highest plant height of wheat was obtained by 2% sewage sludge. The percentage of increase in plant height with 1, 2 and 4% sewage sludge were 4, 11 and 8% respectively. Number of grains spike^{-1} was highest in 4%

sewage sludge, resulted in 42 % increase. The percentage of increase in number of grains spike^{-1} in response to rice compost, corn compost, cotton compost and lime compost were 29, 32 30 and 27 %, respectively. The increase in 100 grain weight values could be arranged in the following sequence: lime compost >corn compost > rice compost. The highest wheat straw and grain yields were obtained in response to treatment with 4% of sewage sludge. The percentage of increase in straw yield as a result of 1, 2 and 4% sewage sludge were 8, 14 and 20%, respectively. The percentages of increase in grain yield were 49, 58 and 65% for 1, 2 and 4% sewage sludge application respectively.

Table (13): Effect of sewage sludge and compost on some growth parameters, yield and yield components of wheat plant.

Yield components Treatment	Plant Height,(cm)	No of grain/spike	100 grain weight,(g)	Straw Yield,g / pot	Grain yield, g / pot
SS (T)					
0%	58.33	28.07	1.70	26.83	13.33
1%	60.73	36.47	1.75	29.03	19.87
2%	64.75	38.47	1.80	30.61	21.17
4%	63.07	40.07	1.98	32.33	22.11
F-test	*	**	*	**	**
L.S.D.0.05	4.15	4.95	0.32	1.25	1.06
0.01	6.28	7.51	0.50	1.79	1.60
Comp. (C)					
0	63.96	33.00	1.77	32.01	20.12
RC.	61.11	36.44	1.58	28.22	18.89
CO.	61.23	37.06	1.72	28.55	18.30
CT.	61.55	36.63	1.71	28.62	19.14
L.	60.77	35.70	1.72	31.12	19.18
F-test	Ns	*	*	**	**
L.S.D. 0.05	-	2.46	0.13	0.91	0.69
0.01	-	3.30	0.17	1.22	0.93
Interaction T x Comp.	Ns	ns	*	**	ns

Ns: not significant ***: significant at 5% level**
****: significant at 1% level** **L.S.D.: Least significant difference**

This result is in good accordance with Radwan (1991) and Talha (1997), who reported that incorporation of different rates of sewage sludge into soil up to 4% caused a significant increase in all growth parameters of plant. This increase may be due to that sewage sludge is an important organic fertilizer containing high amounts of nutrients which help in growth successfully.

Wheat plants treated with plant residues composts and lime compost showed increase in growth parameters, which were less than the plant treated with sewage sludge. This may be due to that sewage sludge amount was decreased in compost combination. Our results are in agreement with Kaloosh (1994), who found that increasing the level of compost from 0 to 48 ton / ha. increased the length and weight of stem, root and nodules weight and seed yield of Faba bean(Vicia faba).

7- Heavy metals content of 170 kg grains of wheat plants grown on clay soil fertilized with sewage sludge and compost:

According to Heyne (1987) who reported that the Egyptian adult consumes about 170 kg of wheat grains per year, data presented in table 14 show the content of trace elements enter the Egyptian human at eating wheat grains cultivated in soil treated by sewage sludge and compost.

Table (14): heavy metals contents of 170 kg grains of wheat grown on clay soil fertilized with sewage sludge and compost.

Element / Treatments	Zn	Cu	Pb	Cd	Ni
	mg/ 170 kg grain				
C					
	6021	2040	69.7	17	52.7
	SS				
1%	8534	2414	76.5	25.5	68.0
2%	11050	2726	103.7	30.6	86.1
4%	12002	3230	119.0	42.5	102.0
	RC.comp.				
1%	7310	2210	73.1	22.1	59.5
2%	8500	2363	76.5	23.8	69.7
4%	9231	2516	81.6	28.9	73.1
	Co-compost				
1%	7650	2261	74.8	22.1	61.2
2%	8670	2414	81.6	25.5	73.1
4%	9350	2550	103.7	30.6	85.0
	Ct. compost				
1%	7820	2312	73.1	28.9	57.8
2%	9350	2533	79.9	27.2	68.0
4%	10540	2669	102.0	35.7	74.8
	L.compost				
1%	6630	2139	71.9	18.7	54.4
2%	8160	2261	74.8	22.1	64.6
4%	8500	2414	79.9	25.5	68.0

The concentration of the elements could be arranged in the following sequence: sewage sludge > different types of compost >lime compost.

It could be observed that, lime treated sewage sludge recorded the lowest concentration of trace elements taken by human per day, as shown in Table (15).

Table (15): The intake of human per day from heavy metals of wheat fertilized by sewage sludge and compost.

Element / Treatments	Zn	Cu	Pb	Cd	Ni
	Mg/ day				
	C				
	16.49	5.6	0.19	0.05	0.15
SS					
1%	23.4	6.6	0.21	0.07	0.19
2%	30.3	7.5	0.28	0.08	0.24
4%	32.9	8.9	0.32	0.12	0.28
RC.compost					
1%	20.0	6.1	0.20	0.06	0.16
2%	23.3	6.5	0.21	0.07	0.19
4%	25.3	6.9	0.22	0.08	0.20
Co.Compost					
1%	21.0	6.2	0.21	0.06	0.17
2%	23.7	6.6	0.22	0.07	0.20
4%	25.6	7.0	0.28	0.08	0.23
Ct. compost					
1%	21.4	6.3	0.20	0.06	0.16
2%	25.6	6.9	0.21	0.08	0.19
4%	28.9	7.3	0.27	0.10	0.20
L. compost					
1%	18.2	5.9	0.20	0.05	0.15
2%	22.4	6.2	0.21	0.06	0.18
4%	23.3	6.6	0.22	0.07	0.19

***Data calculated according to the heavy metals content in wheat grains and The Egyptian adult consumes about 170 kg of wheat grains / year (0.466 kg / day).**

Conclusion and Recommendations:

- The treatment of sewage sludge in Kafr El-Sheikh sanitary Station is not sufficient, thus it can not be used in agricultural purposes.
- Drying bed treatment was cheap and effective in the treatment of sewage sludge to minimize the present pathogens.
- Addition of plant residues (rice straw, corn stalks and cotton stalks) to sewage sludge (compost) could be considered a good method to reduce pollution and effective in agriculture for increasing the yield of wheat.
- Treatment of sewage sludge with lime could reduce the heavy metals content of sewage sludge.

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معالجة بعض المخلفات للاستفادة منها في الزراعة وحماية البيئة

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أقيمت تجارب بحثية بمحطة البحوث الزراعية بسخا / محافظة كفر الشيخ خلال الفترة٢٠٠٣ -٢٠٠٤ حيث قسمت التجارب إلى قسمين . استهدف القسم الأول(الفترة من أبريل ٢٠٠٣- سبتمبر ٢٠٠٣) ما يلي:-

١- تقييم الحمأة المستخرجة من محطة الصرف الصحي بكفر الشيخ كيميائيا وبيولوجيا.

٢- تقدير بعض الخواص الكيمائية للمخلفات النباتية المستخدمة في عملية الكمر مع الحمأ ة (قش الأرز ، حطب الذرة و حطب القطن) .

٣- تحسين الخواص الكيميائية والحيوية للحمأة عن طريق المعاملات التالية :

أ- استخدام أسطح التجفيف الرملية.

ب- المعالجة الكيميائية باستخدام الجير

ج- المعالجة البيولوجية (المكمورات) مع المخلفات النباتية السابقة .

أستهدف القسم الثاني من التجارب البحثية دراسة تأثير إضافة معدلات مختلفة من الحمأة المعالجة(سواء بالتجفيف أوالمعاملة بالجير أو المخلفات النباتية المختلفة بالكمر) على بعض الخواص الكيميائية للتربة المستخدمة وكذلك القياسات الإنتاجية لمحصول القمح (الموسم الشتوي ٢٠٠٣-٢٠٠٤).

يمكن تلخيص أهم النتائج التي تم التوصل إليها فيما يلي:

- انخفض محتوى الحمأة من العناصر الثقيلة كما تم قتل جميع الميكروبات الممرضة(ميكروبات التلوث البرازى – بكتيريا السلمونيلا والشيجلا). كنتيجة لمعالجة الحمأة باستخدام أسطح التجفيف والمعالجة الكيماوية بالجير (٥%) والمعالجة الحيوية باستخدام مخلفات المحاصيل المختلفة (بالكمر لمدة ١٨٠ يوم)
- ارتفعت قيم الملوحة بالتربة نتيجة الإضافات المختلفة من الحمأة حيث كانت أعلى القيم (٦,٨ ديسيمنز /متر مع التربة المعاملة بالحمأة المعالجة بالجير بمعدل ٤% ، يلي ذلك معاملة كمبوست الحمأة مع حطب القطن (٣,٥ ديسيمنز / متر) .
- اعلي قيم الحموضة والقلوية في التربة سجلت في الأرض المعاملة بكمبوست الحمأة مع الجير يلي ذلك كمبوست الحمأة مع حطب القطن يلي ذلك كمبوست الحمأة مع حطب الذرة ثم معاملة التربة بكمبوست الحمأة مع قش الأرز. في جميع الأحوال كانت القيم أقل من معاملة الكنترول.
- زاد محتوى التربة من العناصر الكبرى (النتروجين- الفوسفور البوتاسيوم) والعناصر الصغرى (زنك- نحاس- منجنيز) والعناصر الثقيلة (رصاص- كادميوم- زنك)كنتيجة للإضافات المختلفة للتربة من المواد المكمورة. أعلى القيم سجلت مع معاملة التربة بحمأة المجارى الجافة ثم الحمأة المعالجة بالكمر ، ويمكن ترتيب تأثير هذه المواد على محتوى التربة من العناصر كما يلي:
- معاملة حمأة المجارى > معاملة كمبوست الحمأة مع الجير > معاملة كمبوست مخلفات المحاصيل مع الحمأة.
- محتوى القش من العناصر السابقة اخذ نفس الاتجاه لتركيزات العناصر بحبوب القمح . * ارتفعت جميع قيم القياسات الفسيولوجية (الكربوهيدرات- والبروتين) في الحبوب وكذلك الكلوروفيل الكلى بأوراق نباتات القمح مع معاملة التربة بالمعاملات المختلفة لحمأة المجارى المعالجة مقارنة بالكنترول. يمكن ترتيب تأثير هذه المواد على النحو التالي: حمأة المجارى >الحمأة المعالجة بالجير >الحمأة
- المعالجة ببقايا المحاصيل المختلفة.
- سجلت زيادات معنوية لأطوال النباتات ، عدد الحبوب في السنبلة ،وزن المائة حبة وإنتاجية القمح من الحبوب والقش كنتيجة للاستجابة للإضافات من الحمأة المعالجة للتربة. سجلت أعلى النتائج عند معاملة التربة بحمأة المجارى بمعدل ٤%.
- تشير النتائج إلى أن الممتص من العناصر الصغرى والثقيلة للإنسان البالغ نتيجة استهلاك حبوب القمح سنويا أقل من الحدود الحرجة وذلك اعتمادا على مواصفات منظمة الصحة العالمية (١٩٩٦) وعلى أساس أن الفرد المصري يستهلك ١٧٠ كيلوجرامات من حبوب القمح في السنة.