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Impacts of Different Compost Types Application on Soil Fertility and Plant Growth

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Abstract: This study aims at evaluating the impacts of applying different compost types produced in Alexandria city on the soil and plant. Composting is the biological decomposition and stabilization of organic substrates**.** It is a means of converting objectionable wastes, such as sewage sludge, garbage, organic trash, food processing wastes and farm manures into materials suitable for application to land. Sandy soils and four types of compost with different rates were applied; composted sewage sludge**,** Composted domestic solid waste**,** composted plant residues, and composted animal manure**.** The Tested plant was Wheat (Giza 75). Pot experiments were carried out at lab. the results revealed that application of different types of compost to sandy soil cultivated with wheat plant increased soil salinity (EC), organic matter (OM), available nitrogen, and trace element (Fe, Mn, Zn, Cu, Cr, and Pb) contents while decreased pH and available phosphorus. As the soil treated with different compost types were enriched with macro and micronutrients, the fresh plants and oven-dried weights of the plants of treated soil were higher than those of plants of untreated control soil. It is clear that sewage sludge and domestic solid wastes composts application indicated a highest plant yield among other compost types. This study recommended Application of sewage sludge compost must be under special control, Application of domestic solid wastes could be used at the rate of 10 and 20% for sandy soil, plant residues compost could be applied on sandy soil, at the rate of 10% only for cultivation of all crops, and Application of animal manure compost could be applied at the range of 20-30% in case of sandy soil for all crops.

INTRODUCTION

Over the past 50 years, the disposal of urban wastes has become increasingly difficult problem [(1)]. Landfill has always been the most common disposal method and is likely to remain so, but when sites close to a city have been filled up additional expenditure is necessary to transport the wastes to more distant sites. Thus, it has become more and more important to discover treatment methods which reduce the volume of wastes to be accommodated on scarce landfill sites[(1)]. Composting can have permanent and far-reaching effects on the quality of the

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environment by removing large amounts of refuse from the waste stream, thereby reducing land filling and incineration of wastes(2). Haug(3) has described composting as the biological decomposition and stabilization of organic substrates, under conditions that allow development of thermophilic temperatures as a result of biologically produced heat, to produce a final product that is stable, free of pathogens and plant seeds, and can be beneficially applied to land. Composting is used also as a means of converting objectionable wastes, such as sewage sludge, garbage, organic trash, food processing wastes and farm manures into materials suitable for application to land (2).

The most commonly composted materials include those which are familiar to most people. Kitchen vegetable scraps, yard clippings and wastes from landscaping and farming activities. Most of these materials, with the exception of the most recalcitrant woods and leaves, are easily compostable in the personal backyard compost pile. On an industrial level, many communities are investigating roadside pickup, chipping of materials, and large-scale composting of green wastes in a municipal setting. Composting of biosolids or animal manures is a means of reduction or stabilization of wastes prior to utilization on land or disposal (4).

Compost as managing organic wastes, possess a low risk to the environment assuming it is free of heavy metals or hazardous organic materials(5); improves soil fertility whether in backyard gardens or reclaimed strip-mine soils; its product furnishes the soil with many of the rare elements essential for plant growth; it retains moisture and increases biological life in the soil; stimulates the rate of root growth; and it has relatively higher content of nitrogen, phosphorus and organic matter(6).

Wheat straw, corn stalks, maize cobs, brewer’s grains, seed meals, cotton hulls, sugarcane bagasse and other agricultural residues high in lignocelluloses can be composted in a fermentation reactor[7].The use of organic manure is recommended to substitute the chemical fertilization[8].

Raveendran *et al*.,[9] have found that addition of cow and chicken manures at different application rates increased total nitrogen in the 0-5 cm layer.

According to Mathew and Nair[10] the cattle manure applied alone or in combination with NPK fertilizers increased both available P and K in Indian rice soils. The importance of organic matter for agriculture in Egypt comes next to that of water. It is well-known fact that recycling organic waste materials for increasing agricultural production and reduces environmental pollution.

So, the aim of this study is to evaluate the impacts of application of different compost types produced in Alexandria City on the soil and plant.

MATERIAL AND METHODS

Sandy soils and four types of compost were applied; Composted sewage sludge**,** Composted domestic solid waste**,** composted plant residues, and composted animal manure**.** The Tested plant was Wheat (Giza 75). pot experiments were carried out at lab. Wheat planting took place on Nov. 15th 2003 at rate of 10 seeds/plot and thinned later to 4 seedlings. The soil pots received phosphorus-nitrogen-potassium fertilizers in the form of super-phosphate, ammonium sulfate and potassium sulfate at rates of 200, 120, 50 kg/ at the recommended doses.

One week before cultivation, the soils were mixed thoroughly with compost types by rates 10, 20 and 30% for each type. The treatments were replicated 4 times in a completely randomized block design.

Raw compost samples were chemically characterized before application according to WHO International Reference Center for Waste Disposal[11]. Soil samples were collected and physically and chemically analyzed according to methods of soil analysis[12] before and after the addition of different compost types with its different rates. The wheat plant samples were sampled after about 150 days from the planting date. Morphological Data including fresh, dry weight, and plant height were recorded. All the plant samples were dried and chemically analyzed according to Benton[13].

RESULTS DISCUSSION

1- Before application:

- **Characterization of the soils:**

Sandy soil had pH value (8.51), NH_4-N values (0.023 ppm), available P (2.27 ppm), and organic matter (0.075%). Regarding the heavy metals content, it was characterized by a high content of microelements especially Fe and Zn content.

- **Characterization of the compost:**

It was revealed that sewage sludge compost has the highest content of salinity (6.0 dS m^{-1}), available P (16.29 ppm) and available N in the form of NH_4 (0.237 ppm). Also, it has a high content of heavy and microelements. On the other hand, plant residues compost show a lower content of available N in the form of NH_4 (0.027 ppm) and microelements and heavy metals content.

2- After application:

- **Impacts on the soil Characterization:**

Soil pH

Generally, all different compost types with its different rates caused decrease in pH values as compared with control value for sandy soils. The reduction in pH agreed with Moreno *et al.*,[14] who attributed the reduction in pH results at the end of the growing season to the root exudates, the release of NH_4^+ and the nitrification process which take place during the course of plants growing period.

Narwell[15] reported that the reduction in pH results may be due to the release of organic acids, hydrogen ion ,and the increase in CO_2 as a result of the decomposition of organic matter. These results are in agreement with those obtained by Abou Bakr[16] who revealed that the soil treated with mature compost gives the lowest pH values.

Soil Salinity (EC)

The data revealed a relative increase in soil salinity as compared with control value (0.26 dS m^{-1}) in all compost applications. The highest value was obtained with animal manure compost at the rate of 30% (1.94 dS m^{-1}) as presented in table (6) and the lowest one was obtained with plant residues compost at the rate of 10% (0.28 dS m^{-1}) as presented in table (4).

Dahdoh and Hassan[17] showed the same results where increasing compost application rate increased the EC results and attributed that to the releasing substances from compost treatment which may directly or indirectly raised soil EC due to the microbial decomposition.

Logan *et al*.,[18] rendered the increasing in EC results to the combination of mineralization of composted organic matter (especially sewage sludge compost) and climatic effects.

Soil Cation and anion

Soluble form of Ca^{2+} increased proportional to the application rate of domestic solid wastes, sewage sludge and animal manure composts, having its highest values at 30% sewage sludge (9.23 meq/L).

Regarding Mg^{2+} concentration, it was higher than the control values for all compost types with different rates. Sandy soil detected highest Mg^{2+} value concentration at the rate of 20% added plant residues compost (3.95 meq/L, table 4), while the lowest value obtained at the rate of 20% added domestic solid wastes compost (2.03 meq/L, table 3). Na^{+} and K^{+} recorded higher values as compared with control value for all types of compost with different rate of application. The application of animal manure compost detected the highest values at the rate of 30% (16.52 and 9.98 meq/L) as presented in table 6. As for HCO_3^- and Cl^- concentrations, they reached highest values at 30% application rate of animal manure compost, being 5.88 and 10.25 meq/L, respectively (Table 6). On the other hand, their concentrations in plant residues compost reached the lowest value at 10% application rate for HCO_3^- (2.0 meq/L) and at the rate of 20% for Cl^- (4.88 meq/L), as compared with their control values (1.11 and 2.03 meq/L, respectively), Table (4).

The obtained results revealed that there was an increase in soil soluble cations and anions, except Ca, Na, and HCO_3 in some treatments and some rates. The increase in cation and anion concentrations may be due to their continuous release with the biodegradation of compost[17]. Abou El-Naga *et al*.,[19] agreed with the results of the current study and added that further amounts of available nutrients are released from the decomposed organic materials.

Soil mineral nitrogen

All compost applications resulted in increasing NH_4-N as compared with control value (212.5 ppm) at the different rates. The highest value obtained at the rate of 10% of plant residues and at the rate of 30% of sewage sludge composts (630.0 ppm), as recorded in Tables (4 and 5), while the lowest one was at the rate of 10% of domestic solid wastes compost (262.5 ppm), Table (3).

Regarding NO_2+NO_3-N, the highest value was at the rate of 30% of domestic solid wastes compost (145.0 ppm) compared with control value (95.0 ppm), Table (3), while the lowest value was recorded in animal manure compost application (42.5 ppm) which is the same at the three rates of application and lower than the control value, as presented in Table (6) and shown in Fig. (1).

The obtained increased results are in compliance with several investigators[20,21], who showed that the application of different organic materials increased the availability of soil macronutrients.

Soil available phosphorus

Table (5) recorded the highest value of available P in sewage sludge at the rate of 30% (5.76 ppm), as compared with control value (1.09 ppm), while Table (3) recorded the lowest one in domestic solid wastes application at the rate of 30% (1.80 ppm).

The increased results are in agreement with Abou El-Naga *et al*.[19], who stated that increasing organic manure addition increased nutrient availability in the soil due to further amounts of available nutrients released from the decomposed organic manure.

Soil organic matter

Application of plant residues, sewage sludge and animal manure composts increased soil organic matter with increasing application rates, reaching highest value (5.76%) at the rate of 30% of sewage sludge compost application (Table 5) compared with the control (1.09%). On the other hand, addition of plant residues compost caused the lowest value of soil organic matter at the rate of 10% (3.34%), but still higher than control value, as recorded in Table (4)

Also, Alaa El-Din[20] found that the application of different organic manures increased organic matter content of the soil. Sherif *et al*.,[22] indicated that increasing sludge addition rates increased organic matter content.

Heavy metals and micronutrients content

Obtained data revealed that sewage sludge compost treatment resulted in the highest increase in Cr, Pb, Mn and Cu concentration values at the rate of 30%, they were 48.0, 632.26, 1017,0 and 477.07 ppm, respectively as compared with its control values (5.0, 9.81, 35.13 and 7.13 ppm, respectively), as recorded in Table (5).

The same compost application caused another highest increase in Fe and Zn concentrations but at the rate of 20%, they were 6437.1 and 1883.13 ppm, respectively, compared with control values (495.0 and 92.94 ppm, respectively), as presented in Table (5).

On the other hand, application of domestic solid wastes compost had the lowest values of Cr at the rate of 10% (5.76 ppm) compared with control value (5.0 ppm) and Fe value at the rate of 30% (209.2 ppm) compared with control (495.0 ppm), this value is the lowest value among all treatments and also lower than the control value, as recorded in Table (3). Pb concentration reached the lowest value in plant residues compost application at the rate of 30% (12.25 ppm), as compared with control value (9.81 ppm), as in Table (4). The same application detected the lowest values of Zn and Cu among the other treatments at the rate of 10%, they were 241.07 and 17.07 ppm, respectively, compared with lower control value (92.94 and 7.13 ppm, respectively). Mn lowest value was obtained with animal manure compost application at the rate of 10% (45.13 ppm) compared with control value (35.13 ppm), as recorded in Table (6) and shown in Fig. (2).

These results explained that the Application of different compost types at the different rates resulted in increasing the soil content of measured elements greatly when compared with control soil content of heavy metals and microelements (except Fe and Cu in some applications).

The recorded concentrations of Pb, Zn, and Fe exceeded the normal limits of soil content (22-24 ppm, 48-69 ppm, and 200-1000 ppm, respectively) in some applications and were lower than the normal limits in other applications. Manganese contents were within that normal limit of the soil (709-1489 ppm). It was noticeable that Cu contents were lower than the normal content of the soil (5-5000 ppm).

The previously obtained high results are in accordance with those obtained by

Abdel-Latif and Abdel-Fatah[23], who found that the greatest value of Fe obtained in the soil treated with organic residues could be related to the higher Fe content and the lower pH values of such residues which play an important role in the extracted micronutrients. They also indicated that the decrease in pH and/or the C/N ratio increase of organic residues increased the extractable Zn.

Sherif *et al*.,[22] found that all measured elements, except Cu, Pb, and Cr increased after 120 days of cultivation. This may be due to the influence of dynamic soil microbial biomass that affects nutrient availability.

The obtained lower values of Cu in the present study are in agreement with those obtained by Logan *et al*.[18], who stated that it was possibly due to organic matter binding as organic matter decomposed.

Sherif et al.(22), also, found that the fraction of Cu added which was extracted with DTPA, was smaller than the extractability fraction of the other metals. This may be due to strong tendency of Cu to form complexes with various organic legends.

The decreased values of Fe with increasing compost application may probably be due to the biodegradation of compost which resulted in organic acids having functional groups that can complex this element[24] or due to the release of CO_2 which led to the formation of $Fe_2(CO_3)$[25].

- **Impacts on wheat plant characteristics**

1- Morphological characteristics

According to the measured parameters of fresh weight, dry weight, and plant height of wheat plants, data revealed that the highest values of these parameters resulted from the application of domestic solid wastes compost at the rate of 20% were 11.43 g, 10.08 g, and 47.75 cm, respectively, followed by the application of sewage sludge compost at the rate of 30% (6.76 g, 5.16 g, and 39.5 cm, respectively), as represented in Tables (7 and 8). While the lowest values were obtained with the application of animal manure compost at the rate of 10% (2.52 g, 2.29 g, and 27.25 cm, respectively) which were lower than the control values (4.87 g, 3.85 g and 34.25 cm, respectively), as presented in Table (8), and shown in Fig. (3).

The increased results of the morphological parameters of the current study are in agreement with Hyatt[26], who found that compost application increased crop yield compared with those from untreated control plots, and Bar Tal *et al*.[27], who found that dry matter produced from compost treatment (sewage sludge and cattle manure composts) was significantly greater than the untreated control.

Sewage sludge compost application produced a higher dry matter than animal manure application, so sludge was slightly more effective than the manure compost, as referred by Bar Tal *et al*.[27]

Engball *et al*.,[28] have substantiated the effect of manure on increasing crop dry matter due to the multifold functions of organic materials such as soil structure stabilizer, nutrient storage basin, and buffering agent for soil chemical reactions. Increased plant dry weight by sewage sludge compost compared to the control probably has been attributed to the release of N and P by mineralization. Sewage sludge compost application resulted in increased plant growth which agreed with Arisha and Abd El-Bary[29], who revealed a significant increase in plant growth parameters of spinach and pea due to sewage sludge addition compared to control. Such increase may be induced by higher concentrations of organic matter which, in turn, increases the microbial activity. Moreover, adding sewage sludge increases organic matter in soil which, in turn, increases the proportion of chelation of Mn, Zn, and Cu in the soil to 50, 88, and 98%, respectively.

2. <u>Total macronutrients content (NPK)</u>

Application of different compost types increased the total content of NPK of the plants (except K content with animal manure compost at the rate of 10% was lower than control value), as compared with its values of the control plants.

Nitrogen total content reached the highest value with domestic solid wastes compost application at the rate of 30% (2.78%) while the lowest values of total N were obtained with plant residues compost application at the rate of 10% (1.22%), as recorded in Table (7). Phosphorus total content was at the highest value with domestic solid wastes compost application at the rate of 20% (0.29%) and the lowest P content was obtained also with domestic solid wastes application but at the rate of 10% (0.15%), as recorded in Table (7).Total potassium content recorded its highest value with the application of domestic solid wastes compost at the rate of 20% (120.5%) as presented in Table (7). The lowest K value resulted with animal manure compost application at the rate of 10% (40.50%) which was lower than the control value of total K (42.5%), as recorded in Table (8). According to the previous results, the application of domestic solid wastes compost resulted in increasing all macronutrients content of plant to its highest values as compared with other composts applications, as shown in Fig. (4). These results were in harmony with those obtained by Abdel-Ghany[30] who clearly demonstrated that wheat yield increased greatly corresponding to organic matter residual effects and the favorable effects of treatments (manure, sludge, and garbage) on microbial activity, soil physical properties, and plant nutrients uptake, were all reflected in crop production.

Heavy metals content

In general, as compared with control values of detected heavy metals, all types of compost application at different rates increased its content inside wheat plants. The highest increase in Cr content was obtained with animal manure compost application at the rate of 10% (57.95 ppm), as presented in Table (8), while the highest increase in Pb and Zn was obtained with plant residues compost application at the rate of 30% (10.31 and 288.75 ppm, respectively), as presented in Table (7). Table (8) presented that sewage sludge compost application detected the highest increase in Fe content at the rate of 20% (1172.8 ppm) and Cu content at the rate of 30% (262.63 ppm). In case of application of domestic solid wastes compost, Mn content had the highest increase at the rate of 30% (67.56 ppm), as presented in Table (7). The lowest increase in Cr content was obtained with sewage sludge compost application at the rate of 30% (18.33 ppm), as recorded in Table (8), while the lowest values of Pb and Zn were obtained with domestic solid wastes compost application at the rate of 10% (2.70 and 81.38 ppm, respectively), as presented in Table (7). Fe content reached the lowest value with the application of plant residues compost at the rate of 30% (100.32 ppm), as detected in Table (7). In case of Mn content, the lowest value was obtained with the application of animal manure compost at the rate of 10% (22.07 ppm), as presented in Table (8). Cu content had its lowest value with plant residues compost at the rate of 10% (5.50 ppm), as presented in Table (7), and shown in Fig. (5). It is clear that the beneficial effect of organic amendments on lowering soil pH values and, consequently, increasing the availability of Fe, Mn, and Zn, beside the higher initial content of such nutrient in the applied organic wastes[31]. Sherif *et al*.,[22] also rendered Fe concentration decrease to the formation of complexes with organic matter which increased with increasing organic waste rates.

CONCLUSION AND RECOMMENDATIONS

Application of different types of compost to sandy soil cultivated with wheat plant increased soil salinity (EC), organic matter (OM), available nitrogen, iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), chromium (Cr), and lead (Pb) contents and decreased pH and available phosphorus.

As the soil treated with different compost types were enriched with macro and micronutrients, the fresh plants and oven-dried weights of the plants of treated soil were higher than those of plants of untreated control soil. It is clear that sewage sludge and domestic solid wastes composts application indicated a highest plant yield among other compost types. So the study recommended the following:

- Application of sewage sludge compost must be applied under special control (application with lower rate and to certain plants; e.g., trees and other uneaten crops).

- Application of domestic solid wastes could be used at the range of 10 and 20% for sandy soil.
- Plant residues compost could be applied on sandy soil, at the rate of 10% only for cultivation of all crops.
- Application of animal manure compost could be applied at the range of 20-30% in case of sandy soil for all crops.

Table (1): Physicochemical chemical characteristics of the used sandy soil.

Parameter	Unit	Value
pH		8.51
EC,	dSm^{-1}	0.25
TDS,	ppm	160.0
Ca^{2+},	meq/l	5.5
$Mg^{2+,}$	meq/l	1.0
Na^{+},	meq/l	1.0
K^{+},	meq/l	0.95
Cl^{-},	meq/l	1.85
HCO_3^{-},	meq/l	1.0
NH_4-N,	ppm	0.023
NO_3+NO_2-N,	ppm	0.011
Available P,	ppm	2.27
Organic matter,	%	0.075
Texture,	-	Sand
Cr,	ppm	2.1
Pb,	ppm	1.01
Cu,	ppm	40.0
Mn,	ppm	15.0
Fe,	ppm	70.0
Zn,	ppm	103.75

Table (2): Physicochemical characteristics of the four tested compost types.

Parameter	Unit	Domestic	Plant residues	Sewage sludge	Animal manure
pH		7.53	7.18	6.94	7.12
EC,	dS^{-1}	6.00	5.10	6.00	4.70
PO_4,	meq/l	8.50	7.96	16.29	7.75
NH4,	ppm-	0.039	0.027	0.237	0.064
NO_2+NO_3,	ppm	0.045	0.063	0.024	0.023
Cr,	ppm	1.575	0.99	7.39	3.735
Pb,	ppm	9.25	2.10	10.80	304.5
Fe,	ppm	118.5	98.00	735.5	273.5
Mn,	ppm	5.50	39.00	191.5	58.5
Zn,	ppm	76.45	33.10	770.25	234.55
Cu,	ppm	32.00	5.50	57.50	55.00

Table (3): Physicochemical characteristics and heavy metals concentrations of sandy soil after domestic solid wastes compost application.

Parameter	Unit	Control	Application rate (%)		
			10	20	30
pH		8.53 ± 0.1	8.03 ± 0.31	8.14 ± 0.1	7.81 ± 0.1
EC	$dS\ m^{-1}$	0.26 ± 0.05	0.36 ± 0.04	0.4 ± 0.04	0.93 ± 0.26
TDS	ppm	168.0 ± 30.6	232 ± 30.6	256.0 ± 26.1	665.0 ± 47.2
Ca^{2+}	meq/L	5.83 ± 0.69	6.13 ± 0.6	4.7 ± 0.47	8.15 ± 0.6
Mg^{2+}	" "	0.85 ± 0.19	2.75 ± 0.64	2.03 ± 0.33	2.75 ± 0.65
Na^{+}	" "	1.15 ± 0.23	1.82 ± 0.27	1.19 ± 0.11	1.7 ± 0.42
K^{+}	" "	1.01 ± 0.09	2.08 ± 0.11	1.05 ± 0.12	1.71 ± 0.15
HCO_3^-	" "	1.11 ± 0.27	2.63 ± 0.48	2.63 ± 0.48	2.25 ± 0.29
Cl^-	" "	2.03 ± 0.25	5.74 ± 0.6	8.43 ± 0.61	7.63 ± 0.62
NH_4-N	ppm	212.5 ± 23.6	262.5 ± 20.6	515.0 ± 51.96	247.5 ± 47.2
NO_2+NO_3-N	ppm	95 ± 30.0	110.0 ± 21.6	95.0 ± 19.14	145.0 ± 26.5
Available P	ppm	2.62 ± 0.16	2.18 ± 0.11	2.7 ± 0.03	1.80 ± 0.12
O.M.	%	1.09 ± 0.06	3.55 ± 0.24	3.84 ± 0.03	3.78 ± 0.20
Cr	ppm	5.0 ± 0.2	5.76 ± 0.34	16.56 ± 0.52	12.19 ± 0.24
Pb	ppm	9.81 ± 0.55	80.44 ± 0.59	120.38 ± 0.75	155.06 ± 0.32
Fe	ppm	495.0 ± 0.20	810.37 ± 0.48	922.25 ± 0.41	209.2 ± 0.71
Mn	ppm	35.13 ± 0.43	62.63 ± 4.26	90.81 ± 0.94	127.1 ± 0.59
Zn	ppm	92.94 ± 0.43	453.19 ± 0.24	539.69 ± 0.63	711.5 ± 0.74
Cu	ppm	7.13 ± 0.32	107.19 ± 0.38	117.32 ± 1.14	245.56 ± 1.30

Table (4): Physicochemical characteristics and heavy metals concentrations of sandy soil after plant residues compost application.

Parameter	Unit	Control	Application rate (%)		
			10	20	30
pH		8.53 ± 0.1	8.20 ± 0.08	8.10 ± 0.19	8.26 ± 0.10
EC	dS m^{-1}	0.26 ± 0.05	0.28 ± 0.03	0.36 ± 0.05	0.34 ± 0.06
TDS	ppm	168 ± 30.6	176.0 ± 18.5	232.0 ± 30.6	216.0 ± 40.3
Ca^{2+}	meq/L	5.83 ± 0.69	7.53 ± 0.52	5.88 ± 0.50	5.15 ± 0.31
Mg^{2+}	" "	0.85 ± 0.19	2.53 ± 0.45	3.95 ± 0.49	3.08 ± 0.30
Na^{+}	" "	1.15 ± 0.23	0.52 ± 0.06	1.04 ± 0.16	1.26 ± 0.08
K^{+}	" "	1.01 ± 0.09	0.27 ± 0.05	1.04 ± 0.09	0.60 ± 0.04
HCO_3^-	" "	1.11 ± 0.27	2.00 ± 0.40	2.25 ± 0.29	3.63 ± 0.62
Cl^-	" "	2.03 ± 0.25	5.08 ± 0.29	4.88 ± 0.25	8.06 ± 0.65
NH_4-N	ppm	212.5 ± 23.6	630.0 ± 35.59	437.5 ± 29.9	447.5 ± 27.5
NO_2+NO_3-N	ppm	95.0 ± 30.0	62.5 ± 15.0	90.0 ± 11.54	50.0 ± 14.14
Available P	ppm	2.62 ± 0.16	2.59 ± 0.05	2.33 ± 0.05	2.72 ± 0.04
O.M.	%	1.09 ± 0.06	3.34 ± 0.16	3.78 ± 0.11	3.83 ± 0.26
Cr	ppm	5.0 ± 0.2	9.56 ± 0.55	16.31 ± 0.31	16.93 ± 0.31
Pb	ppm	9.81 ± 0.55	15.2 ± 0.26	12.38 ± 0.32	12.25 ± 0.29
Fe	ppm	495.0 ± 0.20	402.19 ± 0.38	497.0 ± 0.54	507.0 ± 0.54
Mn	ppm	35.13 ± 0.43	62.5 ± 0.54	134.75 ± 0.54	190.31 ± 0.63
Zn	ppm	92.94 ± 0.43	139.38 ± 0.48	247.3 ± 0.75	313.38 ± 0.60
Cu	ppm	7.13 ± 0.32	10.07 ± 0.63	17.56 ± 0.52	15.25 ± 0.54

Table (5): Physicochemical characteristics and heavy metals concentrations of sandy soil after sewage sludge compost application.

Parameter	Unit	Control	Application rate (%)		
			10	20	30
pH		8.53 ± 0.10	8.39 ± 0.15	8.33 ± 0.07	8.42 ± 0.1
EC	dS m^{-1}	0.26 ± 0.05	0.45 ± 0.07	0.65 ± 0.04	0.73 ± 0.06
TDS	ppm	168.0 ± 40.6	288.0 ± 45.3	416.0 ± 26.1	464.0 ± 41.3
Ca^{2+}	meq/L	5.83 ± 0.69	5.45 ± 0.53	7.95 ± 0.61	9.23 ± 0.29
Mg^{2+}	" "	0.85 ± 0.19	2.63 ± 0.48	2.53 ± 0.38	3.28 ± 0.38
Na^{+}	" "	1.15 ± 0.23	1.25 ± 0.08	1.27 ± 0.03	1.64 ± 0.05
K^{+}	" "	1.01 ± 0.09	0.11 ± 0.03	0.17 ± 0.06	0.14 ± 0.05
HCO_3^-	" "	1.11 ± 0.27	2.25 ± 0.50	2.63 ± 0.47	3.13 ± 0.47
Cl^-	" "	2.03 ± 0.25	6.81 ± 0.23	6.94 ± 0.72	5.75 ± 0.86
NH_4-N	ppm	212.5 ± 23.6	545.0 ± 23.8	542.5 ± 45.0	630.0 ± 24.5
NO_2+NO_3-N	ppm	95.0 ± 30.0	110.0 ± 31.62	67.5 ± 15.0	60.0 ± 8.16
Available P		262.0 ± 0.16	2.19 ± 0.03	2.73 ± 0.16	7.33 ± 0.25
O.M.	%	1.09 ± 0.06	3.99 ± 0.09	4.27 ± 0.14	5.76 ± 0.07
Cr	ppm	5.0 ± 0.2	20.81 ± 0.63	25.38 ± 0.25	48.0 ± 0.54
Pb	ppm	9.81 ± 0.55	167.94 ± 0.43	337.21 ± 0.24	632.26 ± 0.37
Fe	ppm	495.0 ± 0.20	3296.88 ± 0.63	6437.1 ± 0.59	4510.31 ± 0.47
Mn	ppm	35.13 ± 0.43	334.94 ± 0.31	572.19 ± 0.38	1017.0 ± 0.43
Zn	ppm	92.94 ± 0.43	1018.43 ± 0.43	1883.13 ± 0.43	1621.19 ± 0.48
Cu	ppm	7.13 ± 0.32	176.88 ± 0.66	247.19 ± 0.38	477.07 ± 0.59

Table (6): Physicochemical characteristics and heavy metals concentrations of sandy soil after animal manure compost application.

Parameter	Unit	Control	Application rate (%)		
			10	20	30
pH		8.53 ± 0.1	8.04 ± 0.16	7.15 ± 0.32	7.66 ± 0.14
EC	dS m^{-1}	0.26 ± 0.05	0.60 ± 0.04	1.19 ± 0.23	1.94 ± 0.31
TDS	ppm	168.0 ± 30.6	384.0 ± 26.1	760.0 ± 153.2	1240 ± 201.3
Ca^{2+}	meq/L	5.83 ± 0.69	6.03 ± 0.21	5.45 ± 0.42	6.98 ± 0.62
Mg^{2+}	" "	0.85 ± 0.19	2.58 ± 0.43	3.88 ± 0.48	2.20 ± 0.24
Na^{+}	" "	1.15 ± 0.23	2.05 ± 0.11	8.07 ± 0.19	16.52 ± 0.49
K^{+}	" "	1.01 ± 0.09	1.21 ± 0.05	3.23 ± 0.30	9.98 ± 0.19
HCO_3^-	" "	1.11 ± 0.27	4.63 ± 0.47	4.5 ± 0.41	5.88 ± 0.75
Cl^-	" "	2.03 ± 0.25	7.25 ± 0.29	9.26 ± 0.59	10.25 ± 0.45
NH_4-N	ppm	212.5 ± 23.6	527.5 ± 35.9	442.5 ± 20.61	235.0 ± 40.4
NO_2+NO_3-N	ppm	95.0 ± 30.0	42.5 ± 12.6	42.5 ± 12.6	42.5 ± 12.6
Available P	ppm	2.62 ± 0.16	2.67 ± 0.01	2.36 ± 0.03	2.44 ± 0.04
O.M.	%	1.09 ± 0.06	3.68 ± 0.18	4.13 ± 0.15	5.18 ± 0.16
Cr	ppm	5.0 ± 0.2	6.06 ± 0.13	8.26 ± 0.30	7.6 ± 0.14
Pb	ppm	9.81 ± 0.55	20.12 ± 0.25	17.06 ± 0.43	12.56 ± 0.51
Fe	ppm	495.0 ± 0.20	255.13 ± 0.32	1057.1 ± 0.31	1356.9 ± 0.75
Mn	ppm	35.13 ± 0.43	45.13 ± 0.32	117.31 ± 0.24	202.1 ± 0.31
Zn	ppm	92.94 ± 0.43	241.07 ± 0.24	402.25 ± 0.68	517.56 ± 0.47
Cu	ppm	7.13 ± 0.32	17.07 ± 0.31	65.13 ± 0.32	87.19 ± 0.24

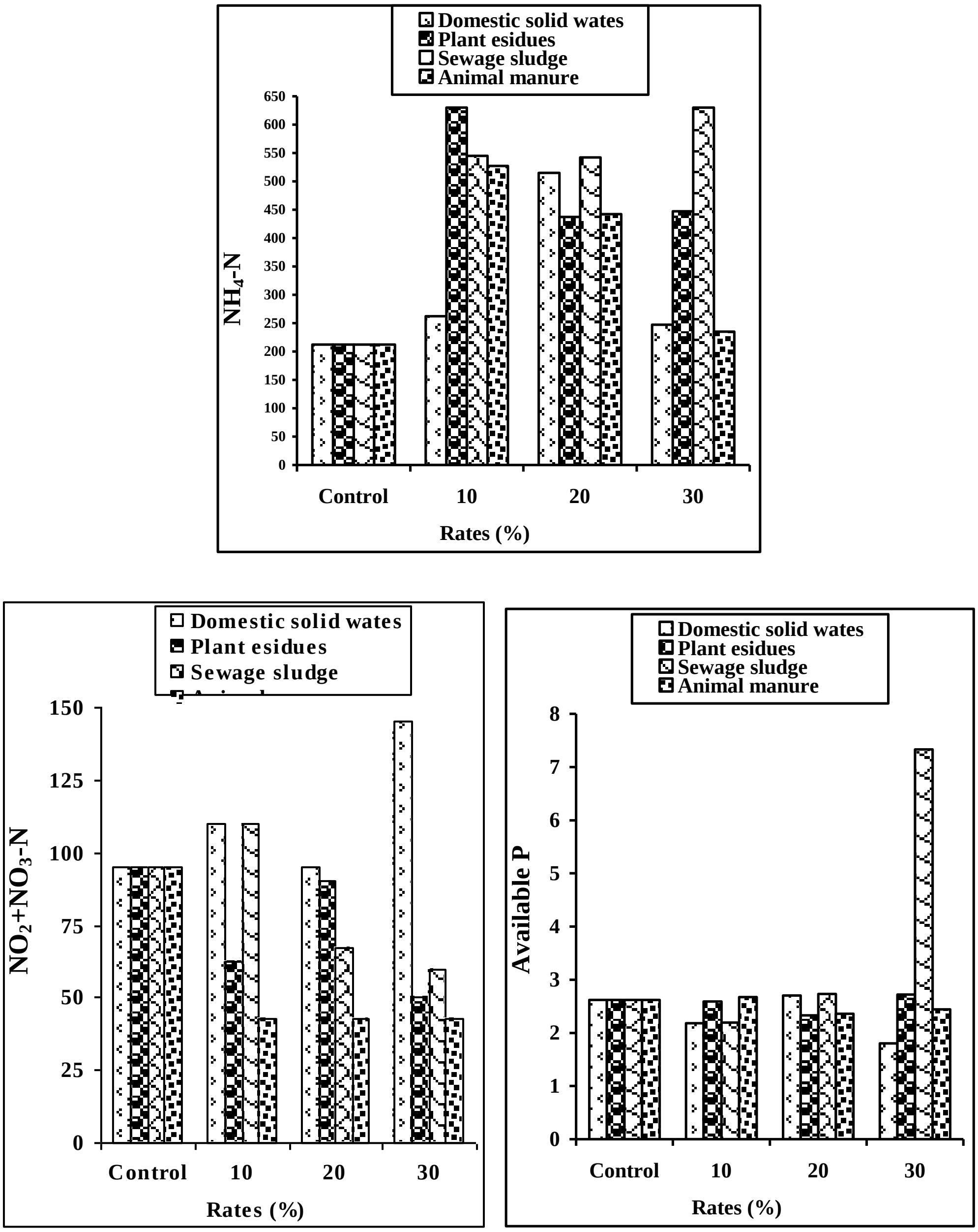


Figure (1): Available nitrogen and phosphorus concentrations (ppm) in sandy soil treated with different types of compost after wheat growing season.

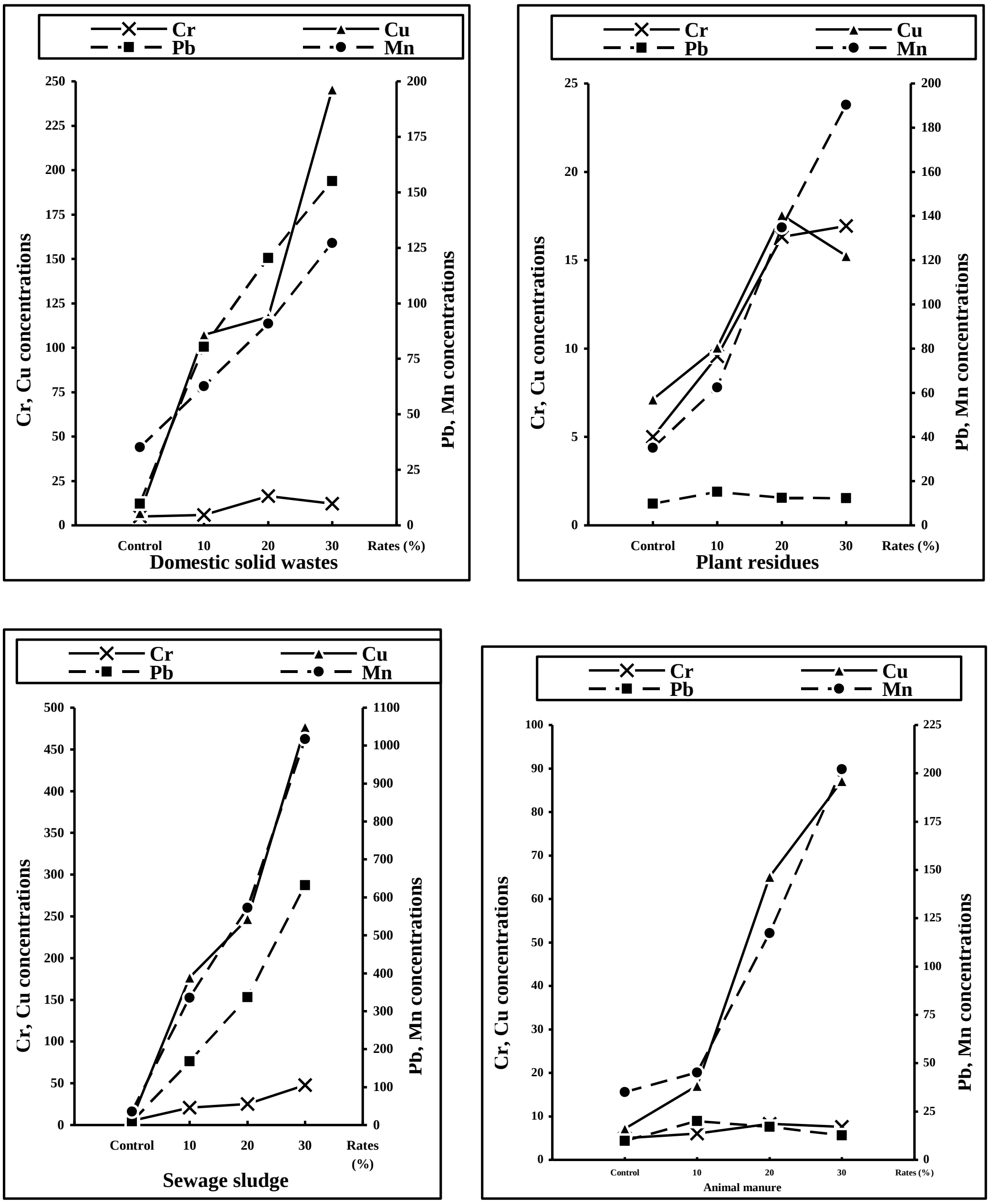


Figure (2): Heavy metal concentrations (ppm) in sandy soil treated with different types of compost after wheat growing season.

Table (7): Morphological characteristics of wheat plant and its contents of macronutrients and heavy metal after domestic solid wastes and Plant residues compost application.

Parameter	Unit	Control	Application rate (%)					
			Domestic solid wastes compost			Plant residues compost		
			10	20	30	10	20	30
Fresh weight	(g)	4.87 ± 0.10	6.51 ± 0.03	11.43 ± 0.04	10.62 ± 0.04	5.21 ± 0.02	6.31 ± 0.03	5.26 ± 0.03
Dry weight	(g)	3.85 ± 0.10	5.22 ± 0.22	10.08 ± 0.08	9.38 ± 0.15	4.19 ± 0.02	5.23 ± 0.05	4.13 ± 0.14
Plant height	(cm)	34.25 ± 1.71	38.5 ± 1.91	47.75 ± 2.21	46.5 ± 1.91	28.25 ± 1.26	36.75 ± 1.63	36.00 ± 1.25
Total N	(%)	1.03 ± 0.016	1.39 ± 0.025	2.10 ± 0.016	2.78 ± 0.049	1.22 ± 0.02	1.39 ± 0.034	1.26 ± 0.02
Total P	(%)	0.10 ± 0.017	0.15 ± 0.018	0.29 ± 0.012	0.16 ± 0.039	0.20 ± 0.025	0.23 ± 0.024	0.25 ± 0.03
Total K	(%)	42.5 ± 2.08	56.25 ± 1.71	120.5 ± 1.73	96.0 ± 2.58	63.25 ± 2.22	50.50 ± 2.38	103.0 ± 6.48
Cr	ppm	14.83 ± 0.64	28.38 ± 0.43	45.63 ± 0.32	50.25 ± 0.20	33.14 ± 0.49	42.69 ± 0.54	51.19 ± 0.24
Pb	ppm	2.56 ± 0.31	2.70 ± 0.74	5.0 ± 0.20	7.31 ± 0.24	4.63 ± 0.48	7.50 ± 0.54	10.31 ± 0.47
Fe	ppm	95.44 ± 0.97	122.5 ± 0.41	147.25 ± 0.35	552.38 ± 0.25	280.0 ± 0.41	385.75 ± 0.64	100.32 ± 0.80
Mn	ppm	21.63 ± 0.32	35.38 ± 0.66	42.81 ± 0.47	67.56 ± 0.31	32.63 ± 0.63	40.75 ± 0.35	50.44 ± 0.59
Zn	ppm	75.38 ± 0.66	81.38 ± 0.32	172.69 ± 0.59	193.5 ± 0.73	90.81 ± 0.69	158.75 ± 0.73	288.75 ± 0.65
Cu	ppm	2.56 ± 0.13	16.63 ± 0.52	37.63 ± 0.43	72.25 ± 0.46	5.50 ± 0.54	7.31 ± 0.43	15.19 ± 0.24

Table (8): Morphological characteristics of wheat plant and its contents of macronutrients and heavy metal after sewage sludge animal manure compost application.

Parameter	Unit	Control	Application rate (%)					
			Sewage sludge compost			Animal manure compost		
			10	20	30	10	20	30
Fresh weight	(g)	4.87 ± 0.10	6.22 ± 0.03	4.62 ± 0.04	6.76 ± 0.04	2.52 ± 0.02	4.79 ± 0.02	8.45 ± 0.03
Dry weight	(g)	3.85 ± 0.10	5.11 ± 0.07	3.05 ± 0.04	5.16 ± 0.04	2.29 ± 0.06	3.68 ± 0.02	7.31 ± 0.03
Plant height	(cm)	34.25 ± 1.71	38.25 ± 2.09	37.0 ± 1.83	39.50 ± 1.71	27.25 ± 2.21	34.0 ± 0.95	36.75 ± 2.21
Total N	(%)	1.03 ± 0.016	1.57 ± 0.043	1.75 ± 0.02	2.15 ± 0.057	1.41 ± 0.015	1.81 ± 0.029	1.72 ± 0.022
Total P	(%)	0.10 ± 0.017	0.22 ± 0.023	0.27 ± 0.02	0.17 ± 0.025	0.19 ± 0.014	0.21 ± 0.019	0.25 ± 0.026
Total K	(%)	42.5 ± 2.08	64.0 ± 1.63	90.75 ± 1.71	51.50 ± 1.91	40.50 ± 2.08	51.0 ± 0.82	58.0 ± 1.83
Cr	ppm	14.83 ± 0.64	27.24 ± 0.30	42.06 ± 0.13	18.33 ± 0.25	57.95 ± 0.29	53.5 ± 0.20	25.31 ± 0.43
Pb	ppm	2.56 ± 0.31	7.50 ± 0.40	4.89 ± 0.22	5.0 ± 0.61	5.0 ± 0.39	2.89 ± 0.58	7.5 ± 0.41
Fe	ppm	95.44 ± 0.97	347.5 ± 0.82	1172.8 ± 0.74	687.88 ± 0.48	176.88 ± 0.63	285.31 ± 0.37	322.3 ± 0.89
Mn	ppm	21.63 ± 0.32	47.38 ± 0.66	67.13 ± 0.32	55.0 ± 0.41	22.07 ± 0.31	27.38 ± 0.43	35.13 ± 0.25
Zn	ppm	75.38 ± 0.66	192.69 ± 0.63	201.56 ± 0.89	252.69 ± 0.77	118.31 ± 0.52	100.5 ± 0.35	132.63 ± 0.66
Cu	ppm	2.56 ± 0.13	70.32 ± 0.75	109.94 ± 0.43	262.63 ± 0.63	45.44 ± 0.59	55.19 ± 0.43	104.94 ± 0.13

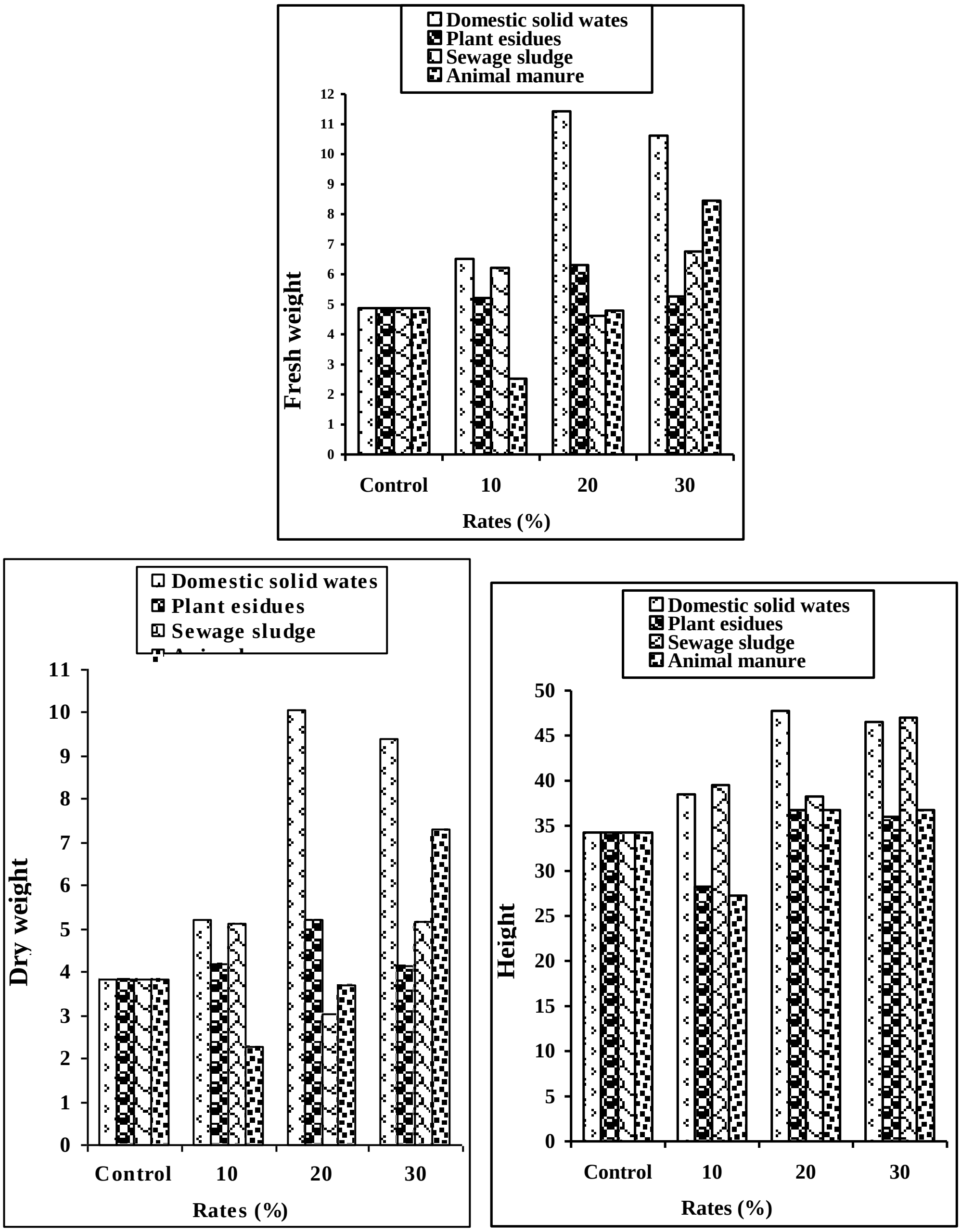
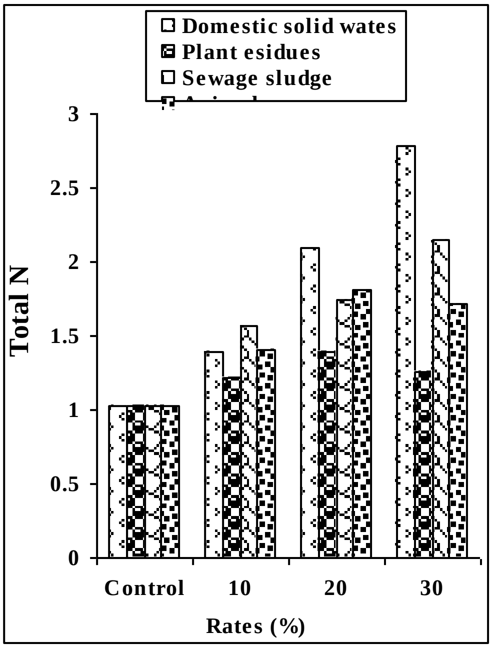
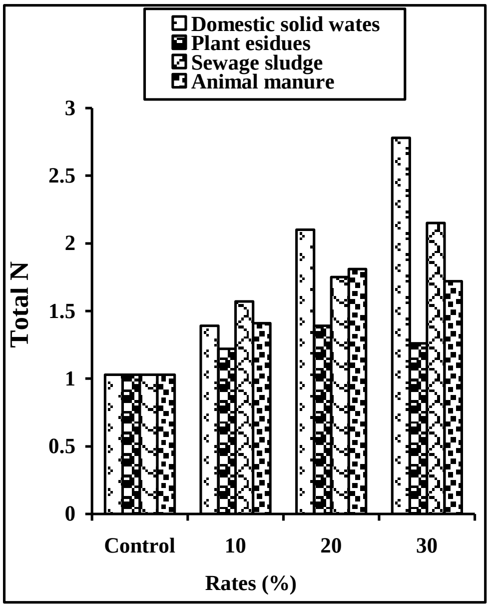


Figure (3): Morphological parameters of wheat plants grown on sandy soil treated with different types of compost





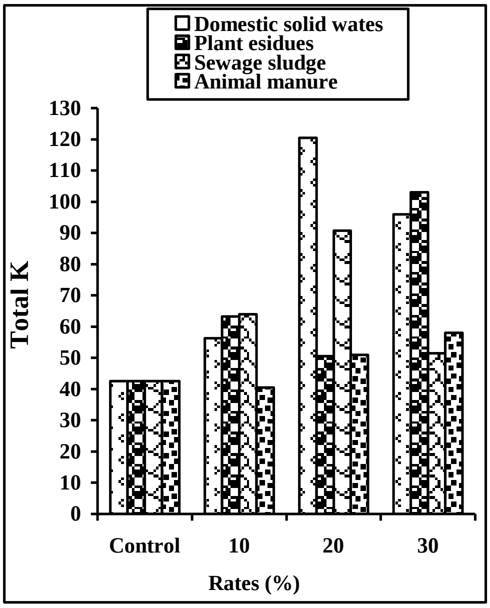


Figure (4): Total contents of N, P, K of wheat plants grown on sandy soil treated with different types of compost.

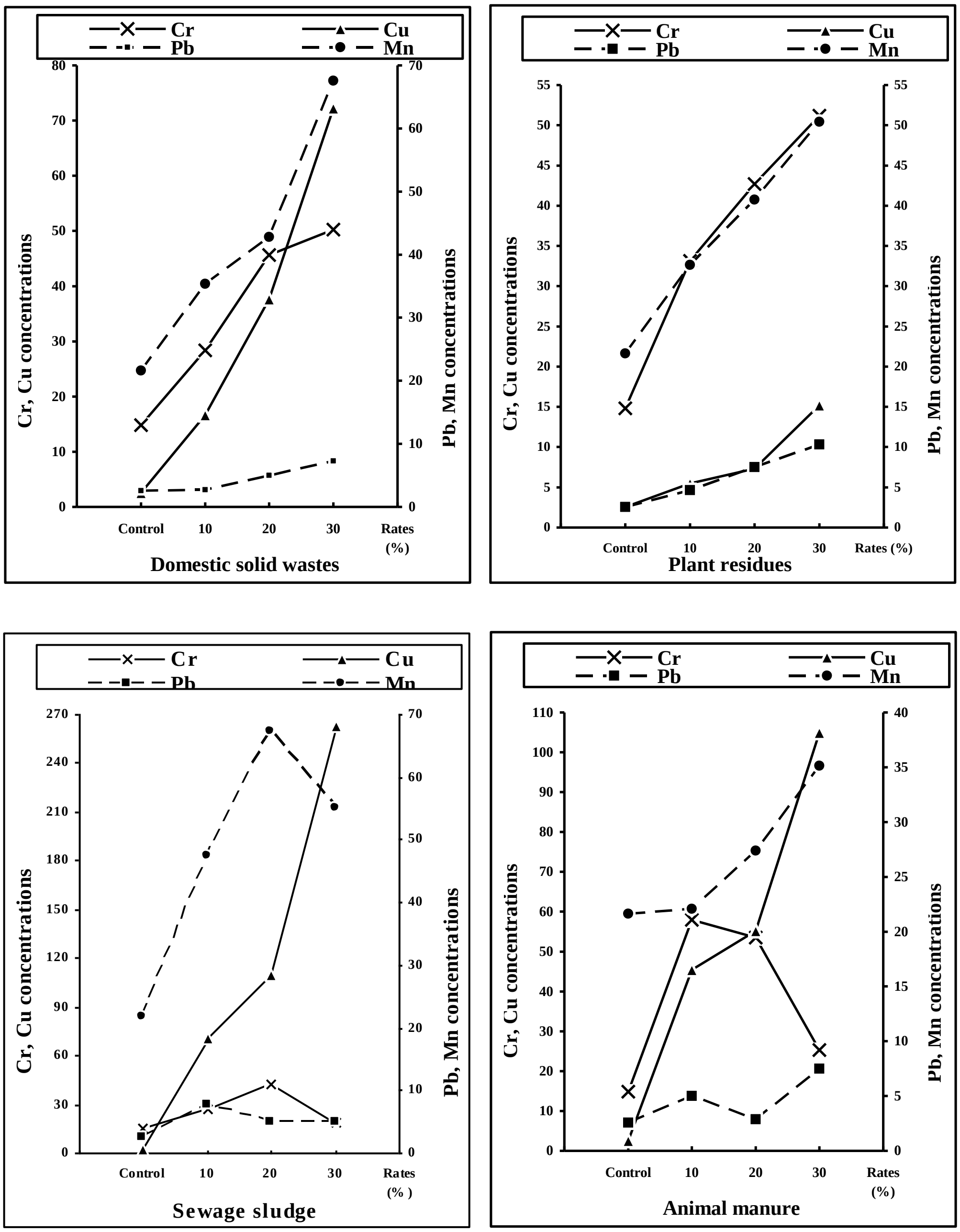


Figure (5): Heavy metal concentrations (ppm) in wheat plants grown on sandy soil treated with different types of compost.

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