Journal of Environmental Science and Technology

ISSN 1994-7887

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Environmental Science and Technology 2 (1): 63-67, 2009
ISSN 1994-7887
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Analysis the Plant Nutrients and Organic Matter in Textile Sludge in Gazipur, Bangladesh

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Abstract: The present research was carried out to determine the content of essential macro nutrients (N, P, K and S) as well as Fe, total organic carbon and total organic matter in textile sludge of Apex Weaving and Finishing Mills Ltd., Gazipur, Bangladesh and assess its possibility to use as a soil conditioner or fertilizer in agricultural land. The results revealed that plant macro nutrients Nitrogen (N), Phosphorous (P), Potassium (K) and Sulphur (S) were found in significant amount compared to some commonly used organic manures. The range of various macro nutrients was 1.53-2.37, 0.09-0.14, 0.11-0.17 and 2.69-3.42% for N, P, K and S, respectively. The concentration of iron (19.52%) was also very high in the sludge than that of in soil. Moreover; total organic carbon (19.89%) and total organic matter (34.67%) were abundantly available in sludge. In addition, thermal study explores that after 400°C the sludge was thermally stable and it was also confirmed by IR study that dried sludge samples showed significant presence of water at room temperature while the samples heated up to 400°C, the presence of water was barely indicated.

Key words: Waste management, macro nutrients, organic manure, textile waste

INTRODUCTION

The pollution of natural waters with textile waste effluents has become a serious problem in Bangladesh, as industrial growth and development have been on a very large scale. It is also reported that textile and dyeing factories in the world pose a major environmental threat because of the large amounts of water and dyes involved in the manufacturing process (Abd El-Rahim *et al*., 2008; Ranganathan *et al*., 2007). Environmental pollution caused by textile wastewater results in adverse effects on flora, fauna and the general health of the residents of surrounding industrial area. Usually the textile effluents contain highly toxic dyes, salts, acids, alkalis and bleaching agents. Heavy metals like cadmium, copper, zinc, chromium and iron are also found in the dye effluents (Mathur *et al*., 2005). Determination of toxic contaminants in sludge is essential as it provides information on the actual risk relating to the presence of the contaminants; their potential degradation or accumulation by organisms and plants as well as their migration deeper into the soil profile (Oleszczuk, 2008; Marian *et al*., 2005).

Although characteristics of sludge depend on the wastewater treatment process and sludge stabilization methods, it is rich in organic compounds and plant nutrients (Hua *et al*., 2008; Teixeira *et al*., 2007). Plant nutrients such as nitrogen, phosphorus and organic material are very abundant in sludge could be regard as soil improvers and replace conventional fertilizer in agricultural production (Luostarinen *et al*., 2008; Gupta and Garg, 2008; Casado-Vela *et al*., 2006).

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The present study investigated the possibility to use sludge in agricultural land as a fertilizer since it can improve the physical, chemical and biological properties of soils which may enhance crop growth. In addition, the use of sludge as a fertilizer would decrease the amounts of chemical fertilizers needed in agriculture and sludge use in agriculture could help to save non-renewable materials or energy, a pre-requisite to achieve sustainable production.

MATERIALS AND METHODS

The eight sludge samples were collected from Apex Weaving and Finishing Mills Ltd., Gazipur, Bangladesh. The samples were collected from the industry's different sludge treatment plants from 5th to 7th April, 2004. Collected sludge samples were dried in an oven at about 110°C for 8 h and then the samples were ground by grinding motor and again dried till constant weight was obtained. Then the dried samples were powdered and sieved through a 0.5 mm sieve. The samples were carefully labeled and kept for analysis.

Aqua-Regia (9 mL HCl and 3 mL HNO_3) was added to the powdered sludge of each sample and heated on sandbath nearly to dryness. After cooling at room temperature, deionized water was added to the samples and was filtered through a filter paper (Whatman No. 42). The filtrate was collected in a measuring flask and was preserved for the determination of iron.

For the determination of sulphur, potassium and phosphorous, concentrated HNO_3 (10 mL) was mixed with the sludge samples and heated nearly to dryness. Then 5 mL of $HClO_4$ was added to the beaker and it was again kept on a hot plate until the mixture was almost dried. When the color turned into white then 15 mL of deionized water was added and mixed thoroughly. The suspension was filtered through a filter paper (Whatman No. 42) and was preserved for the test.

Iron determination was carried out by hydroxylamine and with 1, 10 phenanthroline at pH 3.2 to 3.3. A pH between 2.9 and 3.5, rapid color was formed in the presence of an excess phenanthroline and the reddish-orange iron (II) complex absorbs at 515 nm (Greenberg *et al*., 1998). Phosphorus test was performed by vanadomolybadate reagent (Walsh, 1971) and the absorbance was taken at wavelength of 470 nm. By flame photometry method, potassium was determined at wavelength 766 and 769 mμ (Walsh, 1971). For sulphur, digested sample (1 mL) was taken in the measuring flask followed by 1 mL of 6 N HCl and 3 mL of $BaCl_2$-Tween solution. Then the absorbencies of the samples were taken in between 30 and 45 min at 420 nm wavelength (Walsh, 1971). For each determination, same experiment was also done for standard solutions and blank tests were also done by using blank digest. With these values, each calibration curve was constructed against known concentrations. The concentrations of Fe, K, P and S were found from the graphs by putting the absorbance of these samples.

Kjeldahl Method was employed for the measurement of total nitrogen and Total Organic Carbon (TOC) was estimated by weight loss (dry) method. For Total Organic Matter (TOM), oxidation with potassium dichromate method was followed. In thermo-gravimetric analysis, sludge was heated at different temperatures in a muffle furnace for 4 h from 60 to 200°C at an interval of 20°C and from 200-600°C at an interval of 50°C. FT-IR spectra (Shimadzu FTIR DR-8001) were also taken of the sludge at room temperature (25°C) and heated at 200, 400 and 600°C.

RESULTS AND DISCUSSION

The range of phosphorous and potassium in the sludge samples was 873.36-1413.57, 1083.68-1713.41 mg kg^{-1} and the percentage of P and K were 0.09-0.14 and 0.11-0.17%, respectively (Table 1). The results were nearly similar to the potassium and phosphorous content of some organic manure as shown in Table 3. However, commonly used chemical fertilizers like Triple super phosphate (20%), super phosphate (8%) and diammonium phosphate (20%) contain high concentration of phosphorus. Similarly, muriate of potash (50%), potassium sulphate (42%) contained high concentration of potassium in Table 2. The average amount of nitrogen in the sludge samples was 1.99%. This result revealed that the average concentration of nitrogen in sludge samples was approximately similar to that of some organic manure as shown in Table 3. But Table 2 shows that commonly used chemical fertilizers like urea, ammonium sulphate and diammonium phosphate contained extremely higher concentrations of nitrogen than that of in the sludge samples.

In the present study, the amount of sulphur in the sludge samples was found 2.96% which was higher than the amount of sulphur in the chemical fertilizers such as triple super phosphate and diammonium phosphate. However, the amount of sulphur was significantly lowered compared to the amount in ammonium sulphate, gypsum and potassium sulphate (Table 2).

It is also found that the average amount of iron in the sludge samples was 195229.53 mg kg^{-1} and the samples contained on an average 19.52% of iron but Mengel and Kikby (2004) confirmed that earth's crust contains only 5% of iron and invariably present in all soil. If the sludge is applied in the land without further treatment, it will increase iron's concentration in the land.

The concentrations of total organic carbon of these samples were varied between 15.88 and 24.33% as the components of sludge were not homogeneously distributed. Similarly, the range of TOM of the sludge samples was 28.51-42.13%. The average carbon nitrogen ratio of the sludge samples was 10.2 and the range of the C/N ratio in the samples was 7.74-14.59 which was very similar with the study by Brady and Weil (2007). The study disclosed that the C/N ratio in agricultural top soils varied from 8.1 to 15.1.

Table 1: Amount of Fe, K, S, P, total nitrogen, total organic carbon and total organic matter in sludge samples (mg kg^{-1})

Sample	Fe	K	S	P	Total N	TOC	TOM
SS1	187673.50	1223.04	29638.21	1132.12	20351.20	158838.52	285123.32
SS2	201437.20	1713.41	31297.52	873.36	19827.80	243153.75	421253.62
SS3	173147.80	1148.93	27858.85	1253.07	23726.30	183371.34	312153.57
SS4	221235.80	1087.61	27125.34	1413.57	15274.50	223215.31	391235.25
SS5	157291.60	1446.52	34176.17	1072.82	21035.10	201253.62	351756.22
SS6	168572.20	1513.73	29571.72	1185.53	19529.80	219372.81	378532.37
SS7	256748.60	1083.68	30517.61	916.13	22325.70	198593.67	340372.11
SS8	195729.50	1257.83	26873.89	1347.39	17113.70	163521.53	295253.61
Mean	195229.50	1309.34	29632.41	1149.25	19898.00	198915.07	346960.00
Percentage	19.52	0.13	2.96	0.11	1.99	19.89	34.67

Table 2: Some commonly used chemical fertilizer and their nutrient composition (%) (BARC, 1997)

Source	N	P	K	S
Urea	46	-	-	-
Ammonium sulphate	21	-	-	24.0
Tripple super phosphate	-	20	-	1.3
Muriate of potash	-	-	50	-
Potassium sulphate	-	-	42	18.0
Gypsum	-	-	-	18.0
Super phosphate	-	8	-	-
Diammonium phosphate	18-21	20	-	1.0

Table 3: Organic manure and their nutrient composition (%) (BARC, 1997)

Name of organic manure	N	P	K
Cowdung	0.5-1.5	0.4-0.8	0.50-1.9
Poultry manures	1.6	1.5	0.85
Farmyard manure	0.5-1.5	0.4-0.8	0.50-1.9
Compost (General)	0.4-0.8	0.3-0.6	0.70-1.0

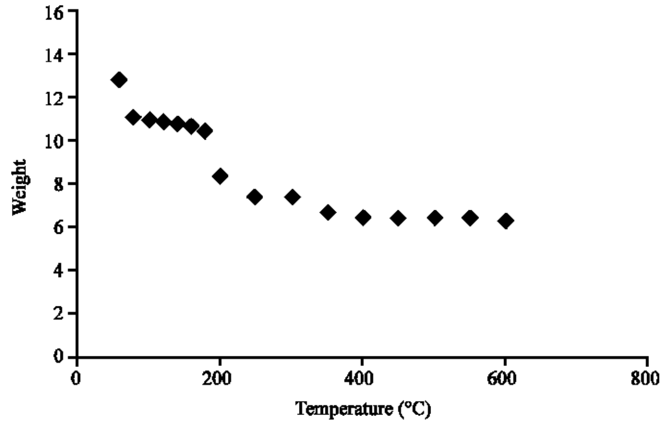

Fig. 1: Weight of sludge in different temperature

Thermo-gravimetric analysis revealed that sludge of textile and dyeing industry mostly contains hydrated oxides of iron, aluminum hydroxide and organic compounds. The rapid loss of weight up to 200°C indicated the loss of water. Gradual loss of weight between 200-400°C indicated the oxidation of organic matter and transformation of hydrated ferric oxide and aluminum hydroxide into respective oxides. At room temperature, the weight of sludge was 14.8381 g and at 200°C the amount was 8.3656 g whereas at 400 and 600°C, the amount was nearly unchanged, figuring 6.4267 and 6.3181 g, respectively in Fig. 1. The infrared spectra of the sludge in nujol at different temperature showed marked changes due to heat treatment. Since dried samples showed significant presence of water while the sample heated up to 400°C, the presence of water was barely indicated.

The present research concludes that P, K, S and N concentrations in the studied textile sludge samples were low compared to the commonly use chemical fertilizers but significant compared to the nutrient compositions of some commonly used organic manures. In addition, the amount of total organic carbon and total organic matter in the sludge samples was also found in very excessive quantity. Therefore, textile sludge can be able to supply small but significant concentrations of important nutrients to soil and it can improve soil structure, physical, chemical and biological properties of soils and water retention property. Therefore, its use as an organic fertilizer is potential.

ACKNOWLEDGMENTS

We would like to extend our thanks to Dr. Syed Safiullah, Professor, Department of Chemistry, Jahangirnagar University, Savar, Dhaka-1342 and Dr. Sirajul Hoque, Professor, Department of Soil, Water and Environment, University of Dhaka, Dhaka-1000, for their sincere help for this research study.

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