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Determination of Carbon/Nitrogen Ratio and Heavy Metals in Bulking Agents Used for Sewage Composting

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Abstract

Improving the soil quality with organic matter content and presence of elements such as N, P and K are some of sewage sludge benefits. Adjusting carbonaceous materials such as plant wastes to dewatered sludge compost increases its moisture and improves C/N ratio. So dewatered sludge has low C/N ratio and should be mixed with bulking agents. This study was performed in a three months period of the year 2002, in laboratory of Chemistry of Water and Wastewater in the School of Public Health of Isfahan University of Medical Science, to determine the C/N ratio and heavy metals concentration of bulking agents in sawdust, leaves, rice hulls and dewatered sewage sludge. The results showed that concentration of chromium and cadmium in the mixture of dewatered sewage sludge and bulking agents was lower than the standard level. Means of cobalt(115.44 mg/kg),nickel(57.44 mg/kg)and zinc(273.48 mg/kg) concentrations were maximum in dewatered sludge but mean concentration of cobalt (25.66 mg/kg) in rice hull samples and mean zinc(8.99 mg/kg) and nickel (5.106 mg/kg) concentrations in sawdust samples were minimum. The optimal conditions sewage sludge composting, each kilogram of sludge needs 350 grams of saw dust, 470 grams of leaves and 388 grams of rice hull. Amount of heavy metals present in the bulking agents is lower than the amount mentioned for the compost.

Keywords: *Bulking agents, Dewatered sludge, C/N ratio, Heavy metals*, *Iran*

Introduction

Usually during agricultural and horticultural production process, a proportion of raw or final product is wasted (e.g. straw from corn, roots and leaves from vegetables). In most cases, the wastes remain in the production site and become part of the organic matter and subjected to the degradation and rotting processes by macro and microorganisms (field composting). In some cases, these wastes are collected as they are valuable. Also, carbon compounds used to the soil can cause nitrogen immobilization and so additional nitrogen fertilizing (1).

Using dewatered sewage sludge in agriculture has many benefits. Organic matter content improves the soil structure while the presence of nutrients such as N, P and K increase soil fertility. Hence this substance is composted and be used for agricultural purposes and be a substitute for expensive inorganic fertilizers. Presence of pathogens and content of heavy metals are limitations in using sludge compost for agricultural purposes (2). Windrow is the most common method of sludge composting, in which dewatered sludge is mixed with bulking agents. Successful compost stabilization process of dewatered sludge depends on maintaining a suitable environment for process control including: a) moisture content, b) oxygen concentration, c) carbon-nitrogen ratio, d) temperature, e) pH and f) macro and micronutrients. Adjusting carbonaceous materials(plant wastes) to dewatered sludge compost increases its moisture content, improves the aeration and C/N ratio. Since dewatered sludge has a low C/N

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ratio, mixing it with bulking agents adjusts its C/N ratio. Also, dewatered sludge is often too wet and adjusting of dry bulking materials to absorb its surplus moisture increases its porosity (3). A biodegradable carbon-nitrogen (C/N) weight ratio of 25 to 35 has been found to provide optimal conditions for compost process. Lower C/N ratio increases the loss of nitrogen by leaching (e.g. nitrate mobilization) and ammonia volatilization; whereas higher levels necessitate progressively longer composting time as nitrogen becomes the microbial – limiting nutrient. Sludge normally has C/N ratios in range of 10 to 20. To offset an imbalance in the C/N ratio, compost amendments usually are necessary. Typical compost amendments include materials with high C/N ratio such as 1) sawdust, 2) leaves, 3) wood chips, 4) rice hulls and 5) old compost.

Dewatered sewage sludge composting with bulking agents converts it into a useful product. Land application of sewage sludge compost is restricted due to its content of heavy metals, pathogens and persistence of organic pollutants in the sludge(4).

The major nutrient elements or macronutrients in the compost include carbon, nitrogen, phosphorous and potassium. The micronutrient elements mostly used are cobalt, manganese, magnesium, copper and zinc. Micronutrients are essential for the growth and development of microorganisms, zinc and copper are essential for many microorganisms in the compost while toxic metals are not. Toxic metals include chromium and cadmium, etc.

Cadmium is easily taken up by plants (it is highly bioavailability for plant uptake). Mixing dewatered sewage sludge by adding the bulking agents decrease the toxicity content (5).In this study C/N ratio and heavy metal contents of bulking agents (such as sawdust, leaves, rice hulls and dewatered sewage sludge) were assessed, to use such information in sludge composting.

Materials and Methods

This study was performed during a three month period from June to August 2002, in laboratory of Chemistry of Water and Wastewater in the School of Public Health, Isfahan university of Medical Science, Iran. Dewatered sludge was collected from Isfahan sewage treatment plant. Sawdust was collected from sawmills. Leaves were collected from municipality of Isfahan and rice hull from rice mills. Samples were obtained three times per week, and then were transferred to the laboratory for conducting various tests according to standard methods (6). Fifteen and twenty tests were conducted to determine C/N ratio and heavy metal analysis respectively. Total carbon content of the samples determined through combustion in ovens at 750 ^{o}C for 2 h. Total nitrogen analysis was performed by Kjeldahl method. Samples were digested by nitric acid 1+1 and heavy metals contain Cr, Cd, Zn, Ni and Co analyzed by flame atomic absorption (7).

Results

Carbon and nitrogen percentage and C/N ratio changes in the leaves, rice hull, sawdust and dewatered sludge samples are shown in Figs. 1, 2, 3. Chromium, cadmium, cobalt, zinc and nickel changes in the leaves saw dust, rice hull and dewatered sludge are shown in Figs. 4, 5.

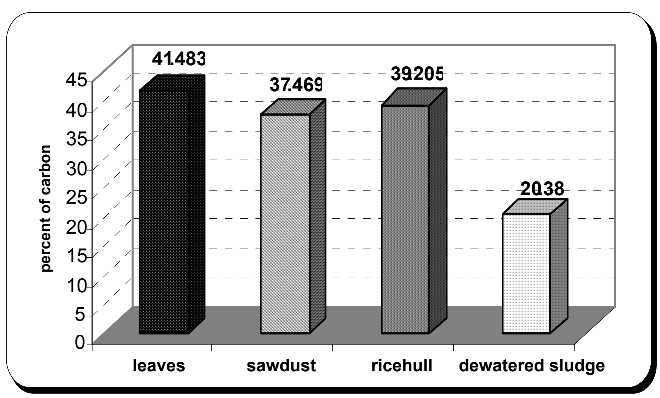

Fig. 1: Carbon content of different samples

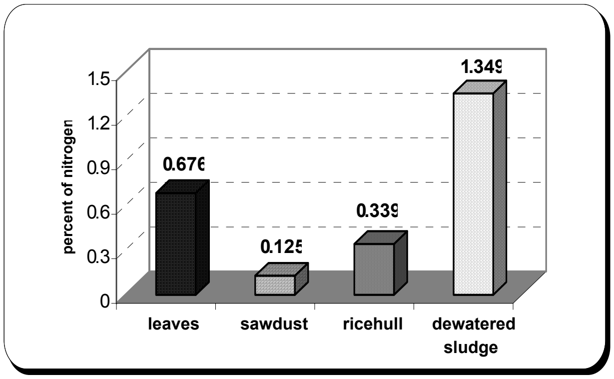

Fig. 2: Nitrogen content of different samples

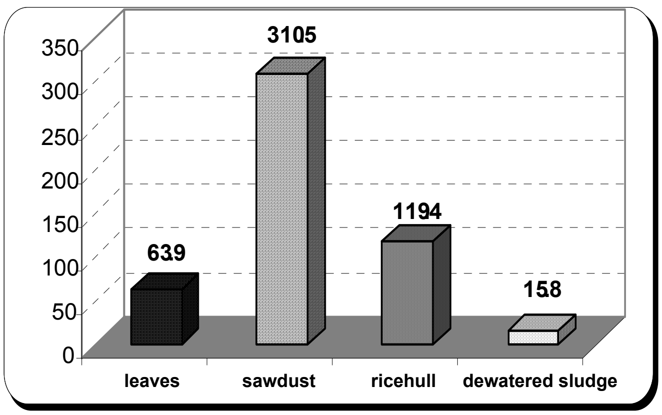

Fig. 3: C/N ratio in different samples

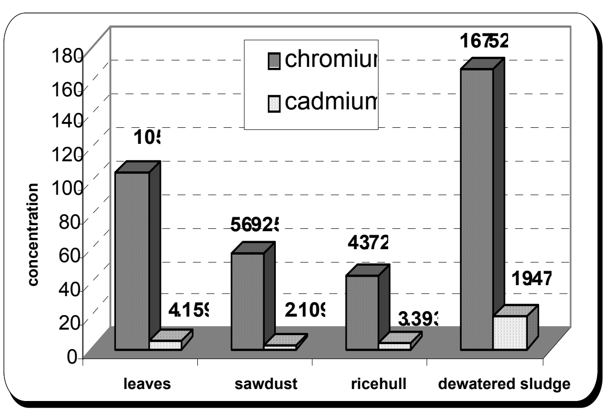

Fig. 4: Range of concentrations of chromium and cadmium in different samples

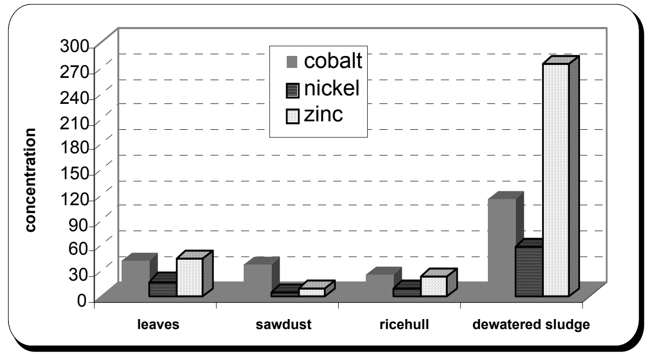

Fig. 5: Range of concentrations of cobalt, nickel and zinc in different samples.

Discussion

This study showed that sufficient amounts of nitrogen and trace elements (cobalt, zinc and nickel) are found in dewatered sludge, but, its carbon content is low; for adjusting its C/N ratio it should be mixed up with amendment agents and so leaves, rice hull and saw dust should be added to dewatered sludge used for composting. According to Fig. 3, the mean of C/N ratio in the leaves, saw dust and dewatered sludge is similar to that of obtained by Warman and Jones (8, 9). This study showed that dewatered sludge contained harmful toxic metals (chromium and cadmium). These metals kill the microorganisms of the compost and prolong the composting time. Thus mixing dewatered sludge with bulking agents decreases the concentration of toxic metals. This study showed that the amount of heavy metals present in the bulking agents was lower than that of the compost. According to Fig. 4, the mean of chromium, zinc and nickel in the leaves, saw dust and dewatered sludge is the same as Kreith's findings (10). If optimum C/N ratio for sewage sludge composting consider 25, in optimal conditions, 350 grams of saw dust, 470 grams of leaves plus 388 grams of rice hull should be added to each kilogram of sludge for composting which is appreciated by Gibbs (11).

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