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HEAVY METAL CONTENTS IN COMMONLY USED ANIMAL MANURE

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ABSTRACT

The use of animal manure is a common practice particularly among vegetable growers in Sri Lanka. Animal manure provides considerable amounts of plant nutrients and many other beneficial effects for crop growth. However, animal manure may contain appreciable quantities of heavy metals, and the toxic heavy metals added to soils through these manures could be entered to human body through the food chain. In this study manure samples, which are commonly used by farmers such as deep litter, broiler litter, cow dung, buffalo dung, goat dung, and pig dung, were oven dried at 60°C and heavy metal contents were determined. Deep litter contained the highest amount of Mn (361 mg kg^{-1}) and Cd (4.7 mg kg^{-1}), while broiler litter contained the highest amount of Zn (159 mg kg^{-1}) and Cd (4.7 mg kg^{-1}). The highest Fe (8858 mg kg^{-1}) and Cu (63 mg kg^{-1}) contents were reported in pig dung. Buffalo dung contained the highest amount of Pb (23.2 mg kg^{-1}) among all animal manures tested. Both deep litter and broiler litter had the highest amount of Cd (4.7 mg kg^{-1}), which is considered as the most harmful heavy metal for human health. Results revealed that though animal manure contains variable quantities of heavy metals, their amounts were significantly lower than the heavy metal levels permitted in composts as identified by the Sri Lanka Standards Institute (SLSI). Hence, build-up of these heavy metals is unlikely to occur in soils where animal manure is applied at the recommended rates. However, regular analyses of soil as well as vegetable samples have to be done in situations where continuous application of high quantities of animal manure is being practiced.

KEYWORDS: Animal manure, Heavy metal contents.

INTRODUCTION

The use of animal manure for crop production is a common practice in many cropping systems in Sri Lanka (Wijewardena, 1993; Wijewardena 1995; Wijewardena and Yapa, 1999; Wijewardena, 2000a). In general, the use of animal manure is well adopted by farmers especially for crops such as vegetables, potato and to a lesser extent for rice and local tuber crops. The use of animal manure in crop production has being encouraged by many researchers and crop research institutes due to prevalence of poor soil fertility in many parts of the country. In addition, the application of animal manure has shown an increase in the yield of crops as well as improvement of soil fertility (Wijewardena, 1993; Wijewardena 1995; Wijewardena and Yapa, 1999). As a result, the Department of Agriculture has recommended the application of both animal manure and chemical fertilizers for crop production. However, the perception of many scientists has been that the animal manure contain considerable quantities of heavy metals, which are harmful to human health.

Heavy metals, which are added to soil through animal manure, may directly or indirectly affect the chemical composition of crops grown, in particular soil as well as water supplies (Singh and Steinnes, 1994). The practical implication of these in the environment relates to their availability for plant uptake their release into water systems. In consideration of the ever-increasing pressure being placed on land by more intensive land management practices and the increasing use of agricultural land for waste management, it is important to study the heavy metal contents in animal manure popularly used in Sri Lanka.

Heavy metals such as Zn, Cu, Fe and Mn could be considered as useful trace elements for crop growth. However, continuous and heavy application of organic manure to soil could increase heavy metal contents to toxic levels. Phytotoxicity of Zn occurs in leaves at levels of 100-400 mg kg^{-1} (Kabata-Pendias and Pendias, 1992). In the case of Cu the most prominent symptom of Cu toxicity is chlorosis, superficially resembling Fe deficiency. Copper levels toxic to plants range from 20-100 mg kg^{-1} (Kabata-Pendias and Pendias, 1992). Iron toxicity symptoms in lowland rice, the crop frequently affected by excess Fe, appear on the lower leaves as tiny brown spots starting from the tips and spreading towards the base. In severe Fe toxicity the entire leaves are purplish brown. However, incidences of Fe toxicity to plants have not been reported under upland conditions (Jones, 1972). The most prominent Mn toxicity symptoms are raised interveinal areas giving a puckered appearance and brown speckling of older leaves. However, Mn toxicity does not appear until leaf concentrations of the heavy metal reach the level of 400-1000 mg kg^{-1} (Kabata-Pendias and Pendias, 1992).

Heavy metals such as Cd, Pb, Ni and Hg are not considered as essential for crop growth. However, Cd is phytotoxic to leaves at levels of 5-30 mg kg^{-1} (Kabata-Pendias and Pendias, 1992). Among heavy metals, Pb could be considered as the least mobile. Lead accumulates in the surface horizons of soils and is not usually leached (Davies, 1990). Its concentration in solution is low, and this limited amount is available for plant uptake (Davies, 1990). Despite being identified as not essential for plant growth, Ni may be active in hydrogenase and translocation of nitrogen, and is known to be present in urease (Kabata-Pendias and Pendias, 1992). It is easily translocated within plants and accumulates in leaves and seeds. Plants show symptoms of Ni toxicities at leaf levels of 10-100 mg kg^{-1} and may exhibit chlorosis, gray-green leaves and stunted root and plant growth (Kabata-Pendias and Pendias, 1992). Murcury is toxic to plants at levels of 1000-3000 mg kg^{-1}, resulting in chlorosis and severe stunting of seedlings and roots (Kabata-Pendias and Pendias, 1992).

Heavy metals could be considered as metallic elements with a density over 5 g cm^{-3} (Brady, 1985) or with an atomic weight greater than that of Fe

(Pierzynski *et al.*, 2000). Bockman *et al.* (1990) categorized heavy metals as metallic elements with high specific weight, often toxic to mammals. Heavy metals could be categorized into three groups according to their toxic levels i.e. toxic (Cd), moderately toxic (Pb, Ni, Hg) and low toxic (Zn, Fe, Mn, Cu). It is a well known fact that vulnerability of man to heavy metal toxicity is high when compared to many other animals and plants (Lagerwerff, 1972). Once heavy metals are introduced to crop lands, they can be taken up by plants and subsequently become incorporated into the food chain. If heavy metals leach through the soil, they may also contaminate ground water. In recent years, the plant uptake of heavy metals has received a great deal of attention due to its potential health effect on humans. The heavy metals accumulate in human and other animals, particularly in kidneys, liver, etc. Accumulation of heavy metals in the human body can cause diseases such as heart attack, brain damage, cancer, diseases in digestive system, anemia, gout, chronic nephritis, encephalopathy, etc. (Logerwerff, 1972). Cadmium is toxic to human at high levels causing neuropath logical symptoms and renal dysfunction. In addition, the balance of other minerals such as P and Ca in the body is also disturbed by high intake of Cd (IFDC, 1996). Tolerable daily Cd intake for humans is 1 μg Cd per kilogram body weight (IFDC, 1996).

In agriculture, organic manure applied to soils could increase the levels where as the movement of heavy metals could vary with soil pH, where movement of heavy metals may be high under low pH when compared to high pH ranges (Kabata-Pendias and Pendias, 1992). Vegetable growing soils in the wet and intermediate zones of Sri Lanka are acidic in nature.

However, limited information is available on heavy metal contents in animal manure used in Sri Lanka. In consideration of the ever-increasing use of animal manure as sources of organic manure for crop production, it is important to evaluate the contribution of heavy metals by different animal manure types. Hence, the objective of this study was to evaluate heavy metal contents in animal manure types commonly used in Sri Lanka.

MATERIALS AND METHODS

Twenty five fresh samples from each category of deep litter, broiler litter, cattle manure, buffalo dung, goat dung and pig dung were collected from the western and southern regions of Sri Lanka, dried to a constant weight in a forced draught oven at 60°C, and dry matter content of manure were determined. Thereafter, dried samples were ground to a fine powder using a glass motor and pestle. Ground manure samples were digested with 1:1 perchloric acid:nitric acid mixture using 1 g sample with 10 ml of acid mixture in a fume cupboard and dissolved in water (Jackson, 1958). Aliquots of the sample extracts were analysed for Zn, Cu, Fe, Mn, Pb and Cd contents using GBC Atomic Absorption Spectrophotometer at appropriate wavelengths.

RESULTS AND DISCUSSION

Zinc

The total contents of Zn in different animal manures are given in table 1. Results showed that mean value of Zn is high in broiler litter followed by deep litter, pig manure, cow dung, goat dung and buffalo dung (table 1). However, the Zn contents in the tested animal manures were low when compared to the maximum permissible level of Zn (1000 $mgkg^{-1}$) in composts as reported by the SLS (2003).

Table 1. Total Zn contents (dry matter basis) in different animal manure (mg kg^{-1}).

Type	Range	Mean	SD
Deep litter	49 – 216	129.4	44.1
Broiler litter	49 – 456	159.0	121.2
Cow dung	10 – 175	50.3	41.5
Buffalo dung	6 – 109	23.8	23.2
Goat dung	10 – 171	64.2	49.4
Pig dung	30 – 325	118.3	87.5
Maximum permitted level by SLS for compost		1000	

SD- Standard deviation

Manganese

The total contents of Mn in different animal manure are given in table 2. Results showed that the highest Mn content is found in deep litter, followed by broiler litter, pig dung, buffalo dung, goat dung and cow dung (table 2). Unlike in the previous case, the maximum permissible level of Mn in composts has not been identified by SLS (2003).

Table 2. Total Mn contents (dry matter basis) in different animal manure (mg kg^{-1}).

Type	Range	Mean	SD
Deep litter	102 – 651	361	133
Broiler litter	81 – 961	317	238
Cow dung	10 – 400	197	129
Buffalo dung	11 – 774	233	172
Goat dung	126 – 381	216	86
Pig dung	68 – 858	298	243
Maximum permitted level by SLS for compost		NA	

NA- Not available

Iron

The highest content of Fe was present in pig dung, followed by goat dung, buffalo dung, cow dung, deep litter and broiler litter (table 3). As in the case of Mn, SLS (2003) has not reported the maximum permissible level of Fe in composts.

Table 3. Total Fe contents (dry matter basis) in different animal manure (mg kg^{-1}).

Type	Range	Mean	SD
Deep litter	135 – 6610	1816	1676
Broiler litter	866 – 2924	1762	669
Cow dung	765 – 7931	3418	2033
Buffalo dung	1371 – 6249	3673	1378
Goat dung	1007 – 1717	5797	4243
Pig dung	884- 27858	8858	7932
Maximum permitted level by SLS for compost		NA	

NA- Not available

Copper

Table 4 shows that the highest Cu content among the tested animal manures is in pig dung followed by deep litter, broiler litter, goat dung, cow dung and buffalo dung. However, this amount is far below the maximum permissible level of Cu in compost (400 mgkg^{-1}) as reported by SLS (2003).

Table 4. Total Cu contents (dry matter basis) in different animal manure (mg kg^{-1}).

Type	Range	Mean	SD
Deep litter	5 – 98	30.0	21.6
Broiler litter	5 – 82	22.4	21.8
Cow dung	2 – 62	16.0	17.7
Buffalo dung	4 – 45	15.8	10.7
Goat dung	3 – 42	17.4	10.3
Pig dung	4 – 232	63.0	76.4
Maximum permitted level by SLS for compost		400	

Lead

Results of the present study revealed that the highest lead content among the tested animal manures is in buffalo dung, followed by broiler litter, goat dung, deep litter, cow dung and pig dung (table 5). All the tested sample contained Pb, which is the least mobile among the heavy metals studied (Davies, 1990), at amounts significantly lower than the maximum permissible contents of the this heavy metal in composts (250 $mgkg^{-1}$) as reported by the SLS (2003).

Table 5. Total Pb contents (dry matter basis) in different animal manure ($mg\ kg^{-1}$).

Type	Range	Mean	SD
Deep litter	1.9 – 34.2	13.7	9.0
Broiler litter	2.5 – 43.6	18.6	11.7
Cow dung	1.6 – 26.6	13.1	6.5
Buffalo dung	5.0 – 44.4	23.2	9.8
Goat dung	2.3 – 38.6	16.1	9.0
Pig dung	2.9 – 32.5	12.1	6.9
Maximum permitted level by SLS for compost		250	

Cadmium

Cadmium has been identified as the most toxic heavy metal to human beings (Lagerwerff, 1972). Results indicated that the broiler litter contained the highest content of Cd, followed by buffalo dung, pig dung, cow dung and goat dung (table 6). However, similar to the case of many other heavy metals reported in the present study, the Cd contents in the tested animal manures were significantly lower when compared to the maximum permissible level of this heavy metal in composts (10 $mgkg^{-1}$) as reported by the SLS (2003).

Table 6. Total Cd contents (dry matter basis) in different animal manure ($mg\ kg^{-1}$).

Type	Range	Mean	SD
Deep litter	1.6 – 9.1	4.7	1.9
Broiler litter	1.3 – 7.8	4.7	1.9
Cow dung	0.5 – 7.3	2.6	1.8
Buffalo dung	0.5 – 7.8	3.9	1.9
Goat dung	0.3 – 7.3	2.2	1.8
Pig dung	0.4 – 2.5	3.2	2.5
Maximum permitted level by SLS for compost		10	

The heavy metal contents of animal manures reported in the present study are in accordance with those of CRI (1994) and Hernandez *et al.* (1991). Hernandez *et al.* (1991) reported that the animal manure contain low levels of heavy metals. In addition, different animal manures tested showed a high variation in heavy metal contents, probably due to the variation in animal feed, sources of water, age of animals, etc.

The uptake of heavy metals by plants depends on soil pH. Heavy metals uptake increases in acidic soils when compared to those in alkaline soils (Keikens, 1990). As application of animal manure is a popular practice among vegetable growers in upcountry areas and low country wet zone where the soils are acidic, vegetable crops may uptake more heavy metals from the cultivated soils. However, the heavy metal contents in tested animal manures were low when compared to the acceptable values reported in composts by the SLS (2003). Of the heavy metals analysed, Fe was found in the highest quantities in all samples of the six animal manure types, while Cd was recorded at the lowest quantities. Though the total Fe content is higher depending on its bioavailability it may not be problematic to plants or humans. Zinc, Mn, Cu and Fe are considered as useful trace elements for crop growth (FAO, 1983; IFDC, 1996). As a result, application of animal manure has been recommended as sources of trace elements for crop production (Wijewardena, 2000b; Maraikar and Nambuge, 2001). However, transfer of Cd to food crops is of major concern due to its toxicity to human health. Hence, vegetable samples as well as soil samples should be periodically analyzed for heavy metals especially when animal manure is being used heavily.

CONCLUSIONS

Deep litter, broiler litter, cow dung, buffalo dung, goat dung and pig dung contain variable quantities of heavy metals. The highest amount of Zn was present in broiler litter, Mn in deep litter, Fe and Cu in pig dung, Pb in buffalo dung, and Cd in both deep litter and broiler litter. However, amounts of Zn, Cu, Pb and Cd found in the tested animal manures were far lower when compared to the acceptable levels of these heavy metals in composts as reported by the Sri Lanka Standards Institution (SLS, 2003). Hence, the application of recommended rates of animal manure for crops is necessary to avoid the build-up of heavy metals in cultivated soils. However, it is prudent to monitor heavy metal contents in soils as well as vegetable products where animal manures are being used frequently in large quantities.

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