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Effect on Soil Quality and Plants on Utilization of Domestic and paper mill sludge in Farm Lands

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Abstract

Organic material being applied to agricultural field improves the physical and chemical properties of the soil. Organic matter contains essential nutrients like Nitrogen and Phosphorus for plant growth. Application of sludge to soil not only improves the nutrients of the soil it also helps in improving soil quality and effectively disposal of the wastes. Domestic and paper mill sludge regarded as a waste product due to expected high level of contaminants such as pathogens, pollutants and waste materials discharged in sewer from homes and industries which were often incinerated or dumped. So application of sludge to agricultural soil may be sustainable and economical due to nutrient cycling and disposal of domestic and paper mill sludge.

Keywords: Domestic and paper mill sludge, nutrient cycling, pathogens.

Introduction

Application of domestic and paper mill sludge to agricultural soil is a common practice due to easy availability Heavy metal transfer is rapid in soil profiles and they can pollute ground water supplies also. The soil is like reservoir for contaminants as it possesses an ability to bind various chemicals and different forces keep them bound to soil particles. The excessive accumulation of heavy metals in agricultural soils through sludge contaminates and affects the soil profile. The domestic and paper mill sludge also contains useful concentration of Nitrogen, Phosphorus, and Potassium. On applying domestic and paper mill sludge to soil may affect the soil which will result in contamination of the food chain. The fertilizer effect of sludge enables a reduction in cost for nitrogen and phosphorus mineral fertilizers and may improve crops yield.

Recycling of sludge for agricultural purpose seems to be an appealing solution for sustainable management of sludge.
There is an interesting trend in the agricultural application of domestic and paper mill sludge obtained from wastewater treatment plant due to the possibility of recycling valuable components: organic matter, N, P and other plant nutrients. Characterization of domestic and paper mill sludge is extremely important prior to sludge disposal or application to farmland because there is a risk of toxic elements accumulation in soil.
In this study, the effect of domestic and paper mill sludge on the heavy metal up-take was examined in case of cow pea and black gram. The soil and plants was examined on how this modifies especially the heavy metal up-take.

Materials and Methods

Experimental Conditions

The investigation was carried out in Salem located in Tamilnadu. Some characteristics of soils and sludge used in the experiment are given in Table 1, 2 and 3. In general, the experimental soils were clay in texture, slightly alkaline in reaction (pH), moderate level of organic matter. The soils have no signs of salinity problem, available phosphorus (P) content was at poor level, available potassium (K) content was high (Table 1).

Table 1: Initial characteristics of the soil.

p-H	Nitrogen (mg/kg)	Phosphorus (mg/kg)	Potassium (mg/kg)	Organic matter (%)
6.11	530	50	630	4.88

Table 2: Initial characteristics of the domestic sludge.

Nitrogen (mg/kg)	Phosphorus (mg/kg)	Potassium (mg/kg)	Organic Matter (%)	Lead (mg/kg)
5575	32.53	8205	5.36	0
Iron (mg/kg)	Manganese (mg/kg)	Copper (mg/kg)	Zinc (mg/kg)	
772	113	0	65	

Table 3: Initial characteristics of the paper mill sludge.

Nitrogen (mg/kg)	Phosphorus (mg/kg)	Potassium (mg/kg)	Organic matter (%)	Lead (mg/kg)
11438	53.84	1443	7.5	0
Iron (mg/kg)	Manganese(mg/kg)	Copper (mg/kg)	Zinc (mg/kg)	
6127	298	0	130	

APPLICATION OF SLUDGE TO SOIL

The application of domestic and paper mill sludge can either stimulate soil microbial activity, due to an increase in available carbon and nutrients, or inhibit activity, due to the presence of heavy metals and other pollutants. Soil respiration, metabolic quotient, and soil enzymatic activity have been true indicators of microbial activity occurred in the soil to evaluate the effects of domestic and paper mill sludge disposal in agriculture soil.

RATE OF APPLYING SLUDGE

While applying 30 t/ha of domestic and paper mill sludge to soil it has been determined that they increase in plant supply degree with mineral elements especially N and P. It has also provided a mean annual supply of 8-12 t/ha organic matter, by which we can see the increase in soil organic content.

Experimental design

The field setup (fig-1) has been done by randomly taking 4-split pits. The paper mill and domestic sludge were applied at an estimated rate of 30 t/ ha of dry matter. All the treatments were applied before cow pea and black gram were sown as shown in Table 4.

Figure 1: Site area

Plant characteristics study

Cowpea

Cowpea is a warm-season, herbaceous legume. Plant types are often categorized as erect, semi-erect, prostrate or climbing. There is much variability within the species. Growth habit ranges from indeterminate to fairly determinate with the non-vining types tending to be more determinate. Cowpea generally is strongly tap rooted.

Season and Seeding Rate

Cowpea can be grown in the month of September to February for the chosen site area (Salem). Cowpea should not be planted until soil temperatures are consistently above

65°F and soil moisture is adequate for germination and growth. Cow pea can be sown at the rate of 25kg/ha. Cow pea seeds were sown at the depth of 1 to 1.5 inches. The cow pea plants can be harvested from 60 to 90 days after planting.

Black Gram

It is an erect, sub-erect densely hairy, annual herb. The tap root produces a branched root system with smooth, rounded nodules the pods are narrow, cylindrical and up to six cm long. The plant grows 30–100 cm with large hairy leaves and 4–6 cm seed pods

Season and Seeding Rate

Black gram can be grown in the month of September to November for the chosen site area(Salem). Black gram should not be planted until soil temperatures are consistently above 60°F and soil moisture is adequate for germination and growth. Cow pea can be sown at the rate of 25kg/ha. Cow pea seeds were sown at the depth of 0.5 to 2.0 inches. The cow pea plants can be harvested from 60 to 75 days after planting.

Table 4: Specification on sludge and seed utilization in each plot

Sludge used	Plant sown	Amount of seed used (kg)	Amount of sludge used (kg)	Size of the plot (meter)
Paper Mill	Cow pea	0.015	17.8	2.4×2.4
Domestic	Black gram	0.015	17.8	2.4×2.4
Paper Mill	Cow pea	0.015	17.8	2.4×2.4
Domestic	Black gram	0.015	17.8	2.4×2.4

Plant growth study

Suppressiveness to soil-borne plant pathogens is one of the most important soil properties, and the applications of organic matter alter this characteristic. On the other hand, incorporation of domestic and paper mill sludge into the soils can reduce or increase the severity of plant disease. In this way, the effects of domestic and paper mill sludge on plant diseases should be studied further, since the production of domestic and paper mill sludge continuously increasing worldwide, whose final disposal is mainly in agriculture.

Analytical Method

The concentration level of the heavy metals has been analysed by using the ICP-OES (Inductively Coupled Plasma Optical Emission Spectrometry). The heavy metals were determined in plant samples. Samples were digested by the wet method in a mixture of nitric acid and hydrogen peroxide with the closed-vessel microwave system. ICP-OES was used for the determination Lead (Pb), Iron (Fe), Manganese (Mn)in the plants as in Table 5, 6.

Table 5: Heavy Metal content of the plants grown in domestic sludge

Heavy metal	Cow pea (mg/kg)	Black gram (mg/kg)
Pb	BDL	BDL
Fe	20.6	165
Mn	7.41	16.6
Cu	BDL	BDL
Zn	7.54	10.4

Table 6: Heavy Metal content of the plants grown in paper mill sludge

Heavy metal	Cow pea (mg/kg)	Black gram (mg/kg)
Pb	BDL	BDL
Fe	21	138
Mn	4.07	12.9
Cu	BDL	BDL
Zn	5.57	8.10

Heavy metal concentrations in plants grown in domestic sludge applied soils were significantly higher than in plants grown in the paper mill sludge applied soil. These heavy metal concentration level variations might be due to reduction in soil bulk density and also depends on the plant intake characteristics.

Soil Characteristics Study after Application of Sludge

Biosolids typically contain from 50 to 70% organic matter, and their continued application over several years will gradually increase soil organic matter. In most cases there was no significant increase of Pb in crop tissue in relation to Pb in the soil from sludge application, suggesting that lead is relatively unavailable to crops from the soil. The soil characteristics after application of domestic and papermill sludge is given in the table7&8.

Table 7: Soil Characteristics after Application of Domestic Sludge.

Nitrogen (mg/kg)	Phosphorus (mg/kg)	Potassium (mg/kg)	Organic matter	Lead (mg/kg)
1343	11	1178	5.8	BDL
Iron (mg/kg)	Manganese(mg/kg)	Copper (mg/kg)	Zinc(mg/kg)	
1142	54	BDL	9.2	

Table 8: Soil Characteristics after Application of Paper Mill Sludge.

Nitrogen (mg/kg)	Phosphorus (mg/kg)	Potassium (mg/kg)	Organic matter	Lead (mg/kg)
1225	2.63	1147	6.7	BDL
Iron (mg/kg)	Manganese(mg/kg)	Copper (mg/kg)	Zinc(mg/kg)	
14544	188	BDL	32.6	

RESULTS AND DISCUSSION

It was found in the present study that application of domestic sludge appeared to be more beneficial for the crop due to their effective increase in content of N, P, K and their rate of heavy metal accumulation is lesser while comparing to the paper mill sludge application as in chart-(a), (b), (c) & (d).

Comparison Based On Initial Properties of Sludge and Soil

An initial Sludge and Soil tests measure the relative nutrient status of soil and sludge as they are used for profitable and environmentally responsible fertilizer application. Sampling of soil is important as if not done as it may result in over or under-application of fertilizer. Therefore, it is very important to collect and handle soil samples properly. This soil sample analyses will help to know the nutrient content requirement of the soil to attain the effective yield. Based on the soil requirement the sludge will be applied to the soil thus they help in increasing the yield, adding of the sludge will also improves the quality of the soil.

The chart- (a) shows the initial characteristics of the sludge and soil samples.

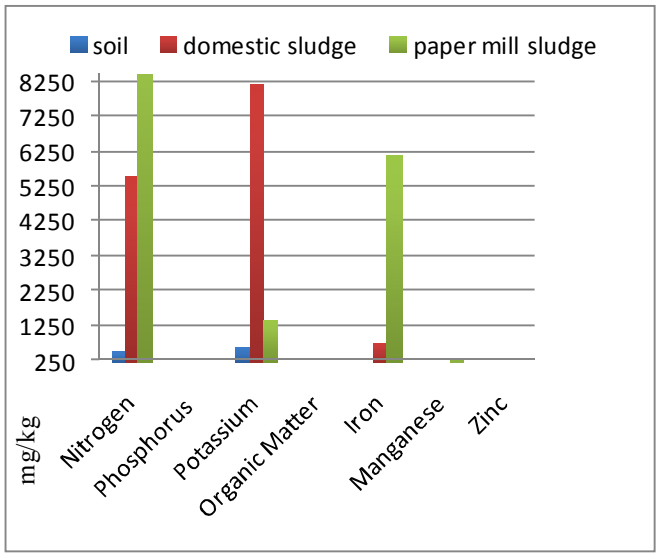

Chart (a): Comparison of soil properties with domestic and paper mill sludge.

The results show that soil sample tends to possess lesser amount of the nitrogen, phosphorous and potassium content, since they have lesser amount of nutrient their level of the fertility will be lesser. On applying the sludge with higher amount of nutrient content will provide a necessary amount of the nutrient level to improves their soil quality. Improving soil quality will help in improve of yield level. But there is risk involved on applying the sludge to the soil because this sludge while applied to the field possess few heavy metals so there is the chance of heavy metal accumulation in the soil and plants.

Comparison of Plant characteristics grown in domestic and paper mill sludge

The plant characteristics analysis is done with the help of ICP-OES for the heavy metal content of the cow pea plant and black gram plants. The cow pea plant absorbs higher amount of iron as compare to the other heavy metals as in chart(b). This excess level of iron content in the plants and the soil is due to kind of the sludge applied for the plant to grow as they possess iron in higher range.

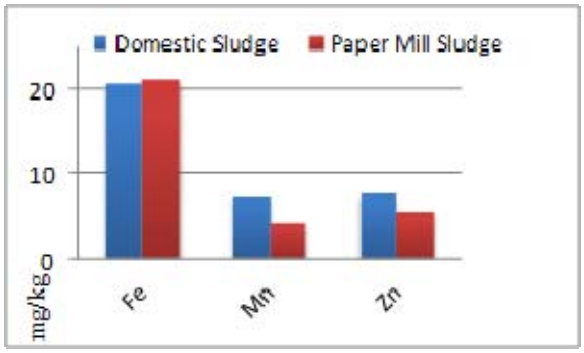

Chart (b): Comparison of Cow Pea Plant Characteristics that grown in Domestic Sludge and paper mill sludge

In the cow pea plant the heavy metal accumulation in the plants as they grown in domestic and paper mill sludge as in the order of Fe > Mn > Zn and Fe > Mn > Zn. Similar to the cow pea plant the black gram plant is also absorbing the higher amount of iron as compared to the other heavy metals as in chart(c) and in the black gram plant the heavy metal accumulation of the plant grown in the domestic and the paper mill sludge is in the order of Fe > Mn > Zn and Fe > Mn > Zn.

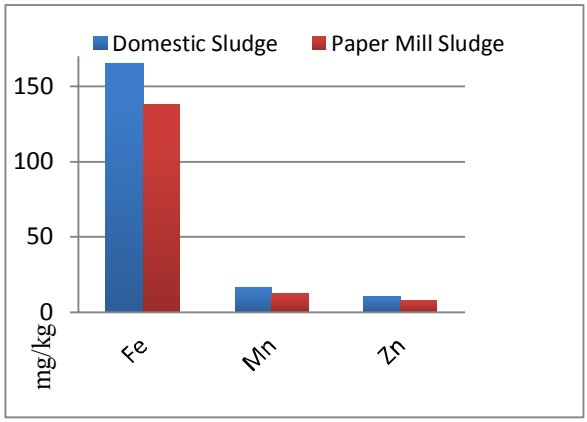

Chart (c): Comparison of Black gram plant Characteristics that grown in Domestic Sludge and paper mill sludge

Hence the heavy metal uptake by the plants mainly depends upon the kind of the sludge applied to the field and they were also depending upon the rate of the sludge application to the particular field.

Comparison of soil characteristics after application of domestic and paper mill sludge

The natural background concentration of metals in the soil is normally less available for crop uptake and hence less hazardous than metals introduced through domestic and paper mill sludge applications**.** In this study, total and available concentrations of Zn, Fe and Mn and soil mixtures are reported. Fe was the most abundant metal, followed by Mn and Zn.

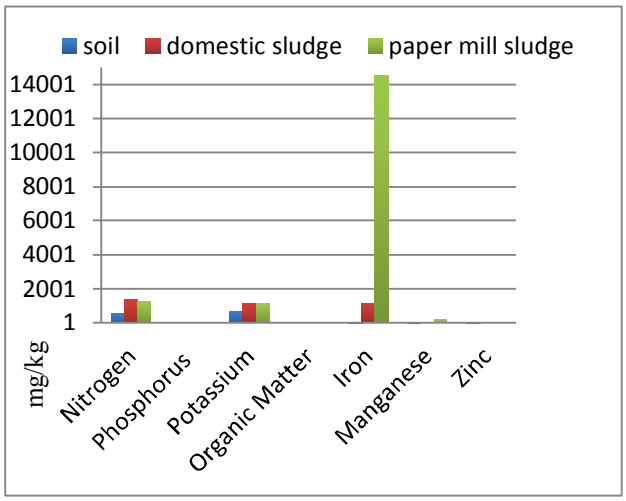

Chart (d): Soil Characteristics after Application of Domestic Sludge and paper mill sludge.

CONCLUSION

1. Use of domestic and paper mill sludge in agricultural land is promoted because it is considered that it will solve not only the problem of disposal but also will increase productivity in agriculture, thus profitable for farmers.
2. Usage of sludge has improved the soil fertility level.
3. On comparing with cow pea plant, black gram plant has accumulated higher amount of heavy metal content.
4. Plants differ in their abilities to absorb sludge-derived metals from the soil.
5. The processed soil becomes very fertile and its water holding capacity also increases. Available food ingredients for plants are high. This reduces the use of organic fertilizer thus increasing the quality of food products.

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