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QUANTITATIVE EVALUATION OF FUTURE WASTE GENERATION VIS A VIS NITROGEN AND METAL LOAD ON SOIL

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ABSTRACT

Quantitative evaluation of some salient features are absolutely necessary in order to assess the impact of co-recycling of municipal wastes in agriculture onto the different components of environment, and future waste generation needs to be estimated to predict the quantity of nutrient (nitrogen) available for application in waste-fields. Such co-recycling of wastes is a unique feature in Titagarh Waste Farming Area where the entire nutrient is recycled through solid waste and treated effluent has been estimated and the probable metal loads are also simultaneously estimated to foresee the expected hazard the environment may encounter in future and necessary safeguards to be undertaken in this regard.

Attempts have been made to forecast the expected wastes (solid and liquid) generation and their potential as nitrogen contributor and the probable metal loads are also simultaneously estimated to foresee the expected environmental hazard.

Total plant available nitrogen (PAN) and metal load concentration in compost generated in 30 years considering the future generation of solid waste and also quantity of compost, and total nitrogen and metal load in wastewater (WSP effluent) generated in 30 years has been calculated. Considering an average value of both PAN and individual metal load, estimation of application rates of nitrogen as well as different metals have been made per year per hectare (250 MT of solid waste used per hectare) and on the basis of load limit of different metals the possible years of application of solid waste without causing significant adverse environmental impact have also been predicted.

INTRODUCTION

Quantitative evaluation of some salient features are absolutely necessary in order to assess the impact of co-recycling of municipal wastes (solid and liquid) in agriculture onto the different components of environment. Future waste generation needs to be estimated to predict the quantity of nutrient (nitrogen) available for application in waste-fields. As per present CPCB of India norms, entire nutrients in the wastes should be recycled and reused. In case the entire nutrient is recycled through solid waste and treated effluent, the probable metal loads are also simultaneously estimated to foresee the expected hazard the environment may encounter in future and necessary safeguards to be undertaken in this regard.

Attempts have been made to forecast the expected solid and liquid wastes generation and their potential as nitrogen contributor and also as hazard creator due to their metal contents. Nitrate nitrogen leaching through the soil mantle has been considered.

MATERIALS AND METHODS

Future generation of solid waste and quantity of compost estimation from it, considering 30 years design period (design year 2031) based on census population of 1991 and 2001 has been estimated on assumption that the whole of the waste will be subjected to composting in future assuming 50% reduction of compostable fraction.

Equation 1 = Population × Waste generation rate × Number of days per year
Equation 2 = $P (1 + r)^T$

Where, P = Initial population; r = Percent growth rate/100; T = Years (30 years)

Plant available nitrogen (PAN) and metal load concentration in compost is considered as:

PAN = Nitrate + Ammonium Nitrogen + 0.2 Organic Nitrogen

Organic Nitrogen = TKN - Ammonium Nitrogen

Liquid wastewater generation has been calculated for 30 years. Considering an average value of both PAN and individual metal load, estimation of application rates of nitrogen as well as different metals have been made per year per hectare on the basis of load limit of different metals (except Cr and Fe).

RESULTS AND DISCUSSION

The total municipal solid waste generated in Titagarh Municipality is 65 MT d^{-1} from the population of 1,24,198.

Waste generation rate (65 MT × 1000 kg × 1000 g)/1,24,198 = 523 g/person/day
The population in the year 1991= 1,13,831
The population in the year 2001= 1,24,198
Percent growth rate in ten years = [(1,24,198 – 1,13,831)/1,13,831] × 100
= 9.11%
Per capita waste generation rate = 523 g/day
Percent growth rate per year = 0.911 %
Population in the year 2021 = $1,24,198\ [1+ 0.911/100]^{20}$
= $1,24,198\ (1.00911)^{20}$
= 1,48,897
Solid waste expected to be generated in the year 2021 = $1,48,897 \times 523 \times 10^{-3} \times 365$
= $2.84 \times 10^{10} \times 10^{-3}$
= 2.84×10^{7} kg
= 2.84×10^{4} MT
Compostable fraction (assuming 74% of the total waste generated) = $2.84 \times 10^{4} \times 0.74$
= 2.10×10^{4} MT
Noncompostable fraction = $(2.84 \times 10^{4} - 2.10 \times 10^{4})$ MT = 0.74×10^{4} MT
Quantity of compost (assuming 50% reduction through compost) = $0.5 \times 2.10 \times 10^{4}$
= 1.05×10^{4} MT
Solid waste quantity after composting = $(1.05 \times 10^{4} + 0.74 \times 10^{4})$ MT
= 1.79×10^{4} MT

Table 1 present plant available nitrogen (PAN) and metal load concentration in compost. The total PAN and metal load in compost generated in 30 years considering the future generation of solid waste and also quantity of compost, and the whole of the waste will be subjected to composting in future. Similarly Table 2 presents total nitrogen and metal load in wastewater (WSP effluent) generated in 30 years. Considering an average value of both PAN and individual metal load, estimation of

Table 1: Total plant available nitrogen (PAN) and metal load in compost generated in 30 years.

Quantity of MSW after composting, 10^7 kg	PAN content of MSW after composting, 10^7 mg	Metal load of MSW after composting, 10^7 mg							
		Zn	Cu	Pb	Cd	Cr	Ni	Co	Fe
51.61	45657.37	11625	3301.08	20379	124.35	1643.83	3060.16	621.99	58658.1

Table 2: Total nitrogen and metal load in wastewater generated in 30 years.

Liquid waste 10^7 L	Totat-N 10^7 mg	Zn 10^7 mg	Cu 10^7 mg	Pb 10^7 mg	Cr 10^7 mg	Ni 10^7 mg	Co 10^7 mg
46.329	4.44	2.169	0.735	0.565	0.735	1.285	1.350

Table 3: Metal load on soil by MSW.

Metals	Average conc. in MSW	Application rate of MSW	Application of metals per year	Present metal conc. in soil	Soil load limit of metal	Allow-alable loadin soil	No. of years of possible application of waste
	$mg.kg^{-1}$	10^3 $kg.year^{-1}.ha^{-1}$	10^3 $kg.year^{-1}.ha^{-1}$	$kg.ha^{-1}$	$kg.ha^{-1}$	$kg.ha^{-1}$	
Zn	225.333	250	56.333	245.32	2858.12	2612.80	46
Cu	63.987	250	15.997	115.6	1535.54	1419.94	89
Pb	26.987	250	6.747	19.93	307.11	287.18	43
Cd	2.41	250	0.603	8.12	39.23	31.11	52
Cr	31.863	250	7.966	43.57			
Ni	59.317	250	14.829	31.43	429.28	397.85	27
Co	12.057	250	3.014	10.23	2858.12	2612.80	-

application rates of nitrogen as well as different metals have been made per year per hectare (250 MT of solid waste used per hectare), and on the basis of load limit of different metals (except Cr and Fe) the possible years of application of solid waste without causing significant adverse environmental impact have also been predicted (Table 3).

Attempts have also been made for quantitative evaluation of percolation of nitrogen. Wastewater hydraulic loading rate and nitrogen loading rate for irrigation as evaluated by Polprasert (1996) and PAN loading of solid waste as suggested by Franklin (2002) have been used for developing an equation integrating two types of wastes and correlating total nitrogen contribution by both solid and liquid waste with crop uptake, percolation and soil retained nitrogen.

WLR = Wastewater loading rate, cm/week
PPT = Precipitation, cm/week
EVT = Evapotranspiration, cm/week
NRO = Net run off, cm/week
PR = Percolation rate, cm/week

$$WLR + PPT = EVT + NRO + PR$$

$$PR = WLR + (PPT - EVT) \quad \text{(Assuming NRO to be negligible)}$$

$$= WLR + 50 \quad \text{(In humid areas PPT – EVT = 500}$$

WNL = Waste nitrogen loading, kg/ha/year
WLR = Wastewater loading rate, cm/year
ANC = Applied nitrogen concentration in wastewater, mg/L
SWA = Solid waste application, kg/ha/crop period
PAN = Plant available nitrogen concentration in solid waste, mg/kg
= Nitrate-N + Ammonium-N + 0.2 × Organic nitrogen (assuming a mineralisation factor of 0.20 (20%).

CUN = Crop uptake of nitrogen, kg/ha/year
PNC = Percolated nitrogen concentration, mg/L
PR = Percolation rate, cm/year
DNR = Denitrification rate, kg/ha/year
NRS = Nitrogen retained in soil
PR = WLR + 50
WNL = CUN + DNR + 0.1 (PR) (PNC) + NRS [PR (cm/year) × PNC (mg/L) = 0.1PR × PNC kg/ha/year]

Denitrification percentage of applied nitrogen = 20% (assumed)

DNR = 0.2 WNL
WNL = SWA × PAN + 0.1 (WLR × ANC)
= CUN + 0.2 WNL + 0.1 (WLR + 50) (PNC) + NRS
0.8 WNL = CUN + 0.1 (WLR + 50) (PNC) + NRS

Percolated nitrogen concentration can be evaluated and checked against permissible standard provided wastewater loading rate, waste nitrogen loading, and nitrogen retained in soil are estimated from respective analysis.

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