Composting of Mixtures of Sewage Biosolids and Municipal Solid Wastes in a Wastewater Treatment Plant

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Outline

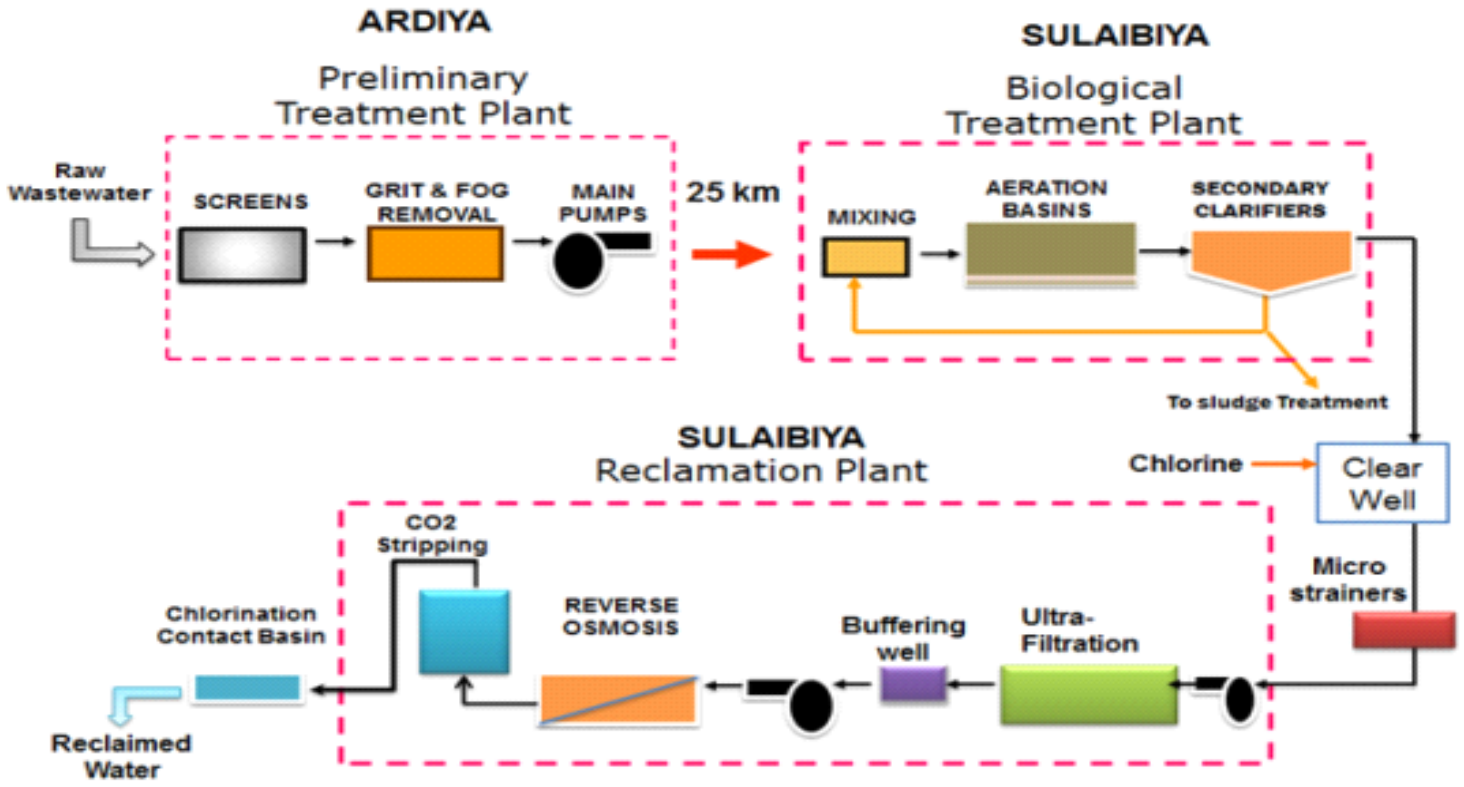
- Introduction
- WWTP Description
- Objectives and Scope
- Field Experimental Analysis
- Results and Discussion
- Conclusions

1. Introduction

- As the population and wastewater flow continue to grow, increasing quantities of sludge are generated daily in wastewater treatment plants.
- Sludge should looked at as a resource to be recovered at a reasonable cost.
- This could be achieved by composting of sludge to produce compost used as a fertilizer or soil amendment.

- Composting is generally achieved by windrow open pile system or in-vessel controlled systems.
- There are usually three ingredients to a composting mix: dewatered sludge cake, an organic amendment, and recycled compost. The term “bulking agent” refers to the combination of organic amendment and recycled compost.

2. Wastewater Treatment Plant



WWTP Description

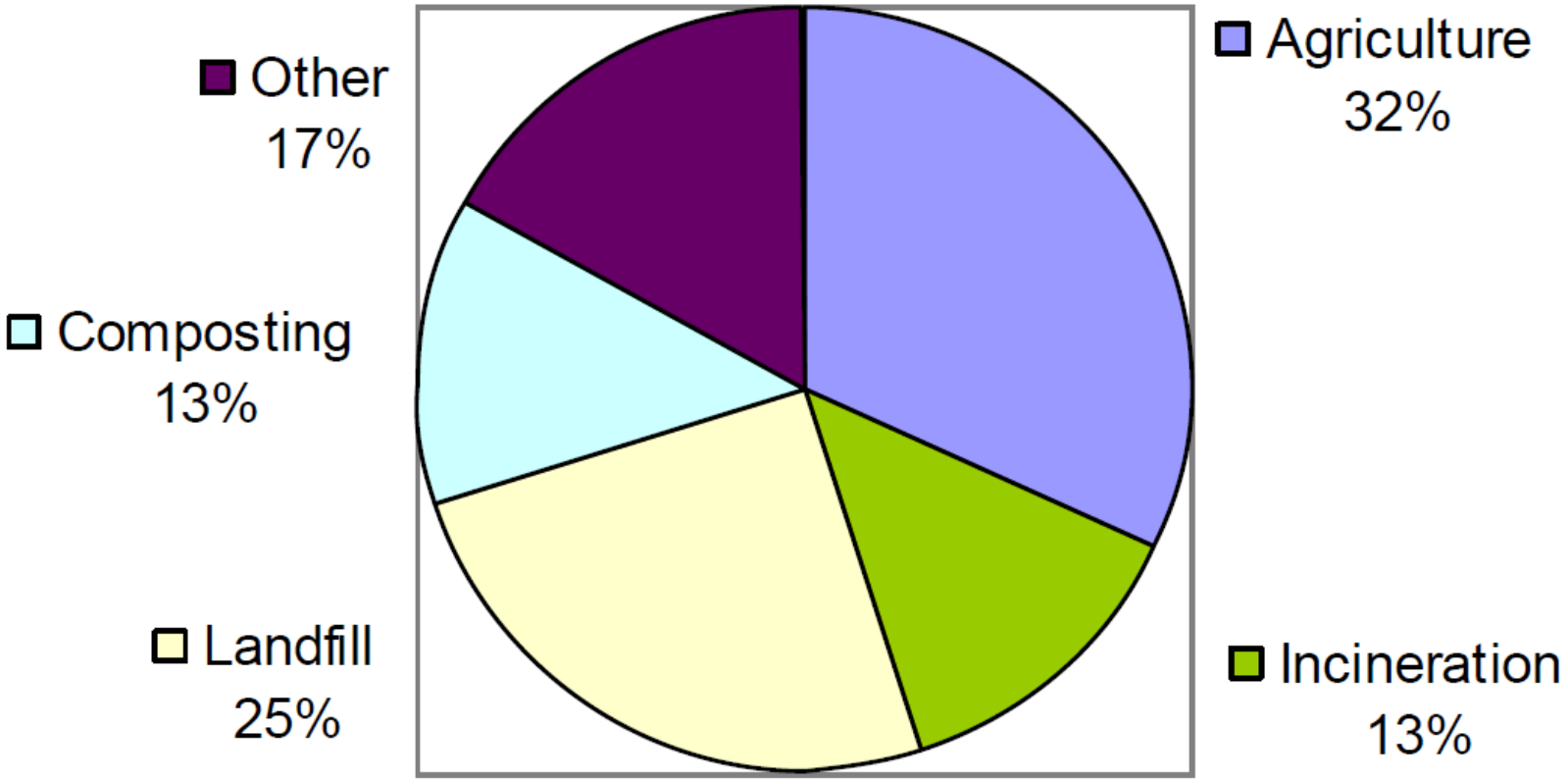
- Avg. Flow Received= 100 MGD (385,000 m^3/ d)
- Design Flow = 110 MGD (425,000 m^3/ d)
- No primary sedimentation, waste activated sludge biosolids are collected from the secondary clarifier to sludge treatment.
- Average sludge quantity generated is about 40 ton VS/d.
- Composting Operating Temperature: temperatures in the range of 60 – 110 °F (15 – 45°C).

Routes for Sludge Disposal

Factors that influence sludge management:

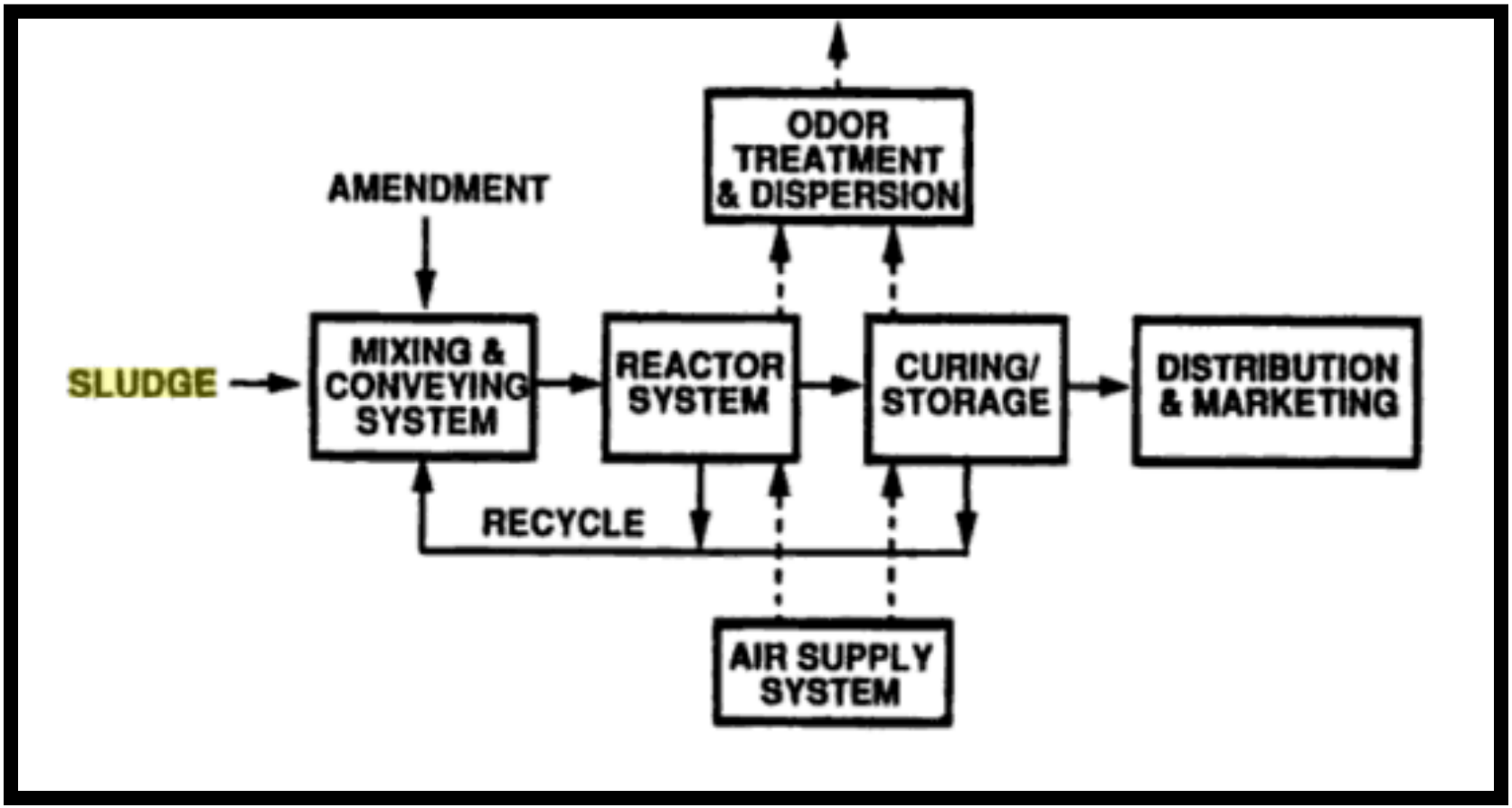
- Cost
- Ease of disposal
- Accessibility of sites
- Human health concerns
- Environmental concerns
- Social concerns

Methods of Sludge Disposal Worldwide



Windrow Composting

Components of an in-vessel composting system



3. Objectives and Scope

- This study was initiated to determine the performance of the composting process at different temperatures.
- Examine process kinetics.
- Field experiments were conducted on samples of sewage sludge mixed with the organic fraction of municipal solid waste.
- Both in-vessel and windrow systems were examined.

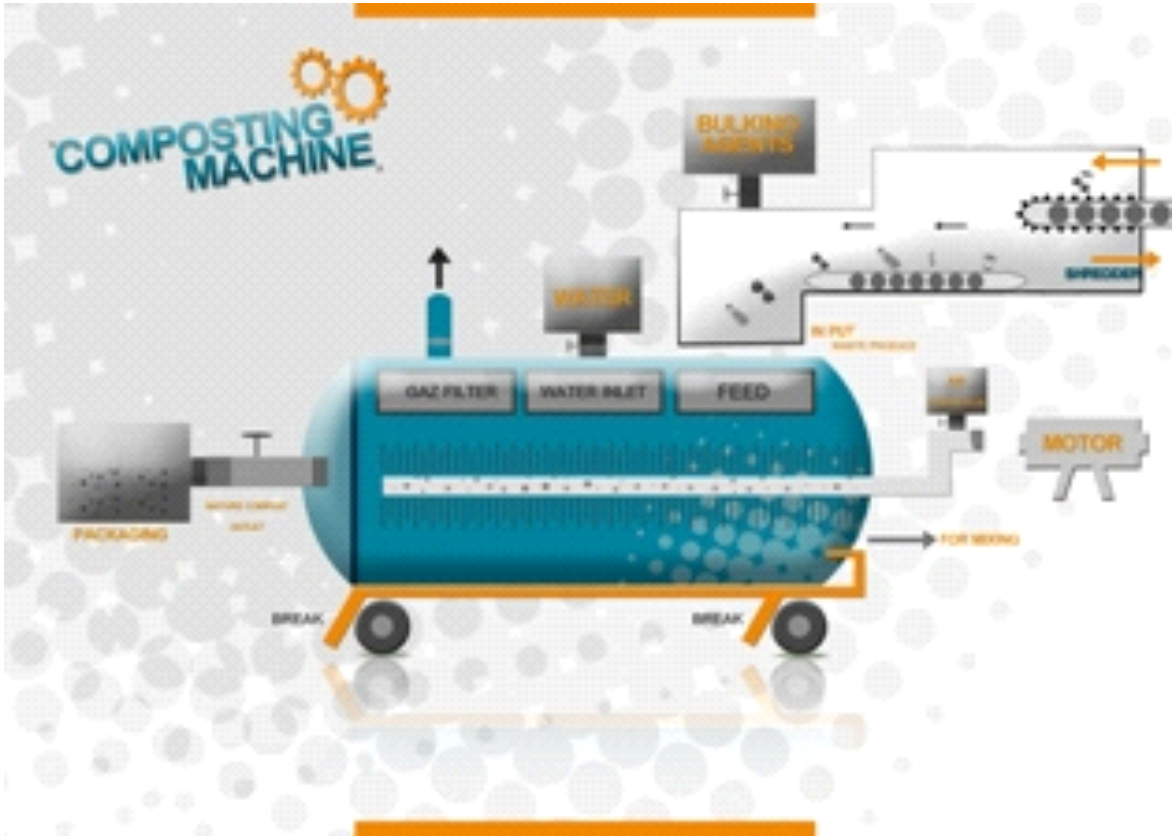
4. Field Experiments

- Experiments were conducted over a period of six months.
- Compared performance of in-vessel and windrow composting.
- Preliminary experiments on mixtures of MSW and sludge showed an optimum ratio of 2:1 (w/w).
- For In-vessel composting, the operating temperature was controlled at preset values to examine process kinetics.

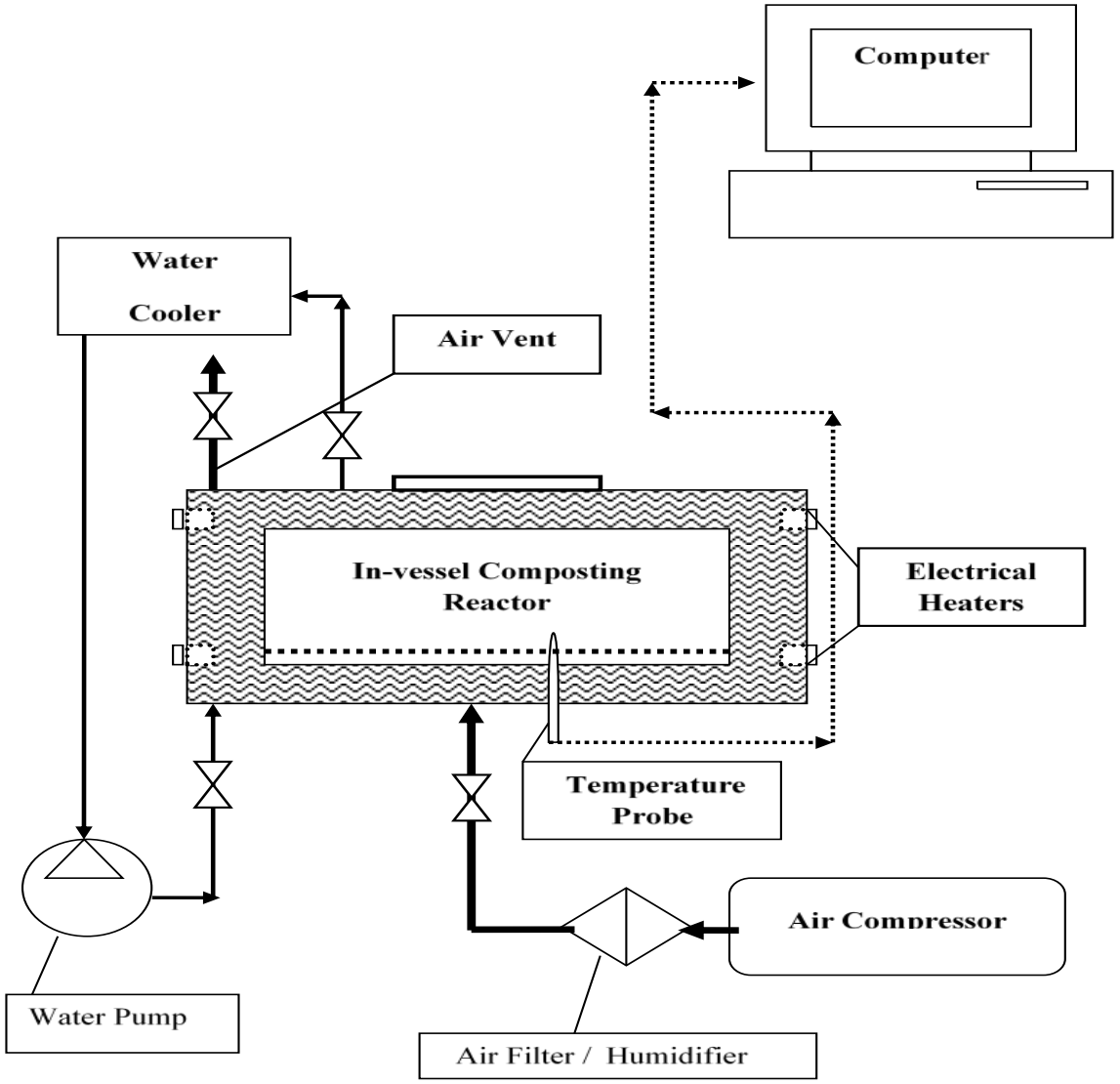
Important Process Parameters

- The chemical & physical characteristics:
  - Moisture will determine the suitability of waste
- Operating conditions of solid waste composting process:
  - carbon-to-nitrogen ratio
  - aeration time
  - reaction temperature
- All of the above impose significant effects on the composting process.
- Therefore it is important to control the above parameters in composting studies.

Pilot Composting Unit



Experimental Set-up



Experimental Analyses

- These included the following:
  - gravimetric analysis to determine:
    - Water content
    - VS content
    - density
  - instrumental analysis
    - Carbon
    - Nitrogen
    - COD
    - OC

Characteristics of Sludge and Solid Wastes

Parameter	SW	MSW
pH	7.4	6.3
Moisture Content, %	85.3	51.4
VS, %	62.33	77.93
Organic Carbon, %	51.1	75.2
Total Kjeldahl Nitrogen, %	2.67	3.14
C:N Ratio	19.1 : 1	23.9 : 1
COD, mg/L	610	420

(a) average values obtained from 12 samples, with standard deviation of ±10% of the average.

Characteristics of mixed MSW and Sludge Waste (SW) at a ratio of 2:1(w/w)

- Sewage is primarily domestic and secondary-settled sludge is thickened (15 % solids)
- MSW is mainly food waste (55%)
- MSW is shredded and screened (particle size : 5mm)
- Highly organic (77%)
- Moisture content (M.C.=60%)
- Carbon/Nitrogen ratio (C/N=20)

Characteristics of Feed Waste Mixture

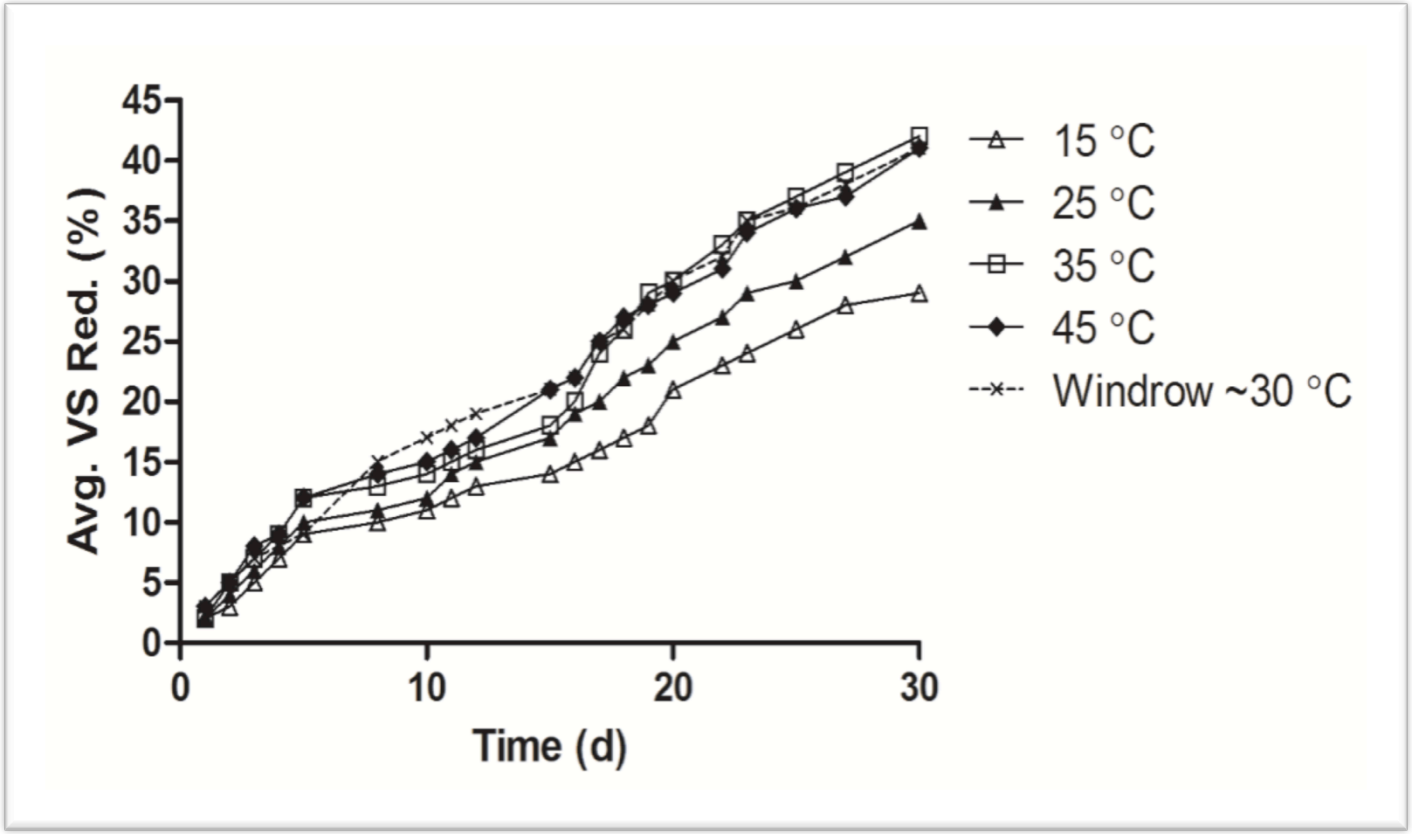
Parameter	Value
pH	6.8
Conductivity (Ms/cm3)	750
Salinity (%)	31
Moisture Content (%)	61.3
Organic Matter @ 550 °C (%)	77.5
Organic Carbon (%)	46.2
Total Kjeldahl Nitrogen (%)	2.97
C/N ratio	20.1

5. Results and Discussion

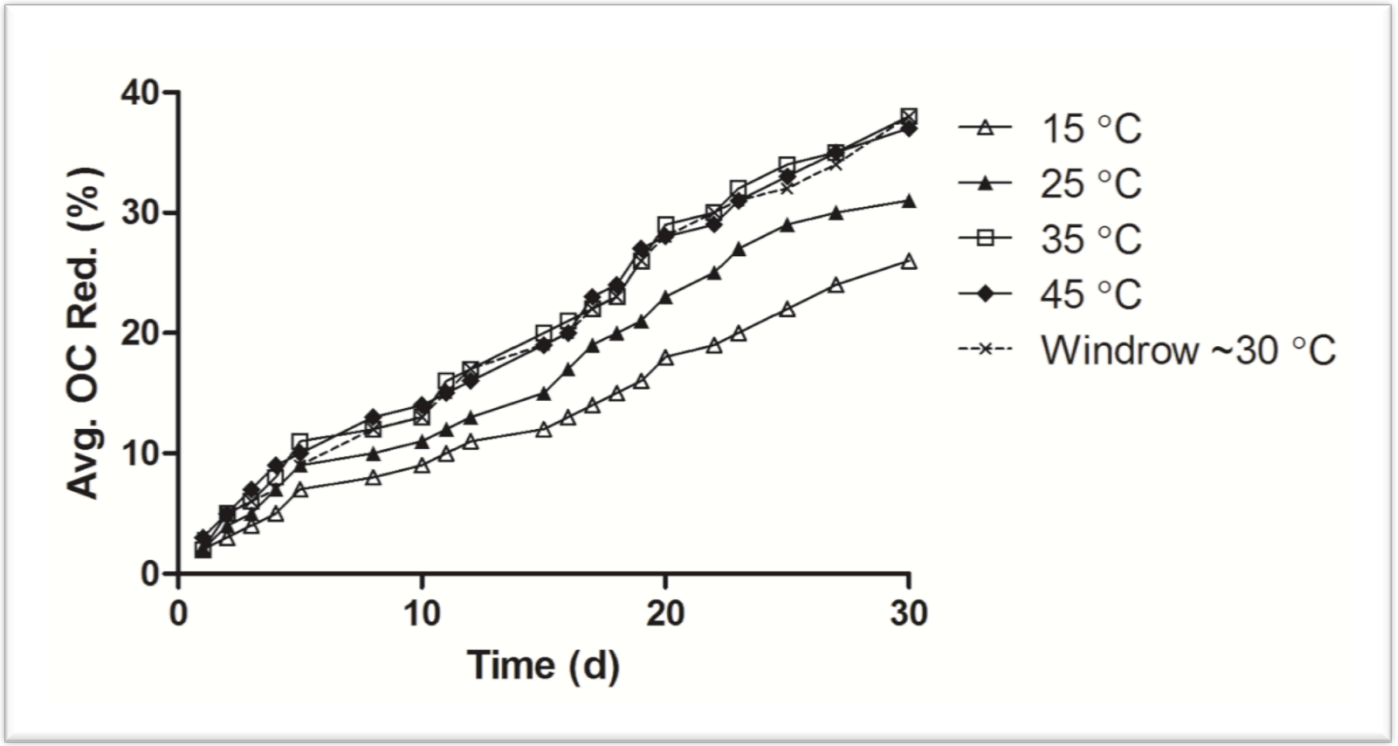
Process performance was evaluated as follows:

- Variations in Temperature
- Reductions in: VS, COD, OC
- Other Parameters: pH, C/N
- Kinetic Analysis
- Temperature Dependence of Reaction Rate Constant
- Statistical Analysis

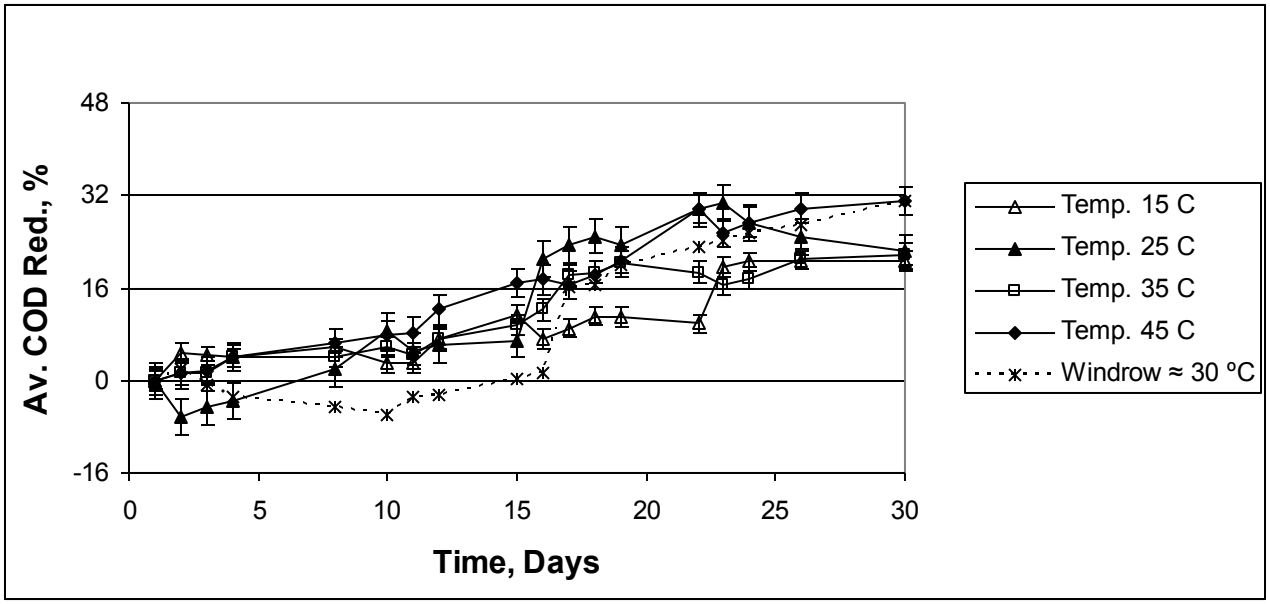
Reductions in Volatile Solids during Composting



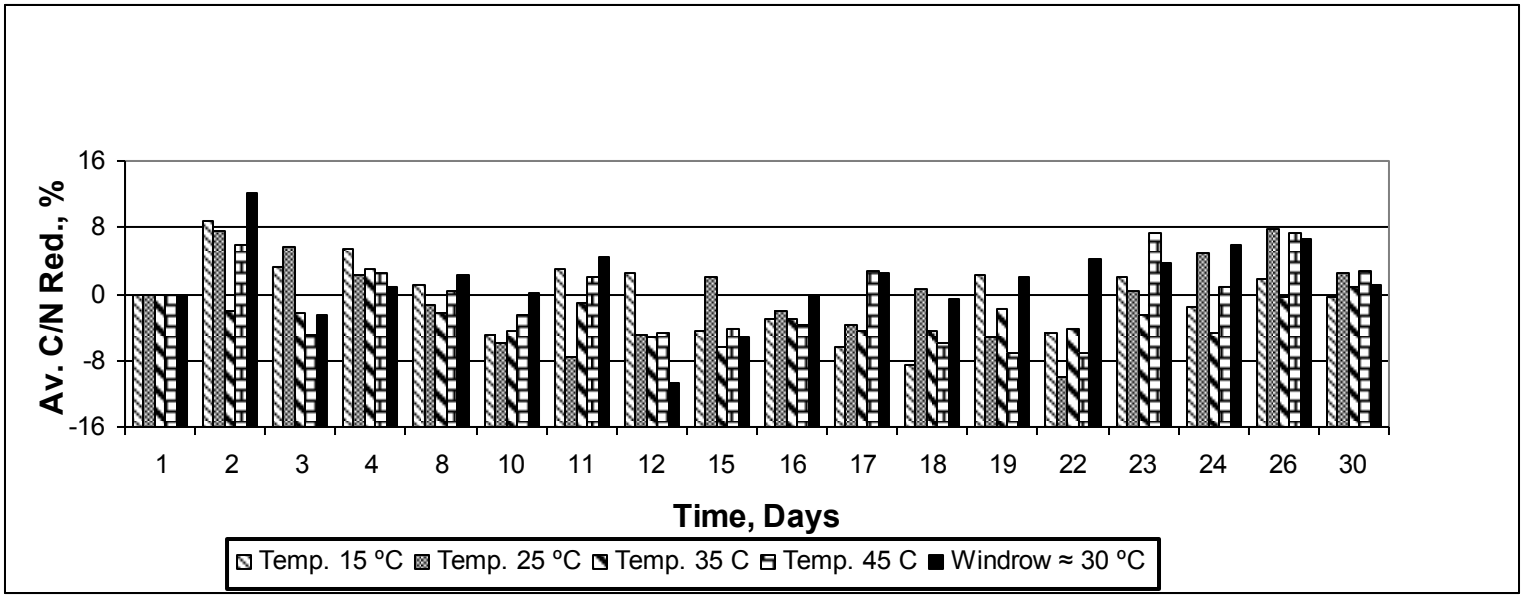
Reductions in Organic Carbon during composting

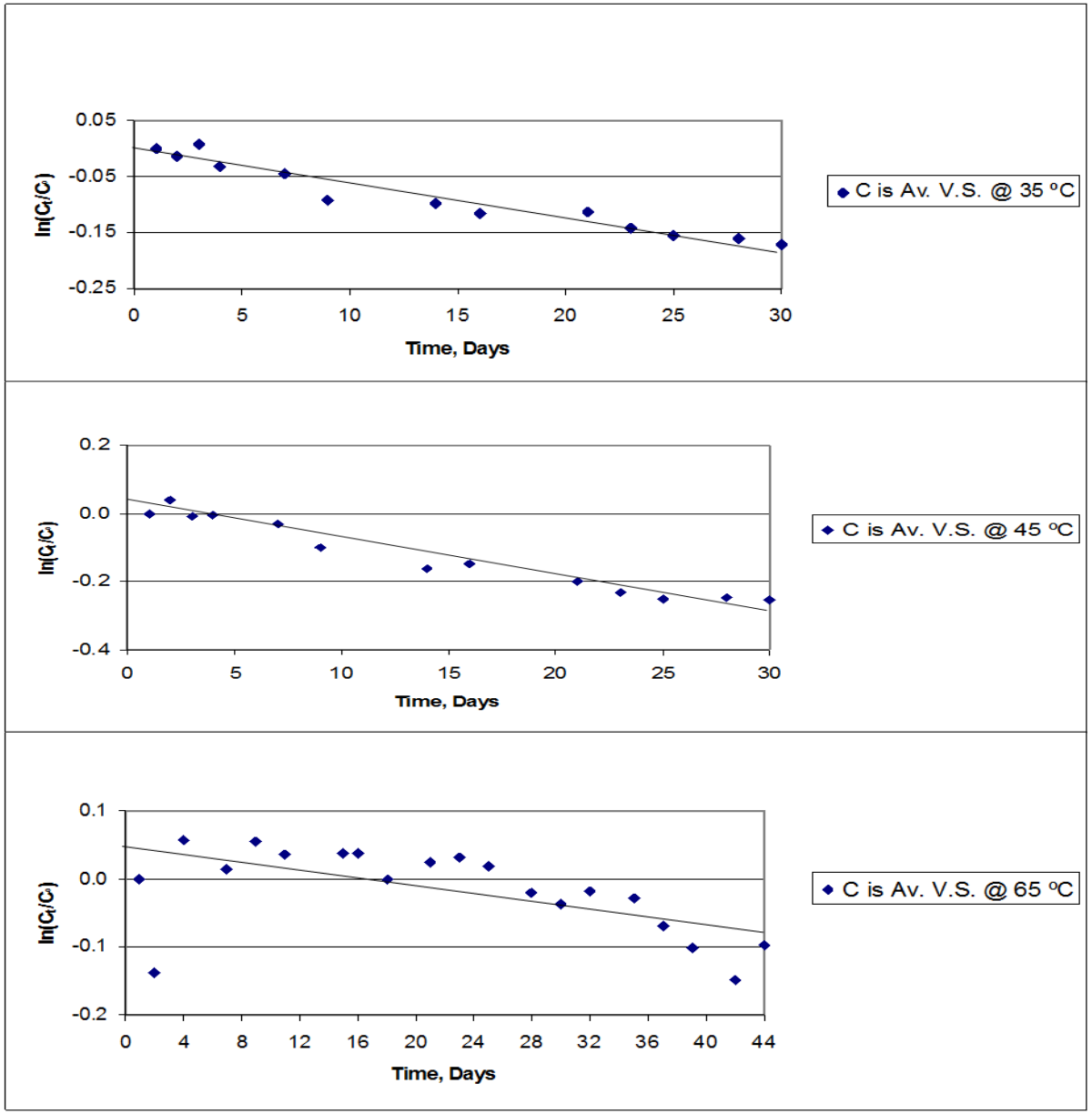


Reductions in COD during Composting



Reductions in C/N Ratio during Composting





Determination of reaction rate constants for composting of 2:1 waste mixture at 25 ºC, 35 ºC, and 45 ºC.

Kinetic Parameters

$Ct / Co = e^{-kt}$ …….. (1)

Where: Co is the initial concentration of organic compound , Ct is the concentration of the organic compound after a degradation time t, and k is the first-order degradation rate constant.

$k2 / k1 = \theta^{(T2-T1)}$ …… (2)

Where: k1 and k2 are the reaction rate constants (d-1) at temperatures T1 and T2 (°C), respectively.

θ is Temperature proportionality constant.

Temp, °C	25	35	45
k, d^{-1}	0.0061	0.0104	0.0126
R^2	0.902	0.945	0.801
θ	1.030	1.050	1. 071

Statistical Analysis : ANOVA test

Variable	Source	DF	SS	MS	F	Pr < F
VS	Model	1	1727.012	1727.011	96.76	<.0001
	Error	62	1106.558	17.84772		
	Corrected Total	63	2833.570			
OC	Model	1	7.08050	7.08050	13.00	0.0006
	Error	62	33.77700	0.54479		
	Corrected Total	63	40.85750			
COD	Model	1	63169	63169	10.70	0.0018
	Error	62	366087	5904.628		
	Corrected Total	63	429256			

Average Properties of Compost *

Property	Value
pH	7.9
Organic Matter (%)	36.1
Organic Carbon (%)	20.3
N (%)	1.1
C (%)	18.9
DOC (mg/L)	400
EC (ds/m)	1.3
N-NO3 (mg/L)	14.5

*30 day composting, DOC = Dissolved Organic Carbon, EC = Electrical Conductivity

6. Conclusions

- The organic content of sludge biosolids is ideal for composting but the high water content of the sludge will make it necessary to add a bulking agent to adjust the water content to 40-60% required for successful performance of composting.
- Municipal solid waste to biosolids mixture of 2:1 by weight is optimal since it has a proper moisture content and generates a compost with good characteristics within 30 days.
- Performance of co-composting system was optimal at 45°C since the organic matter decomposition was accelerated. Reduction in organic content increased with temperature and a linear, first-order kinetic relationship was obtained.
- The optimum carbon/nitrogen ratio is 20:1. In-vessel composting showed slightly better results than windrow composting, which would justify its higher cost.

Conclusions

- Statistical analysis of the data obtained by ANOVA tests at different operating temperatures showed that the level of significance was extremely high with regard to temperature for each of the variables of VS , COD, and OC. This indicates that the operating temperature is an important factor in process performance.
- The process investigated in this study produced a stable compost with balanced nutrients suitable for sustainable use as a plant fertilizer and soil conditioner.
- Safe and long term solutions for the destination of sludge produced by the municipal wastewater treatment is a vital element of a sustainable functioning of the wastewater treatment plants.

Thank You