5th International Conference on Sustainable Solid Waste Management, Athens, Greece

June 21–24, 2017

Co-composting of Sludge and Rice Straw in Full Scale Windrow Piles

A.S. El-Gendy, H. El-Gamal, H.I. El-Kassas, T.M.A. Razik

THE AMERICAN UNIVERSITY IN CAIRO
الجامعة الأمريكية بالقاهرة

Ain Shams University

Contents

- Problem Definition
- Objective
- Materials used and Experimental setup
- Results
- Conclusion

The Problem – Sewage Sludge

- Wastewater collection and treatment facilities in Egypt are currently limited to the main urban centers
- The amount of sludge generated from wastewater treatment plants in Egypt is about **5800 ton** of dry solids **per day**.
- Out of this amount about **2600 ton** is generated **daily** from 340 biological wastewater treatment plants after drying (moisture content around 60%) using drying beds.
- The amount of sludge generated will require disposal or useful use.
- One of the uses of the dry sewage sludge is in agricultural applications. However, sludge has to be treated to be safe during and after applications.

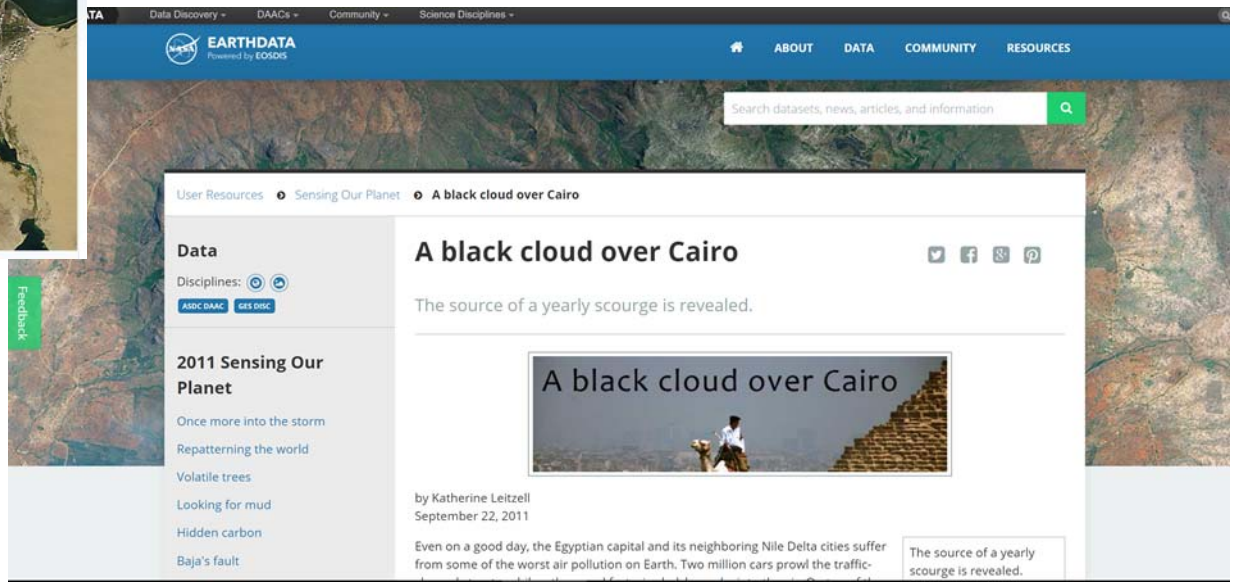
The Problem – Rice Straw

- Rice Straw is an agricultural waste generated from harvesting rice.
- The amount of rice straw in Egypt is about **5.0 million tons/year**; around **3.1 million tons/year** are unutilized and ultimately burnt in open field (Abdelhady *et al.* 2014).

- This practice is one of the main reasons that causes the seasonal air pollution problem in Egypt that is called **Black Cloud**.
- Rice straw is rich in carbon which makes it ideal as a source of carbon in composting process.

The Problem – Rice Straw

Black Cloud



Objective

The current study aims at investigating the possibility of co-composting of rice straw, as a source of carbon, with sewage sludge on a full scale application in Egypt

Waste Materials Used in the Experiments

- Sewage sludge (**S**):
  - Produced from El-Berka biological WWTP.
  - Sludge is collected from drying beds after 4 to 6 weeks of drying. depending on the time of the year.

- Rice straw (**RS**):
  - Collected from farms in the Delta region, Egypt.
  - it stockpiled at the site and shredded before use to pieces of about 10 cm size.

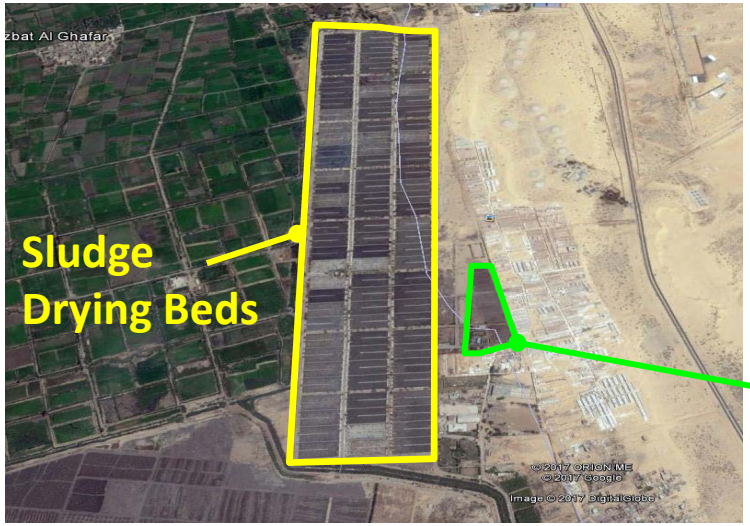
- Recycled Compost (**C**): Part of the produced compost that is coarse in size was used as one of the composting materials.

Waste Materials Used in the Experiments

Parameter	Sludge (S)	Rice Straw (RS)	Recycled Compost (C)
Total Nitrogen (%)	2.5	0.7	1.8
Ash (%)	39.8	18.4	55.0
Total Carbon (%)	34.9	47.3	26.1
Total Phosphorus (%)	0.83	0.11	1.33
Total Potassium (%)	0.31	1.08	0.51
Moisture contents (%)	75	10	30
pH	7.38	7.00	7.80

Experimental Setup – Location and Conditions

The experiments were carried out in a **full scale** level at a composting site (9 Feddans) near El-Berka WWTP, Greater Cairo, Egypt.



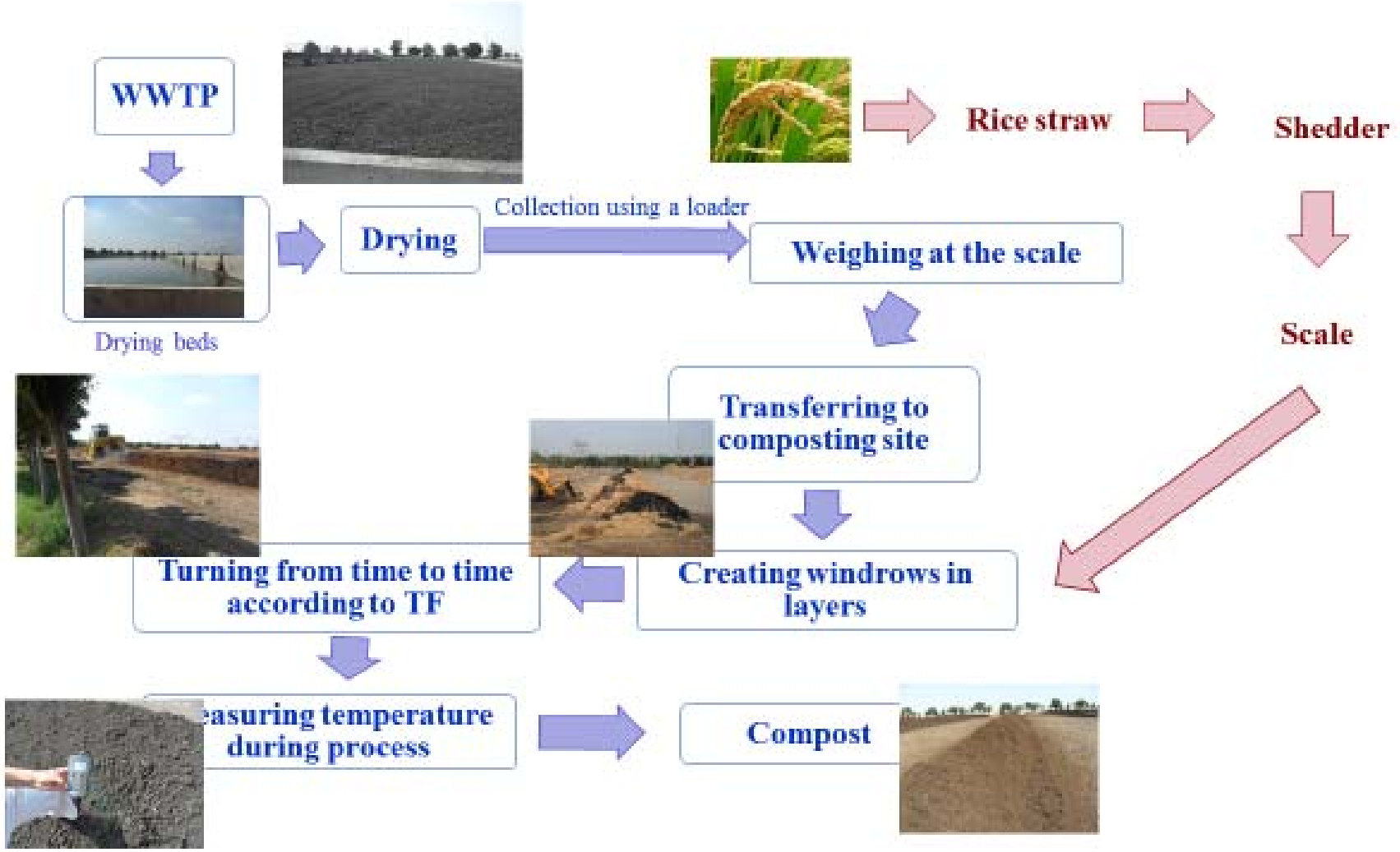
Experimental Setup – Windrows

- **Ten windrows** were constructed to study the co-composting of sewage sludge with rice straw.
- The followings were studied in the experiments:
  - The mixing ratios of S:RS:C (**6 different mixing ratios**)
  - The turning frequencies of the windrows (**3 turning frequencies/week**)

Windrow	MR S:RS:RC	RS	C:N	TF (#/W)	Length (m)	Width at the base (m)	Height (m)
W1	1:1:0	Medium	26:1	2	70	3.0	1.25
W2	3:1:0	Lowest	19:1	2	70	3.0	1.25
W3	1:3:0	Highest	37:1	2	60	3.0	1.25
W4				1			
W5				3			
W6	2:1:1	Lowest	19:1	3	65	3.0	1.30
W7				1			
W8				2			
W9	2:0:1	No RS	14:1	2	50	2.5	1.20
W10	1:0:0	No RS	14:1	2	50	2.5	1.20

Creating the Windrows – Equipment Used

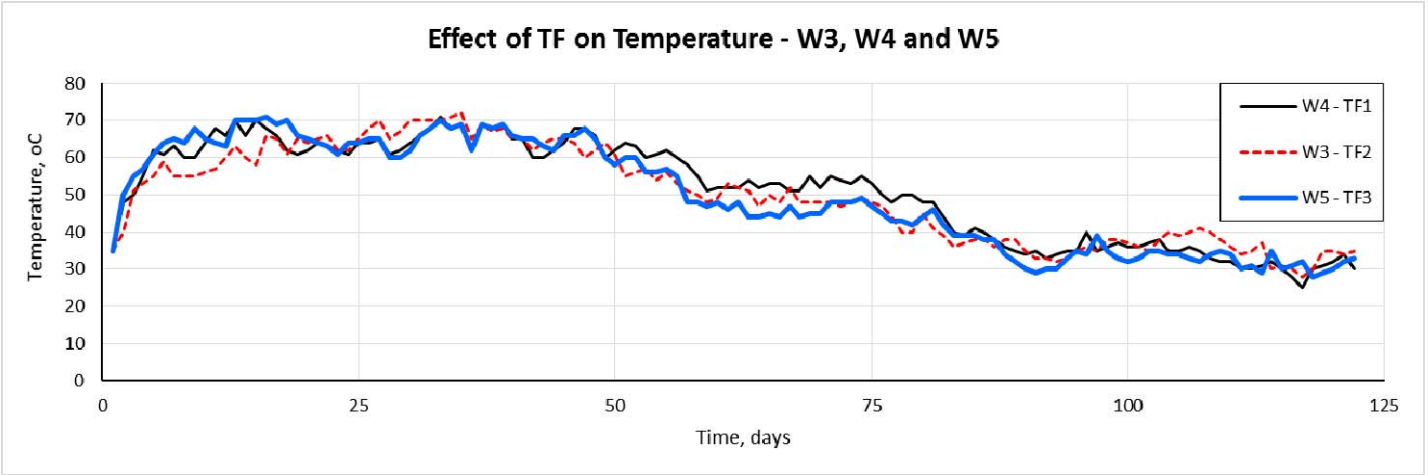
Creating the Windrows - Steps

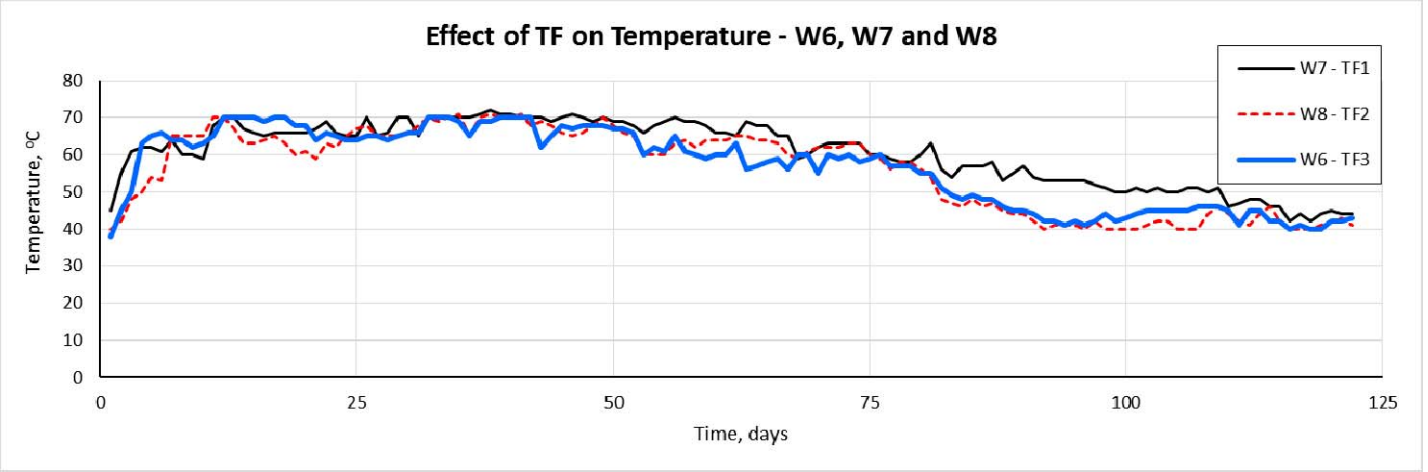


Experimental Setup – Measured Parameters

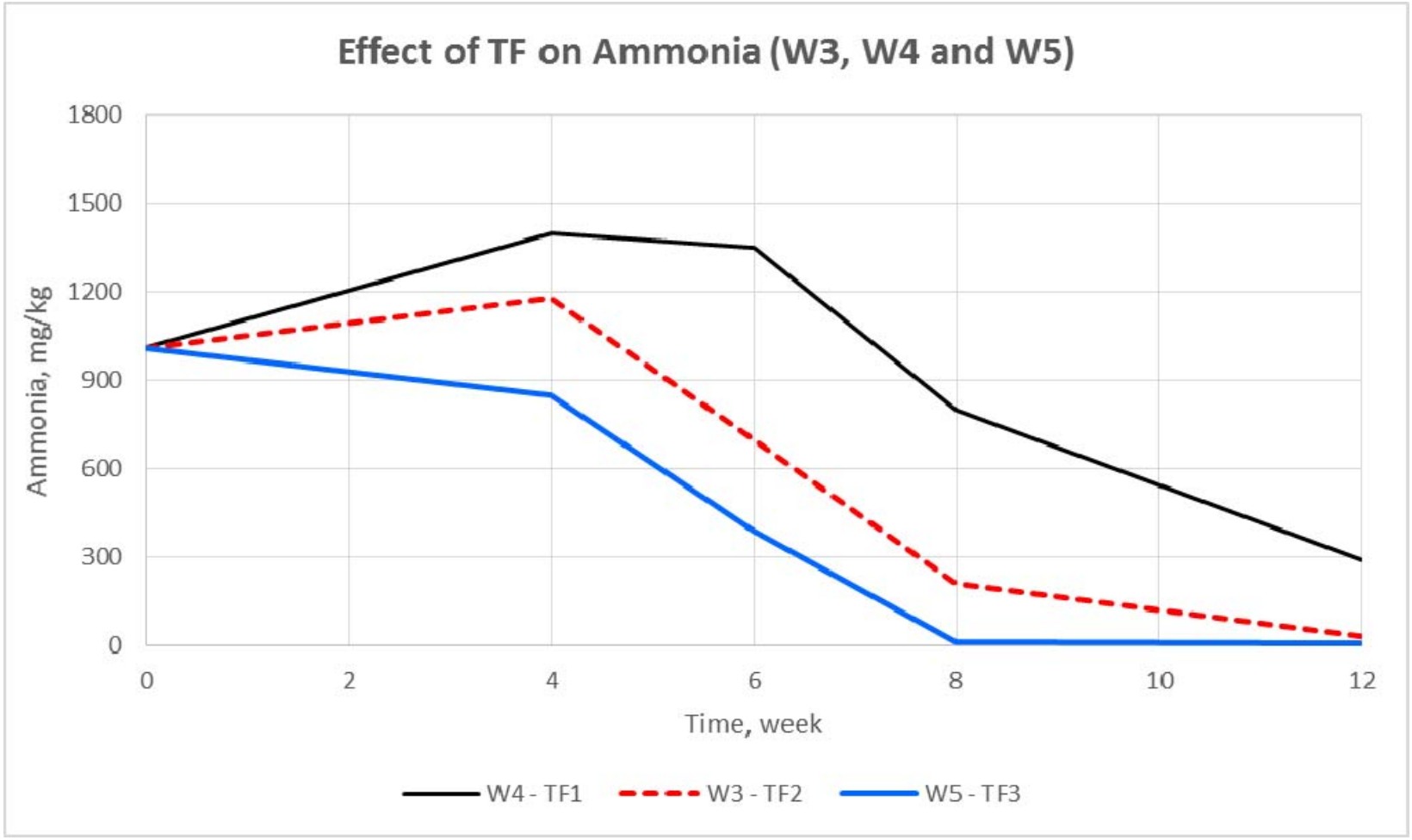
Parameter	Beginning	During (4, 6, 8, 12 W)
Temperature, °C	Daily	
water content	x	x
pH	x	x
organic matter (carbon contents is calculated using Van Bemmelen factor)	x	x
TN	x	x
ammonia	x	x
Nitrate	x	x
TP	x	x
TK	x	x
Pathogenic Indicators	x	x
Heavy Metals		x

Effect of Turning Frequency on Composting - Temperature

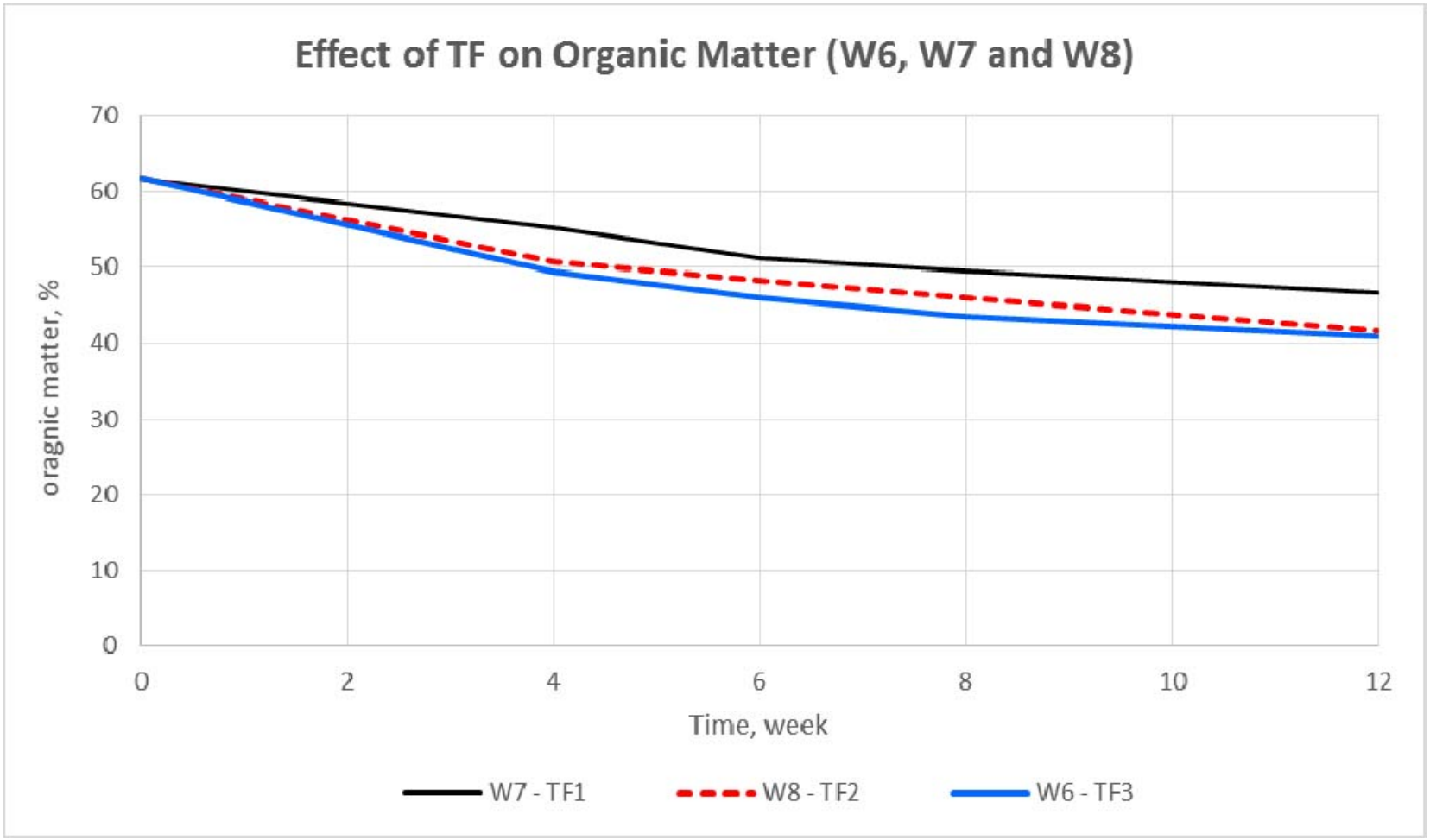




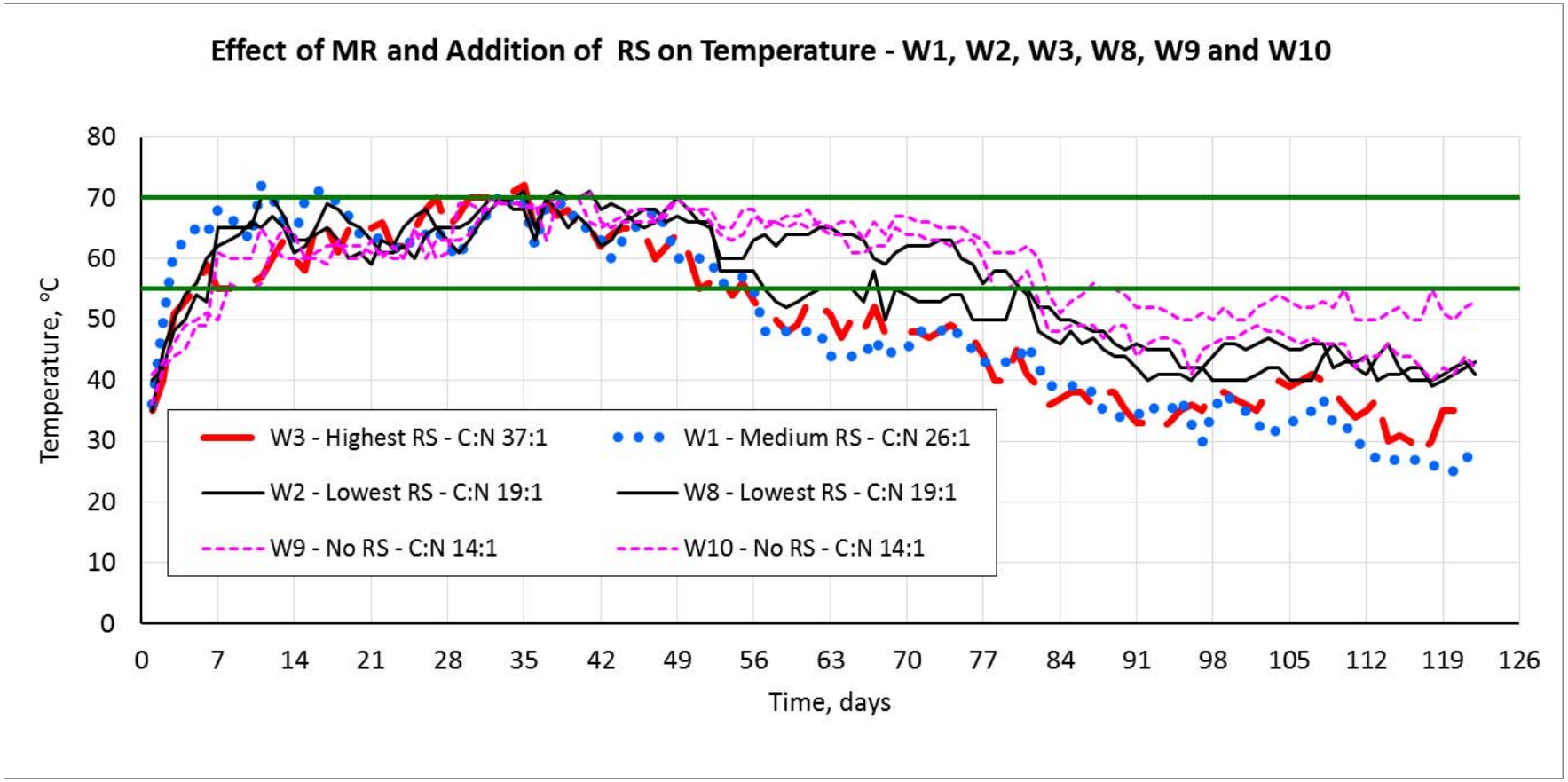
Effect of Turning Frequency on Composting - Ammonia



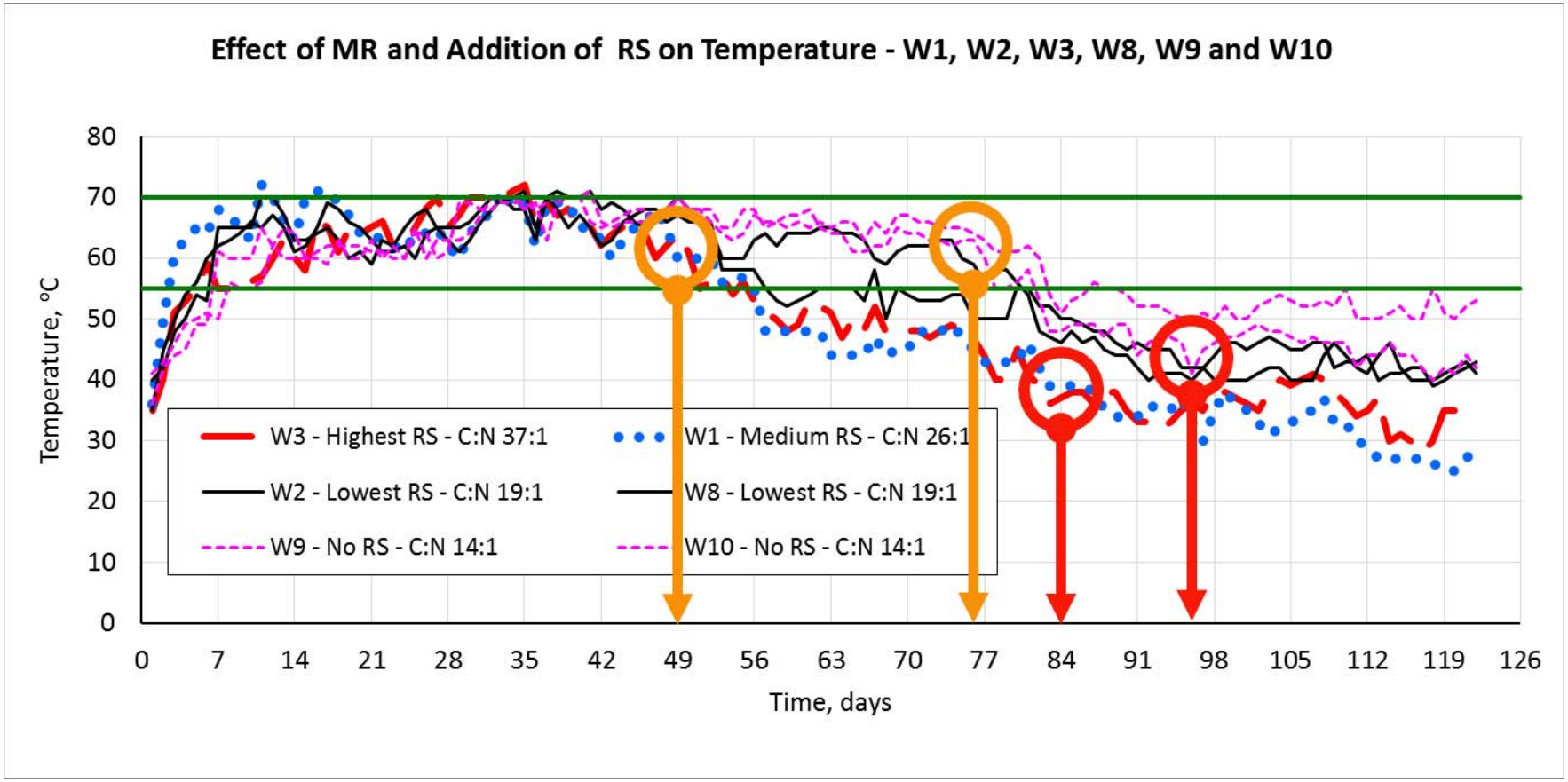
Effect of Turning Frequency on Composting – Organic Matter



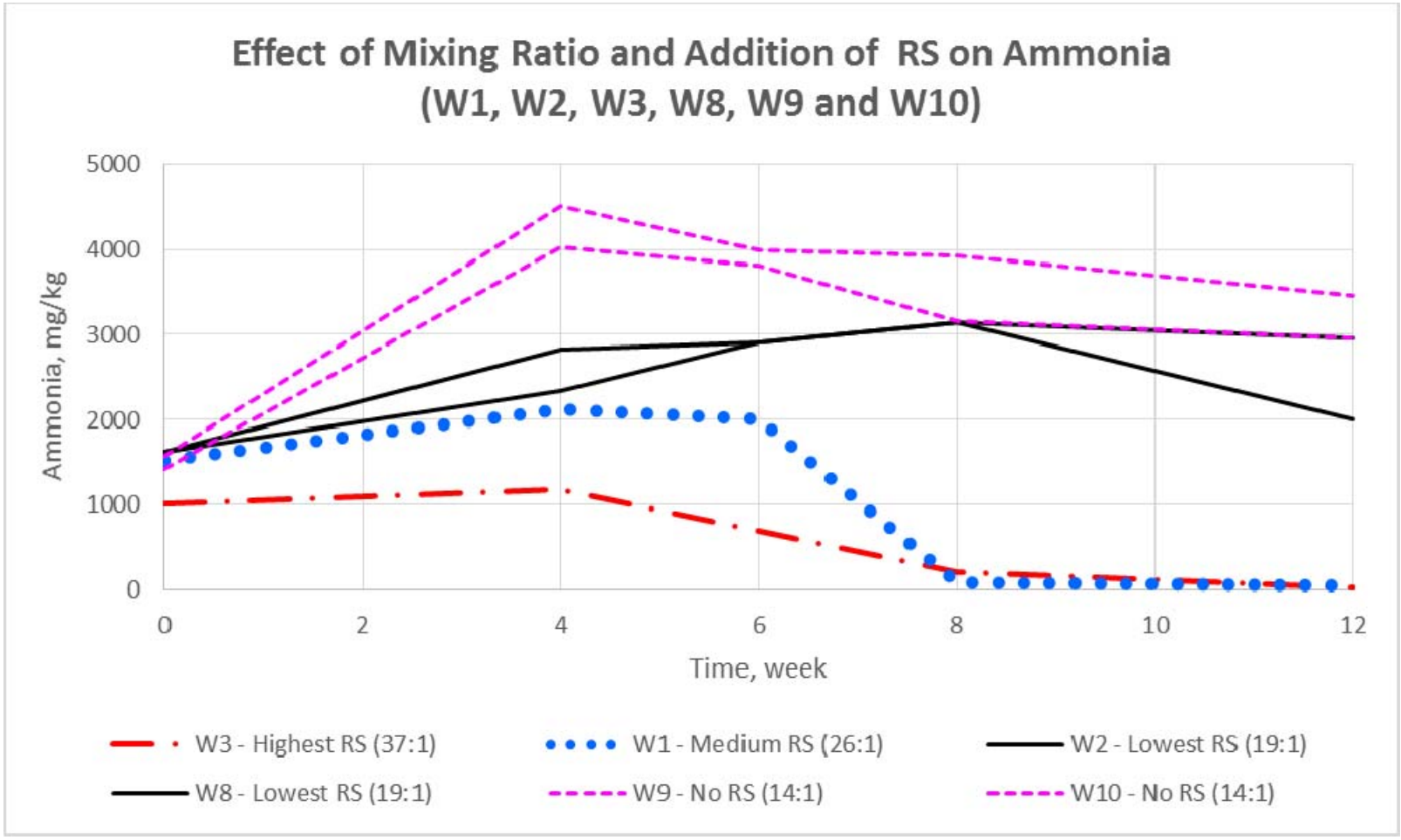
Effect of Mixing Ratio and Initial Contents of RS on Composting (TF = 2 per week) - Temperature



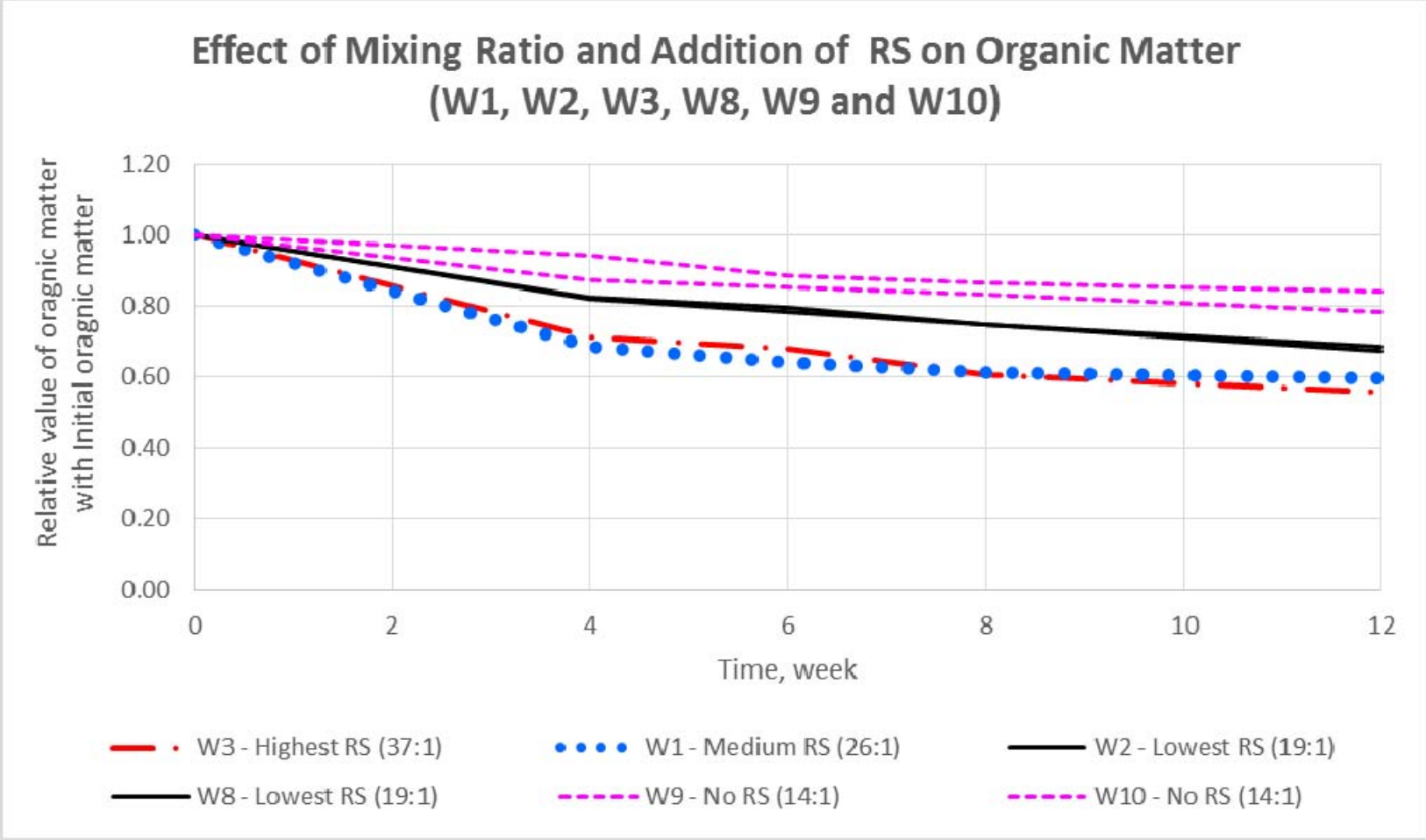
Effect of Mixing Ratio and Initial Contents of RS on Composting (TF = 2 per week) - Temperature



Effect of Mixing Ratio and Initial Contents of RS on Composting (TF = 2 per week) - Ammonia



Effect of Mixing Ratio and Initial Contents of RS on Composting (TF = 2 per week) – Organic Matter



Final quality (12 weeks) of the compost from windrows of the recommended mixing ratio and highest C:N ratio (W1 and W3)

Parameter	W1 (C:N = 26:1) 1:1:0	W3 (C:N = 37:1) 1:3:0
water content	30%	30%
pH	6.7	7.1
C:N	10:1	18:1
TN	2.6%	1.3%
ammonia	58 mg/kg	33 mg/kg
TP	1.72%	1.73%
TK	0.6%	0.73%
Pathogenic Indicators	ND	ND
Volume reduction (after 16 W)	79.4%	69.9%
Density (after 16 W)	777 kg/m^3	759 kg/m^3

Heavy Metals (mg/kg) in the compost (12 weeks) from windrows of the recommended mixing ratio and highest C:N ratio (W1 and W3)

Element	Limits (Egypt)	W1 (C:N = 26:1) 1:1:0	W3 (C:N = 37:1) 1:3:0
Zn	2800	21	20
Cu	1500	3	2.9
Ni	420	12	10
Cd	39	1	1.1
Pb	300	200	200
Hg	17	Nil	Nil
Cr	1200	294.2	272.6
Mo	18	3.8	3.3
Se	36	15	13
As	41	15	13

Conclusion

- Rice straw can be co-composted with sewage sludge from drying beds at biological treatment plants. It is a good supply of carbon and
- For the tested mixing ratios in the current study, mixing ratios (S:RS) of 1:1 to 1:3 (corresponding to C:N ratio of 26:1 and 37:1, respectively) can produce a high quality compost in shorter times.
- Turning frequency has little affects the composting process. A turning frequency of 3 times per week can provide a compost in a shorter time. However, little differences were noticed between a TF two and three times every week. Therefore, for a more sustainable (less energy use) and efficient process, a TF of two times per week is recommended for the optimum mixing ratio (above).
- For each ton of mixed materials (S+RS), compost with a mass range of 0.46 to 0.57 ton can be obtained by the end of composting and depending on the mixing ratio.

Conclusion

- Using the recommended mixing ratios and turning frequency, the duration needed for composting of sludge with rice straw is 7 to 8 weeks in active composting and 4 weeks in maturation to obtain a safe product. Other mixing ratios will require higher time for composting and maturation.

- The utilization of the rice straw (up to 3.1 Mt/yr) and the dry sewage sludge from biological WWTP in Egypt (about 0.95 Mt/yr) can significantly reduce the formation of the seasonal black cloud in the delta of Egypt. This will definitely improve the air quality in the area and reduce the health effects of the black cloud.

- Knowing that most of Egypt is a desert area, the co-composting of rice straw and sewage sludge can produce 1 to 2 Mt of a quality compost per year. This amount can be used in the desert land reclamation and in cultivation to fulfill the needs for expanding the cultivated areas in Egypt to meet the increasing demand on food.

Team

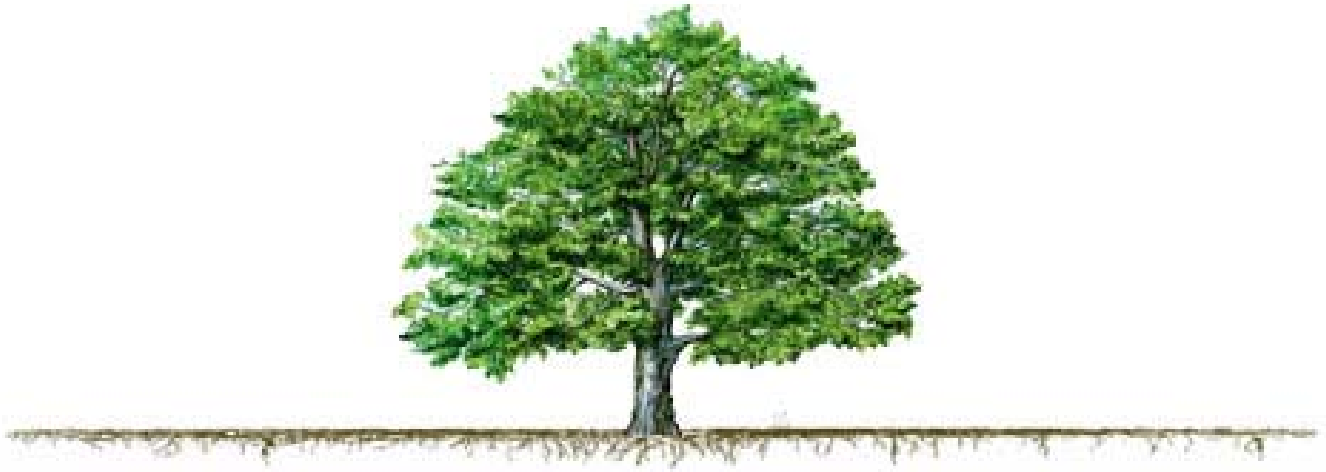
Eng. El-Gamal

Dr. El-Kassas

Dr. Razik

Dr. El-Gendy

Questions



Thank You