Final report

"Composting Project in the China Sweden Erdos Eco-Town"

Dongsheng, Inner Mongolia

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1. Preamble

During my internship at the Center of Sustainable Environmental Sanitation at the University of Science and Technology Beijing (USTB), I got the opportunity to work as a research fellow for the Eco-Town Project in Dongsheng. Since I am studying Agricultural Science, and my studies are focused on plant nourishment and fertilizing, the adviser work in the ERDOS Eco-Town compost plant and to develop its operation was a suitable position for me. My task was described as shared responsibility to support the commencement of operations after the construction works (compost holders, revolving machine) were completed. The main goals during my stay on site were (1) improving the routine of the workers and the composting process; (2) training of the workers in hygienic aspects and proper handling of feces compost. Furthermore, it was my goal to investigate the hygienic level and, respectively, the fertilizing value of the final product. After the construction work of the adapted revolving sorting machine and the aerated compost box holders were done in the beginning of October 2008, I spent my first days from 10/6 until 10/9 in Dongsheng to become familiar with the location. During this stay, I studied the information from Lvhuanben company about their idea on the composting process, and how the composting plant should be taken in operation. When I came back to Beijing, I started literature research about national and international guidelines for composting human feces, rather background information about composting in general. Furthermore, I compiled a "to-do" list for laboratory analysis, as N, P, K and hygienic status. Ffinished my preparations I stayed from 11/12 until 12/19 on site in Dongsheng to work on the start-up and improvement of the compost process, develop and introduce a work routine of the staff and taking samples from the compost for the later one laboratory analysis in Beijing.

Returning to Beijing I handed over compost samples to the agricultural biotechnology research center Beijing for analyzing the hygienic status. My post-editing and research work took again one month. In the sum, I spent almost 4 months during my internship in Beijing on the composting project in Dongsheng.

2. The Composting Process

Lvhuanben, the company that was responsible for creating and installing the compost plant, handed over a manual for composting the feces with the use of *Effective Microorganism (please find a short abstract of the preliminary manual in the appendix)*. However, there was some evidence that determined the necessity for improvements to the manual to adapt it further to local needs. First, the original manual claims a duration of ca. 35 days, but on the other hand it recommends to level the maximum temperature around only 30°C. The duration is more similar to hot-/fast composting, but the temperature of 30°C is a sign of cold-/slow composting. In addition, regarding the potential hygienic risks, and respecting Chinese national and WHO guidelines it is necessary to have higher temperatures (> 60°C) to sanitize the compost. Second, as soon as the air supply (according to the instructions of original manual) was stopped, a distinctive decrease in temperature and an increase of odor (ammonia emissions) was experienced. Furthermore, based on the pilot experience it was recommended to establish an additional weekly mechanical ventilation with a pitchfork or a similar tool. Because of the dead load of the compost pile, a very airtight layer at the bottom was the result, which leads to an insufficient air supply in the inner layer. As further result, the air-exposing schedule was changed. Instead of turning it off after three days, the air-pump remains switched on until day 25, and the work rhythm of it was changed from 1h/1h to 4h/4h rhythm. This allowed to pump more air through the pile in a longer time period.

Another problem that emerges by following the guideline from *Lvhuanben* was a decrease of the compost temperature as soon as the floor heating in the compost holder boxes was switched off. This decrease could be a result of the combination of the small amount of compost paired with the low temperatures of the Inner Mongolian long winter. As the compost holders were filled to the rim, the amount of compost produced biologically enough thermal energy for a steady high temperature at the core. In addition, as soon as the organic waste from the households was added to optimize the C/N ration, it could achieve an increase of temperature as well. However, the outer layers are still problematic, which forced us to use the heating system until the very last ten days resting period – which, besides the need to destroy the airtight bottom layer, further illustrated the need for mechanical ventilation. Unfortunately, the ventilation work became harder as more compost was added to the compost holder.

Reaching the 35th day of maturation, according to the guidelines, cycle #1 was finished. Regarding the odor of the final product, the compost seemed to be finished, there was a soil like smell, but after a closer examination, still many dry fecal and kitchen waste structures were found - which is an evidence of an unfinished composting process. That is why we decided to start some experiments to increase the duration of the maturation period. As mentioned in the beginning, *Lvhuanben* recommended the use of *Effective Microorganism* to inoculate the compost *(If effective MO exists, does ineffective MO exist as well?)*, but until today, *Lvhuanben* didn't communicate what MOs should be used for the *EM* mixture. This reinforced doubts about the objective effect of *EM*. Thus, an experiment inoculating fresh compost with matured compost from a former cycle (with EM) as inoculum was launched, and the timeline of *Cycle #2* provided interesting results *(refer to appendix*).

However, we found out, that it is necessary that the old compost should be not younger than eight days, and the ratio has to be modified. It is correct to say it maintains the same effect of *EM*, but utilizing old compost will cut costs of having to purchase new *EM* strains. What are *Effective Microorganisms*? You find in the web many commercial websites promoting *EM* but hardly one gives objective information about the function of *EM*. In general, EM it is a mixture of three different groups of MO, lactic acid bacteria, yeast and phototropic bacteria. However, very interesting is the information given on www.wikipedia.org:

"Effective Microorganisms, also called EM Technology, is a brand name for a series of products utilizing a base culture called EM 1 Microbial Inoculants. "EM Technology" is an as yet scientifically unconfirmed method of improving soil quality and plant growth using a mixture of microorganisms consisting mainly of lactic acid bacteria, purple bacteria, and yeast which co-exist for the benefit of whichever environment they are introduced. It is reported [1] to include:

* *Lactic acid bacteria: Lactobacillus plantarum; L. casei; Streptococcus Lactis.*
* *Photosynthetic bacteria: Rhodopseudomonas palustris; Rhodobacter sphaeroides.*
* *Yeast: Saccharomyces cerevisiae; Candida utilis(no longer used) (usually known as Toula, Pichia Jadinii).*
* *Actinomycetes(no longer used in the formulas): Streptomyces albus; S. griseus.*
* *Fermenting fungi(no longer used in the formulas): Aspergillus oryzae; Mucor hiemalis."*

According to the guideline from *Lvhuanben,* the moisture content should be leveled between 10% and 20%. This is quite dry for any microorganism life, even dry fermentation works with

at least 40%. Luckily, the feces used were very wet. However, the method to determine the moist content is crude (forming a compost ball and dropping it on the floor, if it collapses while dropping, the compost is too dry and if the ball does not burst after hitting the ground, the compost is too wet). In addition, the compost-holder boxes are adequately protected against too much evaporation. To reach the right level of moisture, the workers add either sawdust or water. The moisture content should be at least around 40%, but according to the mentioned items, it seems the moister content is not a big problem.

Fig.1 Process scheme *: using revolver screen machine

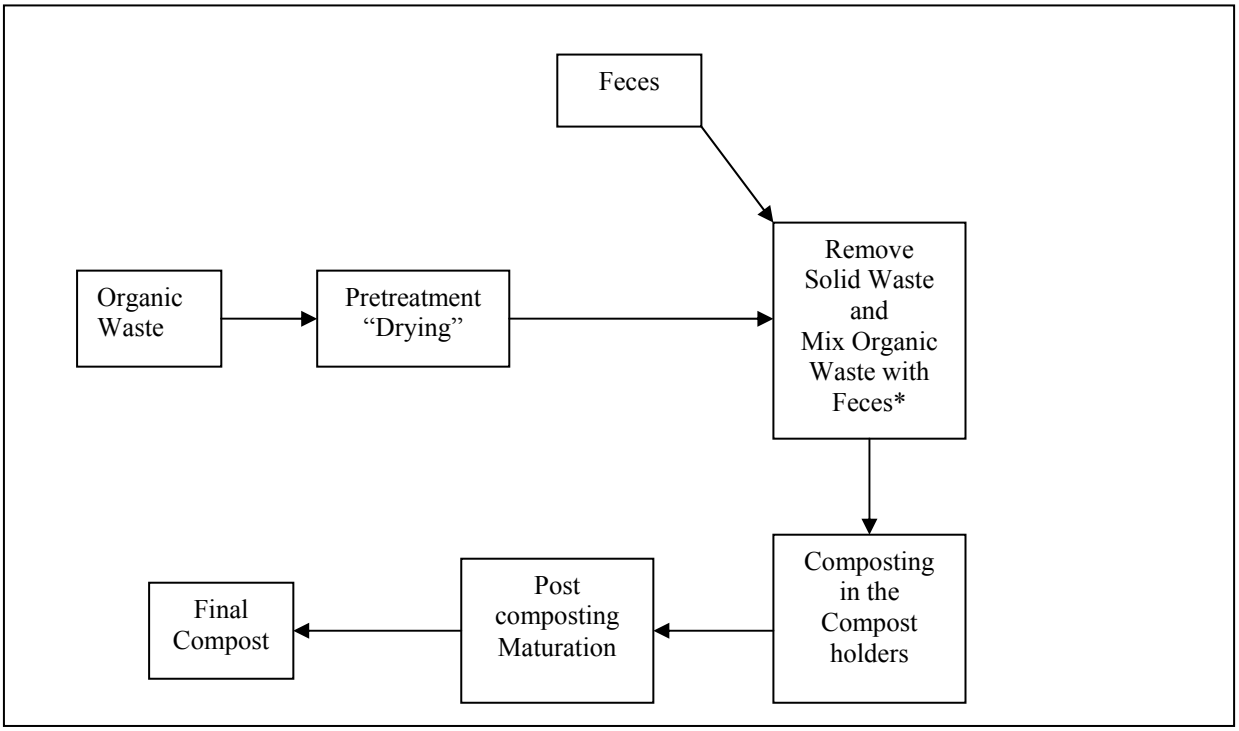


Photo1 Floor of the compost holder box with the air holes

Unfortunately, the revolving machine installed by *Lvhuanben*, which should remove the solid waste out of the feces did not work sufficiently. Therefore, the workers had to remove the waste by using a gripper. In addition, a post-composting cleaning treatment is also necessary. Regrettably, we are faced with a lot of solid waste in the feces bins (Photo6).

Fig.2: improved manual:

- Moisture content of the compost not less the 40%
- To inocculate a new compost cycle mix it in the ratio 1 part mature compost with 250 parts of new compost
- Maturation duration Σ 35+:
  - → Day 1 until Day 3: Air-exposure
  - → Day 4 until Day 25: Air- exposure and heating (30°-40°C) If the ambient temperature is not too low, stop heating after Day 8
  - → Day 26: Changing the compost holder, stop air-exposure and heating. At least resting until Day 35, but if necessary even longer
  - → From Day 4 at least once per week mechanical ventilation until Day 25, and as soon as during the resting period, emerges some ammonia odor, keep on ventilating until the end
- Documentation:
  - → Measuring the temperature of the compost every day twice, in the morning and in the evening
  - → Document the status, progress and further actions for each cycle at the door of the compost holder

This manual is based on one month of personal operational experience on site. I think there is still a lot of space for practical improvement. I can only hypothesize about how the organic kitchen waste will influence the composting, e.g. as source for carbon and providing structure for a better airflow inside the pile. Further, I cannot tell if there will be a need for heating during the summer. Therefore, I recommend that the same research work should be repeated by USTB during July and August 2009.

Another problem in the summer is the potential effect of insect repellant on the composting process, as the workers use repellant to limit fly breeding in the feces bins. It was not possible to find the composition of the repellant they use. Its toxic content and the potential impact on the compost quality and the process should be carefully analyzed, too.

Photo2 Compost holder with marked door

3. Hygienic Considerations

This Chapter deals with both work hygiene and hygienic status of the compost.

For the personal protection of the workers, we bought several sets of work gear. Each worker received a pair of rubber boots, two work jackets and two work pants, two pairs of gloves, two caps, three dust masks and a towel. As the material was handed over to the workers, they had to sign a receipt, and they have been informed about their obligation to wear their work gear anytime they are at the composting plant. Two grippers, four shovels, a pitchfork and two brooms only for use in the compost plant were also bought.

After starting the first cycle, it became obvious that the composting team needs a place to wash tools and boots, as well as a shower room and a washing machine for the work cloths. Therefore, a water hose was installed inside the compost plant for cleaning tools and boots, and in the first floor of the ECO-building, a local Construction Company installed a shower room with a washing machine.

Photo3 workers with work outfit

Photo4 hose inside the compost plant

Further problems included the work hygiene of the compost team, and the fact that the sawdust for the households is packed in the same building where the composting process takes place.

It was a ongoing task to persuade the staff to wash their hands after work and that smoking in the plant while wearing work gloves, is dangerous for their own health →*smear infection.* The need for a proper and clean work and compost plant →*avoiding dispersal of potential pathogens etc*. had to be explained at any time. Additionally, they were informed to change

their work clothes as soon as they were badly soiled or at least every week, and they must wash them with hot water.

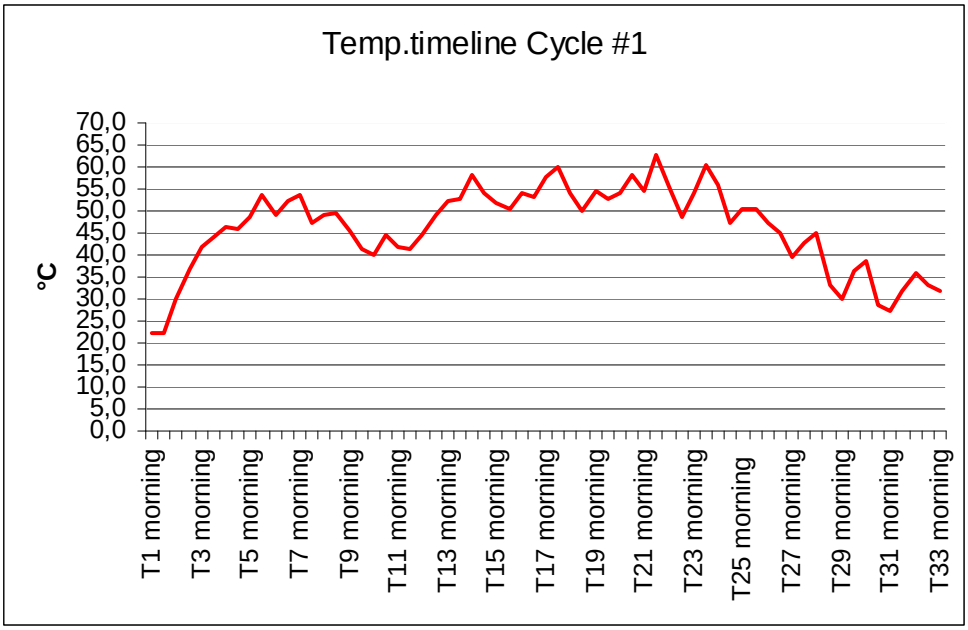
Photo5 Partition wall built to separate compost and saw dust packing

Since the sawdust is dried and packaged in the same building as the composting takes place, the risk of fecal contamination is very high. Especially, if the workers use the dried sawdust for leveling the moisture content using dirty shovels and cleaning their boots with it. To avoid bringing the potential pathogens back to the households a partition wall inside the compost plant was built, to separate clearly composting from the sawdust department.

There are three different methods of determining the hygienic status of the compost: (1) include monitoring the process, (2) investigating the final product, and (3) verifying the process by inserting test pathogens.

On site, the temperature of the compost was measured and recorded every morning and evening. With this data, we could create temperature timelines. According to the German *Bioabfallverordnung*, compost should reach temperatures around 55°C for two weeks or 65°C for one week in order to sanitize the compost. Alternatively, you can find in the WHO Guideline, *Guideline for the save use of Wastewater, Excreta and Greywater Vol.4,* 1-2 days by 65°C under controlled condition is sufficient to kill all pathogens. One can also monitor the pH in order for further investigate the process. And, even though this would have been helpful data, avoiding to make excessive demands to the workers the pH is not yet monitored and recorded. By observing pH levels, one is able to determine whether the process is aerobic, which is good for sanitation, or anaerobic.

Fig.3: Temperature timeline Cycle #1



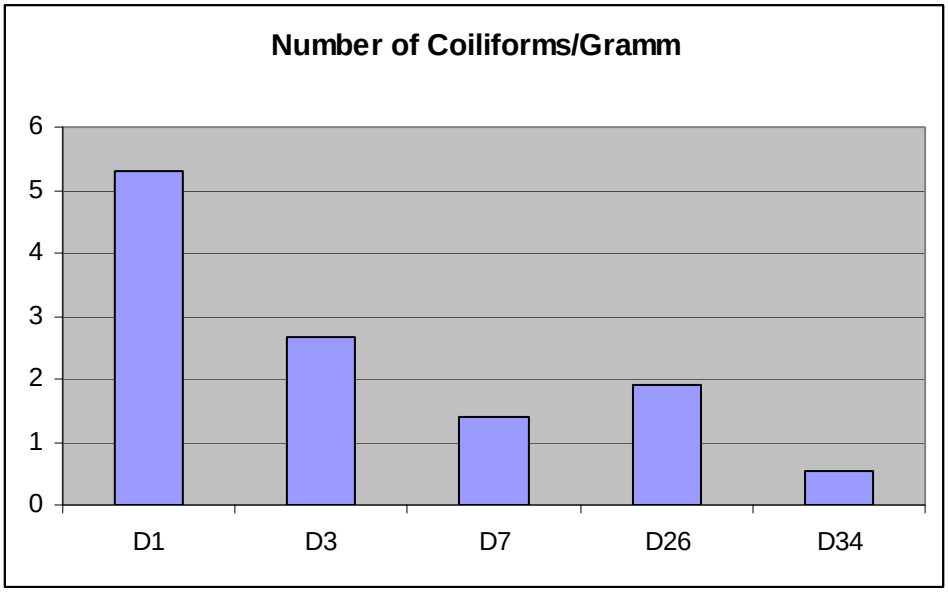
For example, low pH is evidence of an anaerobic process environment, and if the process is anaerobic, the compost temperature will not reach the desired level to sanitize itself. It is recommended that, as soon as the workers improve their routine, someone should introduce them to pH monitoring. Additionally, one took samples on five different days, which were sent over to the *Research Center of Agricultural Biotechnology Beijing* for investigating the content of coli form bacteria, Salmonella and Ascaris eggs. Unfortunately, the Center was not able to deliver an acceptable and proofed result for Salmonella and Ascaris eggs.

Below, you will find the results of the coli form bacteria test. In order to get a correct figure, a variety of samples should be presented. Therefore, I took three sub-samples from a mixture of ten samples of the compost. The Chinese critical value for coli form in fertilizer/compost is >100 per gram. Unfortunately, due to mismanagement on the eco-station (access to working tools) we did not get any values for the single samples from day one and day three.

Fig.4

Time	Sample #1	Sample #2	Sample #3	Ø number/g
D_1				200000
D_3				450
D_7	45	4	not detected	24,5
D_{26}	150	not detected	9	79,5
D_{34}	4	not detected	3	3,5

Fig.5 The data on the y-axis present the ln of the average



The *Research Center of Agricultural Biotechnology Beijing* used the national guideline GB/T 19524.1, for a short description please look at the appendix. The third method of utilizing test pathogens is not yet introduced, but this must be done for a precise reading of how effective the sanitation process has been. Instead of using test pathogens, one can use tomato seeds, which are less risky and easier to handle. Tomato seeds cannot survive temperatures above 40°C, and can be seen as an indicator for the survivability of pathogens and other undesirable elements like pests or weed seeds (cf.: *Wolfgang Berger, Claudia Lorenz- Ladener: Kompost-Toiletten. 1.Auflage, Staufen: ökobuch Verlag, 2008.)*. However, the tomato seed test is not a guarantee for pathogen-free compost. Nevertheless, the combination of all methods, including pH data, seems to give a quite accurate overview about the sanitation level of the compost.

4. The Fertilizer Value

Using the same sampling method as the hygiene investigation, we prepared three samples for Mr. Liu Zhong, SPO's agricultural consultant.

Fig.6: results of analysis of fertilizer value

Moisture Content	31.8%	
Organic Matter	48,80%	of dry mass
pH Value	7,3	
Total Nitrogen[1]	2.43%	of dry mass
Available N[2]	0,76%	of dry mass
Available P[3]	0,23%	of dry mass
Available K[4]	0,21%	of dry mass
Salinity:		
Cl^-	945,8	mg/kg
Na^+	718,4	mg/kg

[1]) Kjeldahl Method [2]) Alkali solution diffusion method [3]) Citric acid extraction [4]) Ammonium acetate extraction

To interprete these results, we compared them with figures for garden waste (Source: *Faustzahlen für Landwirtschaft und Gartenbau, 12th Edition*). Compared to chemical fertilizer, the feces compost has a quite low level of N, P and K, the price determinating elements.

However, for calculating the market price, one should not compare it with chemical fertilizer but rather with other organic fertilizers, like green compost, slurry or crops residue. As potentially organic fertilizers provide the soil with organic carbon and humus, which play an important role for the water- and heat balance. Consequently, the compost obtains a secondary fertilizing activity besides N, P and K.

Fig.7: Results from other organic fertilizers

Garden Waste		
	Range	
Organic Matter	2,00-34,00	% of dry mass
Total Nitrogen	0,40-2,76	% of dry mass
Available P	0,24-1,79	% of dry mass
Available K	0,18-2,20	% of dry mass
pH	6,6-8,3	
Salinity	0,5-6,1	g/l

5. Expenditure

In order to achieve a basic level of hygienic standard, we had to make some investments as detailed in Fig. 8.

Fig.8: list of purchased items for Composting Department

Laundry machine	1.480,00	RMB
Material shopping	1.163,00	RMB
2 Flow heater	2.010,00	RMB
Construction work	22.000,00	RMB
Sum	26.653,00	RMB

The material purchase included the workers' outfits (mentioned in chapter 3), flooring for covering the floor drains while operating, coat hooks for the changing room, washcloths, towels, and soap. The construction work items included the cost for the shower room, partition wall, and the enlarged filling funnel on the compost centrifuge.

I suggest that in order to calculate a profitable market price, SPO/DPO, or the holding company – in process of establishment - should document the inputs including use of electricity, use of sawdust; cost of labor and costs for renew the working equipment.

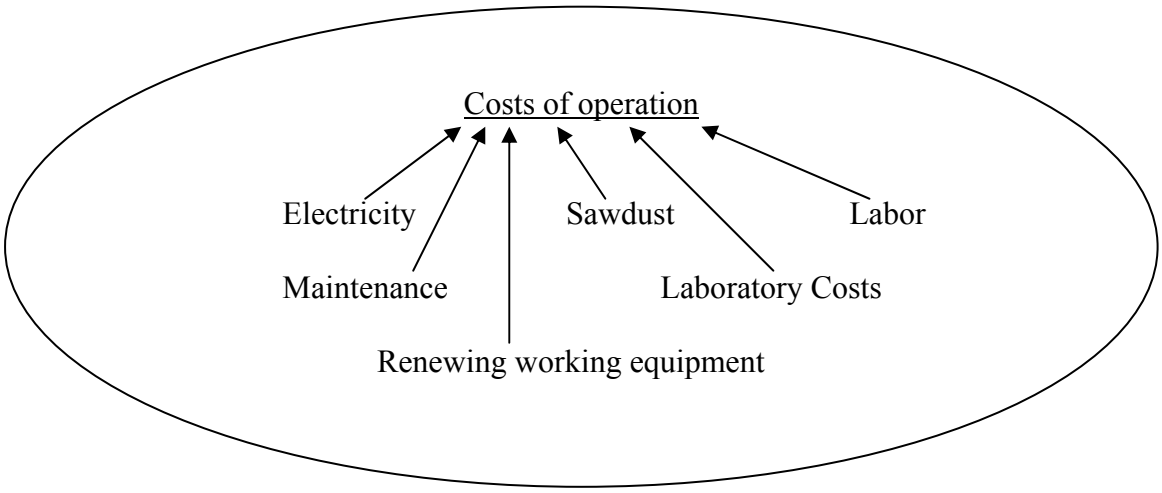
As we started composting November 12th 2008, we recorded the current data of all three electricity meters in the compost plant, and when I left Dongsheng on December 18th 2008.

Fig.9: data from electicity meters

	12. Nov		18.Dec		Used electricity	
#1: 044873	66	kWh	1667	kWh	1601	kWh
#2: 044899	1411	kWh	1442	kWh	31	kWh
#3: 044895	11376	kWh	12138	kWh	762	kWh

During this period, we started six different cycles and finished one. On January 13th 2009, the actual counter data was reported to be: #1 2225 kWh, #2 1444 kWh and #3 13495 kWh. However, to interpret this consumption is quite difficult, as there are many diffuse uses. For example, the sawdust department used two electric radiators for drying the sawdust and an electric cable runs from the compost plant to the house next to the gray-water treatment plant. This should be repeated in summer with pre-installed meters.

Fig.10: Contributors to Cost of Operation



6. Recommendations for Further Steps

As mentioned before, the target was to compost feces and the organic waste from the households. Unfortunately, the organic waste collection did not start yet regularly, so all the results in this paper are mainly from mono feces compost. Therefore, it is recommendable to repeat such an investigation on site after the right organic waste ratio is added to the composting process.

For to evaluate the working process, focusing on following topics is recommended:

1. Training of workers in pH documentation, and introduce the Tomato Seed Method.
2. Taking samples for investigation of the fertilizer value of the final compost and verify the hygienic status.
3. Analyzing whether it is necessary to use the floor heating in summer, and if summer conditions have any negative influence on the compost moisture.
4. Analyzing the impact of the repellant to limit the fly breeding on the composting process and the usability of it.
5. Focusing on the general usability of the compost should also be part of the next test cycle in Dongsheng.
6. Investigation of the level of harmful substances. At least the element zinc, as it is an ingredient in many cosmetic products, is excreted by the human organism, and becomes strongly accumulated in the soil.
7. Moreover, for getting an accurate overview about the operating costs, a closer investigation for the use of sawdust and electricity is necessary. Regarding to the consumption of electricity it is important to know the specific values of the revolving machine, the vents and the floor heating system.

Photo6 Bin at worst case

7. Appendices

Temperature Data

Cycle 1
Compost Temperature (°C)

				Ø
T_0 morning	9,8	10,5	10,5	10,3
T_0 evening	11,4	11,9	11,7	11,7
T_1 morning	18,4	25,5	23,0	22,3
T_1 evening	20,4	21,3	24,8	22,2
T_2 morning	24,9	29,0	36,6	30,2
T_2 evening	32,4	40,8	37,6	36,9
T_3 morning	35,5	37,1	53,5	42,0
T_3 evening	33,0	47,1	51,6	43,9
T_4 morning	41,3	47,2	50,6	46,4
T_4 evening	39,2	43,7	55,0	46,0
T_5 morning	36,8	48,7	60,2	48,6
T_5 evening	43,1	56,9	60,8	53,6
T_6 morning	44,4	47,0	55,5	49,0
T_6 evening	46,7	49,2	60,3	52,1
T_7 morning	50,7	47,0	63,0	53,6
T_7 evening	44,2	44,7	52,8	47,2
T_8 morning	39,3	50,7	57,1	49,0
T_8 evening	43,8	47,7	57,0	49,5
T_9 morning	40,7	40,6	55,5	45,6
T_9 evening	37,0	36,9	50,4	41,4
T_{10} morning	41,2	40,4	39,0	40,2
T_{10} evening	42,5	41,3	50,2	44,7
T_{11} morning	39,4	38,5	47,6	41,8
T_{11} evening	41,1	46,1	36,7	41,3
T_{12} morning	37,4	44,7	52,2	44,8
T_{12} evening	39,1	53,6	54,2	49,0
T_{13} morning	50,1	45,7	61,1	52,3
T_{13} evening	62,1	50,9	45,8	52,9
T_{14} morning	63,0	54,9	56,7	58,2
T_{14} evening	62,4	50,0	49,2	53,9
T_{15} morning	49,6	41,0	64,5	51,7
T_{15} evening	37,7	41,7	72,2	50,5
T_{16} morning	47,5	50,0	65,1	54,2
T_{16} evening	43,7	48,9	67,4	53,3
T_{17} morning	51,3	55,7	66,2	57,7
T_{17} evening	56,3	56,8	67,2	60,1
T_{18} morning	48,8	49,6	64,5	54,3
T_{18} evening	42,8	39,9	67,8	50,2
T_{19} morning	50,4	61,8	51,6	54,6
T_{19} evening	49,8	46,3	62,1	52,7

T_{20} morning	61,4	54,1	46,2	53,9
T_{20} evening	59,9	57,7	56,3	58,0
T_{21} morning	61,8	46,9	54,8	54,5
T_{21} evening	63,4	64,9	59,3	62,5
T_{22} morning	53,6	60,6	50,4	54,9
T_{22} evening	45,5	47,4	52,9	48,6
T_{23} morning	56,8	48,6	57,1	54,2
T_{23} evening	64,1	59,8	56,8	60,2
T_{24} morning	59,1	57,3	51,4	55,9
T_{24} evening	35,9	51,5	55,0	47,5
T_{25} morning	47,6	54,6	48,7	50,3
T_{25} evening	47,7	52,1	51,7	50,5
T_{26} morning	45,0	46,5	50,2	47,2
T_{26} evening	45,6	46,7	42,6	45,0
T_{27} morning	45,3	41,1	32,5	39,6
T_{27} evening	45,8	41,5	41,5	42,9
T_{28} morning	49,5	38,6	46,7	44,9
T_{28} evening	30,2	32,3	37,5	33,3
T_{29} morning	25,3	31,4	33,2	30,0
T_{29} evening	33,6	33,9	41,4	36,3
T_{30} morning	40,3	39,3	35,8	38,5
T_{30} evening	29,9	27,3	28,4	28,5
T_{31} morning	31,9	24,0	26,0	27,3
T_{31} evening	36,2	26,0	33,1	31,8
T_{32} morning	38,1	33,1	36,7	36,0
T_{32} evening	38,7	31,5	29,9	33,4
T_{33} morning	28,9	35,4	30,6	31,6
T_{33} evening	29,1	37,6	34,7	33,8
T_{34} morning	40,0	37,2	38,1	38,4

Cycle 2

Compost Temperature(°C) no EM, inoculation with compost

						Ø
T_0 morning						
T_0 evening	9,6	8,9	8,7	8,8	8,9	9,0
T_1 morning	15,7	14,7	13,6	13,6	13,7	14,3
T_1 evening	21,0	18,8	20,0	21,3	23,3	20,9
T_2 morning	38,6	38,7	35,9	40,1	33,9	37,4
T_2 evening	34,1	32,9	28,3	46,1	40,6	36,4
T_3 morning	30,5	38,8	39,6	54,2	41,1	40,8
T_3 evening	34,7	39,2	40,2	52,4	47,1	42,7
T_4 morning	39,1	34,8	40,7	53,0	42,6	42,0
T_4 evening	41,2	31,0	41,9	42,4	49,9	41,3
T_5 morning	42,6	40,6	49,7	50,0	49,3	46,4
T_5 evening	41,1	38,4	45,1	52,2	47,2	44,8
T_6 morning	39,5	40,8	49,2	53,3	49,5	46,5
T_6 evening	39,7	36,8	50,0	53,1	50,3	46,0
T_7 morning	43,7	41,1	52,5	58,6	46,6	48,5
T_7 evening	45,8	42,2	53,1	53,8	57,9	50,6
T_8 morning	47,5	49,0	49,1	48,3	49,5	48,7
T_8 evening	38,2	53,8	44,6	58,2	59,3	50,8
T_9 morning	46,6	46,2	57,1	58,8	53,2	52,4
T_9 evening	45,2	45,7	54,8	57,4	46,4	49,9
T_{10} morning	52,9	54,6	47,2	46,5	44,3	49,1
T_{10} evening	47,4	47,4	51,9	50,7	48,3	49,1
T_{11} morning	58,3	49,9	49,7	54,4	50,2	52,5
T_{11} evening	55,6	48,9	44,2	43,9	40,0	46,5
T_{12} morning	59,8	49,4	46,7	43,8	47,1	49,4
T_{12} evening	61,1	56,4	58,2	47,3	43,1	53,2
T_{13} morning	49,9	50,8	50,5	58,6	56,5	53,3
T_{13} evening	47,6	62,4	58,8	53,5	48,1	54,1
T_{14} morning	63,6	65,9	58,5	47,5	55,2	58,1
T_{14} evening	64,2	65,9	59,1	50,7	49,7	57,9
T_{15} morning	56,6	61,4	55,2	66,9	49,3	57,9
T_{15} evening	48,8	63,6	57,7	60,4	67,6	59,6
T_{16} morning	64,5	69,2	65,4	45,3	49,1	58,7
T_{16} evening	66,5	63,2	64,1	48,6	48,7	58,2
T_{17} morning	64,9	63,5	63,6	54,8	55,3	60,4
T_{17} evening	65,6	62,7	61,4	53,0	53,4	59,2
T_{18} morning	53,5	68,7	61,2	64,2	57,5	61,0
T_{18} evening	60,0	64,2	62,7	68,5	64,1	63,9
T_{19} morning	55,2	68,9	72,2	64,8	60,7	64,4
T_{19} evening	64,8	56,6	66,3	68,6	67,5	64,8

T_{20} morning	50,0	63,0	64,1	60,9	65,8	60,8
T_{20} evening	51,9	51,6	54,3	55,8	55,2	53,8
T_{21} morning	73,2	72,5	61,1	56,8	51,9	63,1
T_{21} evening	70,6	71,3	64,0	57,4	56,9	64,0
T_{22} morning	66,5	57,3	62,7	63,4	70,4	64,1
T_{22} evening	55,2	66,0	68,5	70,3	60,7	64,1
T_{23} morning	67,3	69,3	68,0	54,4	58,1	63,4
T_{23} evening	63,7	59,9	66,4	49,7	53,3	58,6
T_{24} morning	60,1	62,3	65,7	51,9	50,5	58,1
T_{24} evening	50,9	55,8	53,3	43,3	57,0	52,1
T_{25} morning	44,6	51,9	48,7	49,5	51,8	49,3
T_{25} evening	45,5	51,3	59,7	51,4	47,9	51,2
T_{26} morning	46,5	51,9	53,9	44,8	52,8	50,0
T_{26} evening	43,7	43,9	38,8	37,1	43,8	41,5
T_{27} morning	36,7	41,5	48,5	40,7	41,5	41,8
T_{27} evening	39,7	39,8	44,4	44,3	47,2	43,1
T_{28} morning	47,2	44,6	47,8	45,2	44,1	45,8
T_{28} evening	39,1	36,7	32,0	35,0	30,1	34,6
T_{29} morning	38,0	36,0	37,9	34,0	41,8	37,5
T_{29} evening	42,9	36,0	43,0	48,1	32,0	40,4
T_{30} morning	39,7	41,9	44,3	36,0	48,3	42,0
T_{30} evening	45,8	34,5	46,9	37,8	44,2	41,8
T_{31} morning	43,1	34,0	47,8	33,1	48,1	41,2
T_{31} evening	40,0	40,3	39,6	40,5	36,9	39,5
T_{32} morning	33,0	32,0	34,0	38,0	31,5	33,7
T_{32} evening	35,0	34,0	38,0	35,5	40,0	36,5
T_{33} morning	38,0	37,5	41,0	38,0	40,0	38,9
T_{33} evening	37,0	36,0	40,0	37,5	35,5	37,2
T_{34} morning	46,5	46,0	40,0	42,0	39,5	42,8
T_{34} evening						

Cycle 3

Compost Temperature(°C) no EM, inoculation with compost

						Ø
T_0 morning	5,6	4,9	5,3	7,8	7,7	6,3
T_0 evening	6,8	6,4	6,0	6,6	6,8	6,5
T_1 morning	7,7	7,3	7,1	7,7	7,4	7,4
T_1 evening	8,3	7,5	7,3	7,9	8,1	7,8
T_2 morning	9,9	8,7	9,1	11,2	10,4	9,9
T_2 evening	10,2	9,6	10,4	12,8	10,0	10,6
T_3 morning	14,6	12,1	13,2	30,8	20,9	18,3
T_3 evening	16,5	13,0	14,7	18,2	28,7	18,2
T_4 morning	17,9	20,5	22,3	23,7	31,3	23,1
T_4 morning	20,8	22,7	26,2	31,6	30,5	26,4
T_5 morning	31,2	32,9	34,9	36,0	41,1	35,2
T_5 evening	32,8	34,4	39,2	47,0	42,5	39,2
T_6 morning	28,1	27,8	37,6	40,4	43,8	35,5
T_6 evening	33,6	31,3	40,8	49,3	40,8	39,2
T_7 morning	50,7	43,4	42,1	32,5	33,7	40,5
T_7 evening	45,6	33,7	51,1	46,0	54,9	46,3
T_8 morning	54,7	51,9	44,2	47,5	49,9	49,6
T_8 evening	52,7	54,0	51,5	48,9	46,4	50,7
T_9 morning	49,2	47,9	51,1	50,0	53,1	50,3
T_9 evening	48,7	39,7	38,5	47,3	42,7	43,4
T_{10} morning	46,0	42,3	38,6	42,6	43,6	42,6
T_{10} evening	35,6	39,1	41,3	41,2	29,6	37,4
T_{11} morning	31,7	34,4	44,1	39,7	45,9	39,2
T_{11} evening	42,0	47,1	41,5	35,5	32,5	39,7
T_{12} morning	40,0	44,2	43,1	39,8	46,3	42,7
T_{12} evening	40,5	44,6	44,8	46,2	45,2	44,3
T_{13} morning	36,4	39,9	53,4	51,6	55,6	47,4
T_{13} evening	53,3	52,6	51,4	33,0	35,0	45,1
T_{14} morning	54,7	50,8	52,9	44,9	45,3	49,7
T_{14} evening	49,5	50,9	49,7	43,2	42,3	47,1
T_{15} morning	58,0	56,1	56,2	54,9	57,0	56,4
T_{15} evening	56,9	57,4	57,0	57,3	54,0	56,5
T_{16} morning	43,8	47,7	56,8	55,1	56,0	51,9
T_{16} evening	54,9	54,5	55,4	53,8	54,5	54,6
T_{17} morning	39,8	49,0	51,0	46,4	54,8	48,2
T_{17} evening	42,3	42,1	42,9	42,5	45,8	43,1
T_{18} morning	52,5	56,4	49,5	46,3	45,4	50,0
T_{18} evening	56,9	60,4	51,6	47,4	44,3	52,1
T_{19} morning	46,7	52,2	46,0	54,1	61,8	52,2
T_{19} evening	44,1	46,6	44,1	45,8	46,6	45,4

T_{20} morning	57,6	57,3	51,7	46,2	44,3	51,4
T_{20} evening	55,6	57,4	58,3	50,7	48,1	54,0
T_{21} morning	55,5	57,5	53,6	45,0	48,4	52,0
T_{21} evening	52,8	53,3	57,5	49,1	49,7	52,5
T_{22} morning	53,9	62,4	61,8	60,6	57,5	59,2
T_{22} evening	54,8	59,6	60,7	60,5	55,6	58,2
T_{23} morning	57,1	69,2	60,6	58,6	58,3	60,8
T_{23} evening	56,0	56,3	49,7	42,0	50,1	50,8
T_{24} morning	35,7	45,7	55,8	48,6	55,7	48,3
T_{24} evening	37,8	43,7	44,1	43,8	43,9	42,7
T_{25} morning	55,0	56,5	47,1	44,5	43,1	49,2
T_{25} evening	38,1	46,4	37,9	39,1	42,0	40,7
T_{26} morning	39,1	42,0	50,2	30,0	26,0	37,5
T_{26} evening	36,2	3,0	45,0	47,6	30,0	32,4
T_{27} morning	32,0	44,7	31,0	45,1	50,3	40,6
T_{27} evening	45,4	30,7	43,1	32,7	49,8	40,3
T_{28} morning	45,0	37,0	46,6	28,9	47,2	40,9
T_{28} evening	43,3	36,1	41,4	34,1	37,9	38,6
T_{29} morning	46,5	43,9	40,6	43,6	41,0	43,1
T_{29} evening	39,4	41,3	41,7	41,1	41,3	41,0
T_{30} morning	31,0	34,5	30,0	29,0	29,0	30,7
T_{30} evening	44,0	44,5	45,5	45,5	43,0	44,5
T_{31} morning	41,0	41,1	47,2	45,3	46,8	44,3
T_{31} evening	31,5	33,0	35,0	31,5	30,0	32,2
T_{32} morning	30,0	38,5	32,0	38,3	30,0	33,8
T_{32} evening	28,0	39,8	30,0	40,8	32,0	34,1
T_{33} morning	30,0	42,8	30,0	36,2	30,0	33,8
T_{33} evening	28,0	40,5	30,0	40,2	28,0	33,3
T_{34} morning	37,0	34,4	29,7	42,3	34,4	35,6
T_{34} evening	30,1	38,5	42,3	30,0	32,7	34,7
T_{35} morning	40,3	32,9	40,9	28,9	30,2	34,6
T_{35} evening	40,2	34,1	37,0	30,0	35,8	35,4
T_{36} morning	41,1	38,7	44,1	41,9	43,3	41,8

Composting Manual (Preliminary Version from *Lvhuanben)* 10/9/2008

Feces:

- Dry substance between 80% and 90%, if necessary add sawdust

- Mixing proportion→ 1 part EM compound: 500 parts feces

- Maturation duration: ∑ 35d

  Chamber #1:

  → Day 1 until Day 3: alternate 1 hour air exposed, 1 hour without air exposure.

  → Day 4 until Day 8: heating up to 30°C- 40°C; without air exposing.

  → Day 9 until Day 25: Resting.

  Chamber #2:

  → Day 26 until Day 35: on the 26th day exchange the pile of compost into another chamber in order to mix it, after this, it should remain resting until day 35.

EM compound:

- Mixing proportion→ 1 "black barrel" : 10 parts sawdust, and some water in order to achieve a dry substance around 80%.

- Maturation duration: ∑ ~ 4d

  → first 12 hours steady air exposing.

  → subsequently resting for 3 days by over 25°C.

Testing process GB/T 19524.1

This test process is a classical titer method.

1. Dilution of the sample:
   Take 10g/10ml of the sample and add 90 ml sterile water (10^{-1}), put this for 30 min by 200 rpm into a centrifuge. After this, crate a three-step dilution series out of the dilution. Use 5ml of the produced dilution for each step. It is recommended to start with a dilution of 10^{-2}, 10^{-3} and 10^{-4}.
2. Incubation:
   Inoculate three tubes with three different dilutions. The used culture medium is lactose. Incubate the tubes in a water bath by 44,5±0,5°C for 24±2h.
   If none of the samples produce acid or gas (metabolites of coliform bacteria), the samples are coliform negative. As gas or acid appears, take a little bit of the dilution lactose mix and streak it on an eosin methylene blue agar plate. Incubate it by 36±1°C for 18-24h.
3. Confirmatory test:
   Pick the suspicious colonies from the agar plate and accomplish a gram stain with them (coliform bacteria are obligatory gram-negative). If you get a gram-positive result, the samples are coliform negative. Whether you get a gram-negative result, incubate these colonies again by 44,5±0,5°C for 18-24h. If the samples produce gas, the samples are coliform positive.
4. Result:
   According to the number of tubes, which leads to a coliform positive result, you find the approximate number of coliform per g or ml with the MPN index.

Work Report # 1

Jan H. Mertens (HU Berlin & USTB)
Composting Project Erdos 08/11/12(updated on 08/11/14)

First Day Report

1) Material Purchased for Composting Project Erdos

- working clothes (2 Jackets and 2 Trousers) per each worker
- 2 pairs of gloves per each worker
- 3 masks per each worker
- 1 pair of rubber boots per each worker
- 8 working caps, two per each worker
- 8 towels, two per each worker
- 2 coat racks
- 2 waste gripper
- 3 shovels
- Chalk (tagging the doors of the compost chambers with the starting date etc.)

2) Work Report

2.1 Before we handed over the working outfit, every worker signed to verify receipt; in addition every worker signed a declaration that they had been informed about their duty to wear this outfit during their work in the compost plant. These sheets have been handed over to Mr. Lin Bo (SPO) to be filed.

2.2. Problems which emerged during the launch of the composting plant:

- The workers couldn't collect enough bins for filling one composting chamber; due to the starting rain they couldn't use the lift because of insufficient insulation of the electric cable against water and no proper connection between lift motor and extension cord to the basement.
- The workers were not used to working as a team; some of the workers just stay in the background while others pick up the slack.
- Inadequate awareness to take care of their health: ie. littering feces, smoking in the plant (even when wearing the protection gloves), no hand washing after a job had been completed.
- Not enough grippers for removing solid waste.
- No broom for cleaning the site; they used the brooms from the "sawdust department"
- No wash down yard for tools, boots etc…
- Need for a certain place for storage the uniforms
- Leek in the water tank (filter for the compost exhaust)
- Short circuit in a pump used for moistening the compost, and no reaction of the fuse system in the building

In the evening, the four workers, Mr. Hu and I had a team meeting and spoke about the composting procedure in the morning and welcomed any suggestions from the workers.
Firstly, I informed the workers again about the need for clean operation / wearing safety outfit (for protection of own health, other workers and inhabitants). Furthermore I complained that they lacked a sense of cooperation and ability to divide tasks. They agreed that this was a

problem and then figured out a work plan. Moreover, I expressed my displeasure with the dispersal of the working clothes (vector for disposal potential pathogens). I informed them about the problems I observed in the morning; partly they acknowledged these issues, including the wiring problem of the lift motor and work division. The very last point on my schedule was nominating a team leader. And luckily all the workers agreed to the person I had proposed.

3) List of the suggestions the workers announced during the meeting:

- Need for a shower
- Second Gripper (*done*)
- Laundry for working outfits
- Hats/ caps for protecting their heads/hair (*done*)
- Power plugs in every basement for the bin lift
- Freeze protected bin/tool cleaning place
- Coat hooks (*done*)
- Solving the connection problem of the lift motor

Work Report # 2

Jan H. Mertens (HU Berlin & USTB)
Composting Project Erdos: Second Report 08/11/19

1) Members of the Composting Department
   - Zhang, Yijun *Team Leader*
   - Chen, Zhankui
   - Liu Meifu
   - Xie, Jushan

2) Additional purchased Material
   - 1 extra shovel
   - 2 brooms, one for sweeping the floor of the plat after using
   - Colored tape for tagging all tools which belong to the composting plant
   - 2 meters linoleum flooring for covering the drains while working

3) Work Report

3.1 General Impressions/Experiences:
In order to improve the routine of the workers, I would have like to have started two more cycles. However, on 11/13 we were unable to start because the Diesel in the truck was frozen. Then, again on 11/14, we had a five-hour delay, as the switch for the bin lift on the truck was broken. Therefore, it was not until the afternoon of 11/14 that we started the second cycle, and commenced with the third one on 11/17. I was quite pleased to see how fast the workers adopted the ideas and agreements from our meeting on the 11/12. They worked out a functional system for sharing the work, using the chalk to make remarks about stating date etc. at the doors and even stopped smoking on site. In the second cycle, we used old compost instead of EM to inoculate the feces. The fact that almost all of the workers told me that we forgot the EM was a display of their critical thinking during the work process-I hadn't informed them about my experiment of not using EM. For the 3rd cycle, Mr. Lu ordered special sawdust, which is coarser, and this had a positive effect for composting. The compost gained a better structure, which led the O_2 supplies to increase. The effect on the compost was both better digestion, and a decrease of odor. Furthermore, we achieved the goal of establishing their own changing room in the first floor of the Eco Station building, which was set-up opposite the scheduled plumbing unit with laundry and shower. The workers also covered the drains with the flooring. Due to his proven abilities as a leader and good organizational skills, I trained Mr. Zhang to monitor the temperature and create the schedules for the needed work on the CP (when to start the air supply, when start heating etc.) and since he was put in charge of the CP team, he asked for an increase in salary.

3.2 Further problems, which arose or still remain:
- Disposal of the accumulated solid waste from the feces bins
- The need for a partition in the CP to avoid contamination of the sawdust for the households

- Installation of the sink in the CP, plus connection for a hose to clean the floor after use and cleaning the equipment, boots (and bins)
- The leak in the water tank and the short circuit in the pump remain
- No installation of the shower and laundry (hot water) yet
- The need for a bigger funnel at the Composting Machine
- The connection from the motor on the truck and plugs in the basements

3.3 Tasks in progress or commencing within the upcoming weeks:

- Partition in the Plant - *already instructed a company*
- Installation of the sink and hose in the CP
- Installation of the shower and laundry - *checking the local market for prices*
- Salary discussion for Mr. Zhang - *almost solved, just some administrative dubieties left*
- Looking for a local steelworker for the welding job (funnel)
- Taking samples during the transfer from the heating into the resting period

4) <u>Further ideas</u>

As soon we have the green light for an increase in Mr. Zhang's wage, I would like to give him some more background information and training. This training would regard hygienic standards (cleaning the plant, rotate the uniforms etc.), documentation of the temperature, and composting basics. Moreover, I would like at least one more group meeting, and, if possible, the meeting would be held by Mr. Zhang.

WORK REPORT # 3

Jan H. Mertens (HU Berlin & USTB)
Composting Project Erdos: Third Report 08/12/06

1) Additional purchased Material

- Pitchfork for mechanical ventilation
- Warm lining for each worker's jacket
- Washing Machine
- 2 Flow Heaters

2) Work Report

2.1 General Information on Completed Work:
First, Lin Bo informed Mr. Zhang about the decision to increase his salary. Mr. Zhang is still delivering very satisfying work, and as I already mentioned in the @-mail from last Friday 11/28, we accomplished the hose installation and the enlargement of the funnel.
Since the temperature of the first compost batch decreased after we stopped the air exposure, we turned the air on again. Furthermore, we did not follow the formula of the Beijing Company in regards to the heating cycles because of the low temperatures outside/inside. At this point, the batches are not big enough to keep themselves warm. Perhaps, if the chambers were full to brim, the self-heating energy would be enough to resist the Inner Mongolian winter. Eventually, we just figured out our own methods of procedure, which included using the pitchfork for mechanical ventilation once per week, steady heating and permanent alternate air exposition. Nevertheless, we will change the chambers after 25 days, keeping to the same procedure as the Beijing Company.
Since we had a strong emission of NH_3 in Chamber 5, we started an experiment with vinegar to neutralize the displeasing odor. (The possible source of this odor could be the solute ammonia in the seepage in the intermediate floor) Vinegar provided an effective solution for this problem, but unfortunately it is just a temporary fix. Therefore, each time a worker has to enter a chamber with a NH_3 odor, he should spray, or rather cast, some vinegar into the intermediate floor. Furthermore, I complained about the tidiness in the dressing room. Mr. Zhang promised me to figure out a cleaning schedule, involving all workers from the Compost Department.
The work for the plumbing unit and partition commenced on the 4th of December. In addition, Lin Bo bought a new washing machine and two flow heaters.
Finally, I tried to make an appointment with Miss Fu Rong to be the translator for training Mr. Zhang. I wanted to inform him about the three important parameters air, moisture and temperature. Furthermore, I wanted to instruct him on methods of how to increase the accuracy of the temperature measurement, potential health risks, and how to create significant samples for the laboratory analysis. Unfortunately, Miss Fu Rong did not appear on the date when we were scheduled to meet, she canceled our meeting 5 hours later. I have rescheduled this meeting, as I feel it is important to inform Mr. Zhang about the topics I've mentioned.

2.2 Further Topics to discuss and make decisions about:
- How to clean the end product

- How to store the end product
- We need to find a place to store the saw-dust bags for the customers; status quo is not tolerable (customers have to enter the Compost Plant)

WORK REPORT # 4

Jan H. Mertens (HU Berlin & USTB)
Composting Project Erdos: Fourth Report 08/12/15

Additional Purchased Material

-A new compost thermometer (Mr. Zhang Yijun had complained that the digital thermometer was unreliable)
-3 Washrags, 3 towels and 3 pairs of flip-flops
-Soap and shampoo
-Washing detergent

Work Report

2.1 General Information on Completed Work:
The construction work on both the plumping unit, and the partition has been completed since December 8th.
After we changed the chambers of the first and the second cycles, we started cycles #4 and #5. With the use of mechanical ventilation of the compost, we were able to stop the emission NH_3 and better control the strong odor of it. Also, as a temporary fix, the workers have been using vinegar to control the odor when it becomes excessive. Fortunately, Fu Rong, Zhang Yijun and I were able to have an informational meeting on Friday the 12th. I informed Mr. Zhang about the three parameters (moisture, O_2 and temperature) and their importance in our process. For example, I explained to him how moisture and O_2 are necessary for complete and adequate digestion. Moreover, I explained that the compost must reach a certain temperature in order to reach an acceptable hygienic level.
Furthermore, I instructed Mr. Zhang on how to get accurate temperature data. I suggested that he take the time to measure temperatures in various zones by using different measuring points (the core, wall areas, outer layers and bottom areas). I explained that using more measuring points help to get a better average temperature and overview of the various zones.
The last big topic of our meeting was the work hygiene and the potential risks of the feces. I pointed out, again, the importance of using gloves, work clothes and mouth protection (smear infection). In addition, I stated the need for a strictly no-smoking-policy in the plant and during the work with feces, and that workers must at the very least wash their hands after work. On the same day during the afternoon, we had a meeting with all workers from compost department. Mr. Zhang reported to them the details of the morning meeting, specifically about the way to measure the temperature and the work hygiene. Again, I had to inform them, that the odors being emitted are nonhazardous. Although, excess odor could be evidence for insufficient hygiene (ie. if we have odor in the EcoStaion from dirty boots).
As we passed the one month mark since we started the first cycle, I urged all workers to let me know whether they wanted to continue working in the compost department. I had noticed some of them seemed to lack motivation to work in the compost plant. However, all workers insured me that they, in fact, wanted to remain in the CD. I told them, then, that I demanded that each one of them be more on-task, do reliable work, and that they must follow, more carefully, the instructions of Mr.Zhang.

2.2 Problems we faced the last week:

Though it was already part of Zhang Wei's job to do so, Zhang Yijun and I suggested that he compose a questionnaire for the condition of the feces bins. This would be handed out to the workers, to be filled-in while exchanging the bins. However, when Zhang Wei handed this questionnaire over to Mr. Lu, he refused to distribute the sheet to the workers. Besides this incident, we had to overcome many of these dilemmas of cooperation problems between SPO and DPO (Mr.Lu). For example, none of the workers listen to Zhang Wei nor to Lin Bo, and if Mr. Lu doesn't give the order, almost nothing gets done. We have had the same problem in the compost department, as nobody follows the orders that Zhang Yijun gives. As a result, all the work, like the mechanical ventilation, is up to Mr. Zhang while the other workers stay in the office smoking and waiting. As a result, a half hour job ends up taking more than one and a half.

In my personal opinion, the behavior of Mr. Lu and some workers have really slowed the progress of the project.

Another problem I faced during the last week concerns the distribution of the keys for the storage, compost plant etc. Last Saturday I needed to take samples, but due to the fact the worker with the storage-room key was not on site, I was not able to reach the bags for the samples. Another day, we waited two days for the drilling machine, because of an absent key. I made a proposal for a lockable cabinet in the office for all keys, but first we have to convince Mr. Lu of the need for such cabinet.

Around noon on December 10th, I noticed that the air pump, which supplies the chambers with air, was out of order. Until today, we still have been unable to find a capable electrician who could solve this problem in time(?). Because of the missing air exposure, there emerges a strong odor in the compost plant. I still an unsure how long it will take to fix this problem.

Further Points to Accomplish:

I made the proposal to store the compost in big wooden boxes (at least $5m^3$ big), in the compost plant, instead of storing the product in bags. So, while storing, we have a certain post treatment as a side effect. Furthermore, I informed the workers to make nameplates for each pile for telling which one is which cycle. However, because of budget shortage we cannot start the construction work for these boxes. In addition, for cleaning the compost I instructed Mr.Zhang to build a simple strainer like the one that the sawdust department uses.