Chemical analysis of compost in a field laboratory

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1. Necessary equipment: instruments

- **Shaker** (to perform the compost extracts), with reciprocal motion type or overhead shaker
  - e.g.: Orbital multi-platform shaker, PSU-20i, with Universal platform, with adjustable bars and two fixing levels, 345×430 mm (www.vwr.com)
  - Possibility to build your own shaker (overhead shaker)

- **Oven** with circulating air
  - to dry compost by 105°C during 24 hours

- **Funnel rack** (filtration bench): own construction

- **Precision balance** (weighing range 1000 g, readability 0.01 g)

- **Reflectometer RQflex** (to measure NH4, NO2 and NO3) (www.vwr.com, article number: 1.16970.0001)

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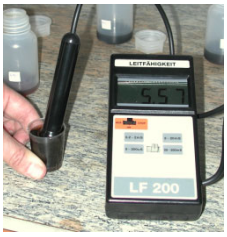
- **pH meter**

- **Conductivity meter** (to measure salinity of compost)



2. Necessary equipment: glassware

- **Aluminium trays**, for determination of the dry substance
  - 10 trays à 500 ml

- **Plastic wide neck bottles for extraction**, 1000 ml, with cap
  - 12 bottles (allows the extraction of 6 compost samples in parallel) (two extracting agents)

- **Plastic wide neck bottles for filtration**, 1000 ml, with cap
  - 12 bottles (allows the filtration of 6 compost samples in parallel) (two extracting agents)

- **Funnel** (upper ø 120 mm, outlet ø 12 mm)
  - 12 funnels (allows the filtration of 6 compost samples in parallel) (two extracting agents)

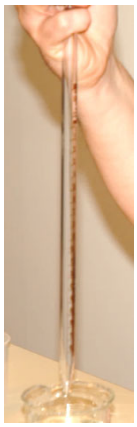
- **Powder funnel** (upper ø 150 mm)
  - 1 funnels (to fill the compost in the extraction bottles)

- **Measuring cylinders**, tall, made in PP, transparent
  - 1 cylinder 1'000 ml
  - 1 cylinder 500 ml
  - 1 cylinder 100 ml

- **Griffin beakers,** made in PP, transparent
  - 10 griffin brakers à 100 ml

- **Wash bottle**, 500 ml, made in PP, transparent
  - 2 wash bottles à 500 ml

- **Measuring cylinders**, tall, made in PP, transparent
  - 1 cylinder 1'000 ml
  - 1 cylinder 500 ml
  - 1 cylinder 100 ml



- **Pipetting ball**
  - 1 pipetting ball

3. Necessary equipment: consumables

- **Standard conductivity,** 1413 µS/cm, to calibrate the electroconductivity meter
- **pH buffer solution**, to calibre the pH meter
  - pH 7,00
  - pH 10.01
- **Folded filters**, type: MN 619 eh1/4, diameter 240 mm
- **demineralised or distilled water**
- **Calcium chloride dehydrate**, CaCl2 x 2 H2O (500 g)
- **Test strips for test method, Reflectoquant®** (www.vwr.com)
  - ammonium: NH4 0.2-7 ppm (www.vwr.com, article number 1.16892.0001)
  - nitrite: NO2 0.5-25 ppm (www.vwr.com, article number 1. 16973.0001)
  - nitrate: NO3 5-225 ppm (www.vwr.com, article number 1.16971.0001)

4. Determination of the dry matter content (DM) of compost

Preliminary remarks

In order to be able to compare the salt content and the mineral nitrogen content correctly, it is useful to relate them to the dry weight of the products. In order to be able to do this, the dry content of the compost must be determined beforehand. DM=dry matter, FM=fresh matter.

4.1. Determine the tare weight

- Weigh empty aluminum trays.
- T = Tara

4.2. Weigh moist compost

- Place approx.. 200 g in the aluminium tray and measure the weight accurately, including the aluminium tray.
- FW: fresh weight

4.3. Drying the compost

- Dry compost in the oven for approx. 24 hours at 105°C (until the weight is constant).

4.4. Weigh the dry compost

- Weigh the digestate or dry compost, including the aluminium tray.
- DW: dry weight

4.5. Result

- DM [% FM] = (DW-T)/(FW-T)*100

5. Production of the water extract, of the $CaCl_2$ extract, and measurement of the pH value

Preliminary remarks

The pH value is measured in the 0.01M $CaCl_2$ extract (10:1) before filtration. The ammonium, nitrite and nitrate contents are analyzed in this extract after filtration of the extracts. Salinity is analyzed in the H_2O extract after its filtration. The extracts must be analyzed immediately. In the worst case, they can be stored for one day in the refrigerator (4°C) or in the freezer.

5.1. Extract H_20

- Fill 500 ml of demineralized or distilled water in one 1 liter extraction bottle (with the graduated cylinder).
- Weigh about 50 g of the fresh compost. Note the exact weight I the protocol of laboratory.
- Add the compost in the extraction bottle.

Close the bottle tightly and put it on the shaker. Shake for 60 minutes.

5.2. Extract 0.01 M of $CaCl_2$

- Mix 1.47g $CaCl_2$ x 2 H_2O per liter of demineralized or distilled water (= $CaCl_2$-extraction medium).
- Fill 500 ml of $CaCl_2$-extraction medium in one 1 liter extraction bottle (with the graduated cylinder).
- Weigh about 50 g of the fresh compost. Note the exact weight I the protocol of laboratory.
- Add the compost in the extraction bottle.

- Close the bottle tightly and put it on the shaker. Shake for 60 minutes.

5.3. Prepare the filters and funnels while the bottles are being shaken,

5.4. pH measurement

- Measure the pH value by immersing the electrode of the pH meter directly in the $CaCl_2$ extract (before filtration). Wait until the value is stable and record it.

5.5. Filtration

- Carefully pour the extracts into the filter. Filtration can last quite a long time (1 to 2 hours). Periodically add more extract to the filter.

6. Measurements of salinity, NH_4, NO_2 and NO_3 content of composts

Preliminary remarks

These analyses are performed with the extracts of filtered digestates or composts or with dilutions. The extracts must be analyzed immediately. In case of emergency, they can be kept one or two days in the refrigerator (at 4°C) or in the freezer.

6.1. Salinity measurements

- Immerse the electrode of the electro-conductivity meter in the H_2O extract and read off the value.
- The value measured is in mS/cm (=EC) n the extract. It is to be transformed in KCl_{eq}/kg DM with following formula:

  Salt content (in KCl_{eq}/kg DM) = EC (in mS/cm)/DM (in % FM)x583.4

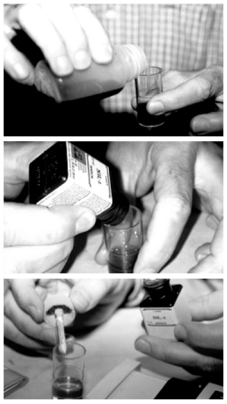
6.2. Measurement of NH_4, NO_2 and NO_3 contents with RQ-flex

- A calibration strip is supplied with each package of test strips. Calibrate the RQ-flex with this strip (see also the RQ-flex instructions for use). This calibration must be performed individually for each test and for each new package of test strips.

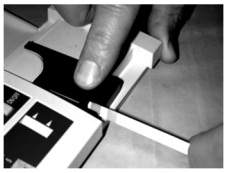
6.2.1. Dilution of compost extract

- An extract that is too dark can interfere with the measurements. In this case, or if the nutrient content is too high (RQ-flex gives the result "hi", the extract must be diluted with demineralised or distilled water.
- Dilution 5x: 1 part extract + 4 parts water.
- Dilution 10x: 1 part extract + 9 parts water.

6.2.2. Determination of ammonium content (NH_4-N)



- Fill the test glass to the first line with the 0.01M CaCl2 extract.
- Add 10 drops of the NH4-1 reagent to the test glass and mix with gentle agitation. Attention: Very aggressive chemical, don't let it touch your skin.
- Add one level blue spoon of the NH4-2 reagent to the test glass and mix with gentle stirring until the reagent is dissolved.



- Check whether the code in the RQ-flex matches the calibration strip.
- Select the NH_4-Test on the RQ-flex once. Press the "Start" button. The test duration is displayed. Immerse the test strip in the extract and press at the same time the "Start" button a second time. The test time is counted down.
- Approximately 20 seconds before the end of the test time, shake the test strip well and insert it into the measuring cell (see also the RQ-flex instructions for use). Read the result. Record the result as well as the dilution of the extract in the laboratory diary.

- The value indicated by the RQ-flex is in ppm NH_4 in the extract. To convert this value into the amount of NH_4-N per kg DM of compost, the following formula is used:
  - A = ppm NH_4 in extract
  - B = compost weight in extract (in g/500 ml)
  - C = Dilution factor
  - D = DM of compost (in % FM) in the $CaCl_2$-Extract

$$\text{mg } NH_4\text{-N / kg DM} = A : B \times C : D \times 50000 : 1.2879$$

6.2.3. Determination of nitrite content (NO_2-N)

- Check whether the code in the RQ-flex matches the calibration strip.
- Select the NO_2-test. Press the "Start" button on the RQ-flex once. The test duration is displayed. Immerse the test strip in the extract and press at the same time the "Start" button a second time. The test time is counted down.
- After about two seconds, shake the test strip well and insert it into the measuring cell (see also the RQ-flex instructions for use). Read the result. Record the result as well as the dilution of the extract in the laboratory diary.

- The value indicated by the RQ-flex is in ppm NO_2 in the extract. To convert this value into the amount of NO_2-N per kg DM of compost, the following formula is used:
  - A = ppm NO_2 in extract
  - B = compost weight in extract (in g/500 ml)
  - C = Dilution factor
  - D = DM of compost (in % FM) in the $CaCl_2$-Extract

$$\text{mg } NO_2\text{-N / kg DM} = A : B \times C : D \times 50000 : 3.2844$$

6.2.3. Determination of nitrate content (NO_3-N)

- Check whether the code in the RQ-flex matches the calibration strip.
- A nitrite content > 0.5 ppm disturbs the nitrate measurement. If necessary, dilute the extract so that its NO_2 content is below this limit.
- Select the NO_3-test. Press the "Start" button on the RQ-flex once. The test duration is displayed. Immerse the test strip in the extract and press at the same time the "Start" button a second time. The test time is counted down.
- After about twenty seconds, shake the test strip well and insert it into the measuring cell (see also the RQ-flex instructions for use). Read the result. Record the result as well as the dilution of the extract in the laboratory diary.

- The value indicated by the RQ-flex is in ppm NO_3 in the extract. To convert this value into the amount of NO_2-N per kg DM of compost, the following formula is used:
  - A = ppm NO_3 in extract
  - B = compost weight in extract (in g/500 ml)
  - C = Verdünnungsfaktor
  - D = DM of compost (in % FM) in the $CaCl_2$-Extract

$$\text{mg } NO_3\text{-N / kg DM} = A : B \times C : D \times 50000 : 4.4266$$

7. Interpretation of analyses from NH_4-N, NO_2-N, NO_3-N

Presence of the N_{min} form[1]			Interpretation
NH_4-N	NO_2-N	NO_3-N	
-	-	-	No available N. Mixture too rich in carbon, or all NH_4-N was lost because of lack of moisture. If the compost is carbon rich: risk of nitrogen immobilization in the field. Recommendation: mix some N-rich material to the mixture (digestate, lawn, chicken litter, etc.).
++ / +++	-	-	Young compost (or digestate). Nitrification has still not started. Recommendation: keep the mixture moist enough to avoid NH_4-N losses and allow nitrification.
++/+++	++	+ / ++	Nitrification process starting. Recommendations: keep the mixture sufficiently moist to avoid NH_4-N losses; make sure that the oxygen supply to the mixture is constantly sufficient
+	+/++	++/+++	Nitrification process is progressing. Recommendation: make sure that the oxygen supply to the mixture is constantly sufficient
-	-	++/+++	Nitrification process achieved. Recommendation: make sure that the oxygen supply in the mixture is constantly sufficient Compost is mature and ready to be used.
-	++/+++-	++	Oxygen starvation problem. Recommendation: improved aeration of the compost.

1 -: none (< 10 mg N / kg DM); +: low quantity (10-50 mg N / kg DM); ++: medium quantity (50-200 mg N / kg DM); +++: high quantity (> 200 mg N / kg DM)

Source: Handbook for Composting and Compost Use in Organic Horticulture, van der Wurff et al., 2016

8. Interpretation of analyses according to the "Swiss quality guidelines 2010"

Criteria	Composts and digestates for agricultural use			Compost for horticultural use	
	Digestate liquid	Digestate solid	Compost	Compost for field horticulture	Compost for covered cultures
DM (dry matter) [% FM]	X	X	X	*> 50 %*	*> 55 %*
OM (organic matter) [% DM]	X	X	X	*< 50 %*	*< 40 %*
pH	X	X	X	**< 7.8**	**< 7.5**
Particle size [mm]		X	X	*< 25*	*< 15*
Coulor of extract		(X)	< 1.0	**< 0.5**	**< 0.2**
Salinity [g KCleq/kg DM]	X	X	X	**< 20**	**< 10**

Minimal requirements, *recommendation*; X: has to be mentioned; (X): mention recommended

Criteria	Composts and digestates for agricultural use			Compost for horticultural use	
	Digestate liquid	Digestate solid	Compost	Compost for field horticulture	Compost for covered cultures
Total nitrogen [g/kg DM]	X	X	X	*> 10*	*> 12*
Ammonium ($N\text{-}NH_4$) [mg/kg DM]	*> 3'000*	**> 600**	**< 600**	**< 200**	**< 40**
Nitrate ($N\text{-}NO_3$) [mg/kg DM]			X	**> 80**	**> 160**
Nitrite ($N\text{-}NO_2$) [mg/kg DM]			(X)	*< 20 mg/kg DW*	*< 10 mg/kg DW*
Nmin. [mg/kg DM]	*> 3'000*	*> 600*	*> 60*	*> 100*	*> 160*
$N\text{-}NO_3$/Nmin.			(X)	**> 0.4**	**> 0.8**

Minimal requirements, *recommendation*; X: has to be mentioned; (X): mention recommended