Ergebnisse von Vergleichsuntersuchungen verschiedener europäischer Parameter zur Bestimmung des biologischen Stabilisierungsgrades

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Results of comparative studies of various European parameters for determining degree of biological stabilization

Abstract

Base for the comparison of various European parameters for determination of biological stability degree of products of biological treatment of residual waste, were investigations conducted on different plants for biological treatment in Europe. Samples of the input material, of intermediate products and the output material were taken and the following parameters were investigated: BM100, SRI, DR4, ASTM, PDRI. The results of laboratory tests were statistically evaluated to find out correlations between the different-parameters.

Inhaltsangabe

Ausgangspunkt für den Vergleich verschiedener europäischer Parameter zur Bestimmung des biologischen Stabilisierungsgrades von Rotteprodukten waren Untersuchungen auf zehn verschiedenen Abfallbehandlungsanlagen für Resthausmüll in Europa. Auf diesen Anlagen wurden Proben des Rotteinputmateriales, von Rottezwischenprodukten und des ausgerotteten Materiales gezogen und auf folgende Parameter untersucht: BM100, AT4, DR4, ASTM, PDRI. Die Ergebnisse der Laboruntersuchungen wurden statistisch verrechnet und überprüft, inwieweit Korrelationen zwischen den untersuchten Parametern bestehen.

Keywords

Resthausmüll, Mechanisch-biologische Abfallbehandlung, MBA, biologische Stabilisierung, AT4, DR4, ASTM, PDRi, BM100
Municipal solid waste, mechanical-biological treatment, MBT, biological stabilisation, SRI,

1 Introduction

The results of the comparison of different biodegradability indices are derived from sampling and analysis from various MBT plants in Europe. The scope of the investigations was to determine the performance of these plants and to establish correlations between different stability parameters.

Following stability parameters, which are used in different countries, were applied:

- Biochemical Methane Potential (BM100) UK
- Dynamic Respiration Rate (DR4) UK
- Static respiration rate (AT4) Germany, Austria
- Potential Dynamic Respiration Index (PDRI) Italy
- Test Method for Determining the Stability of Compost (ASTM) USA

2 Stability tests

In the following the investigated stability test are shortly described.

Biochemical Methane Potential (BM100)

The BM100 test determines the biodegradability of organic wastes under anaerobic conditions by measuring the production of biogas. This method is based on the Blue Book method for measuring the biodegradability of sewage sludge by anaerobic digestion (SCA 1977).

Under anaerobic methanogenic conditions the decomposition of organic carbon proceeds by producing biogas (CH_4 + CO_2) from the organic carbon. The amount of biogas production therefore measures directly the C mineralised. The test is set up in a small vessel containing the test substrate, a mineral aqueous medium and an inoculum of methanogenic bacteria taken from an active anaerobic digester. The test is monitored by collecting the biogas produced and recording its volume, which is then adjusted to standard temperature and pressure. The test is incubated for an extended period until gas production ceases which may be up to 100 days or more. The test therefore measures the complete biodegradation of the waste (ENVIRONMENT AGENCY, 2005).

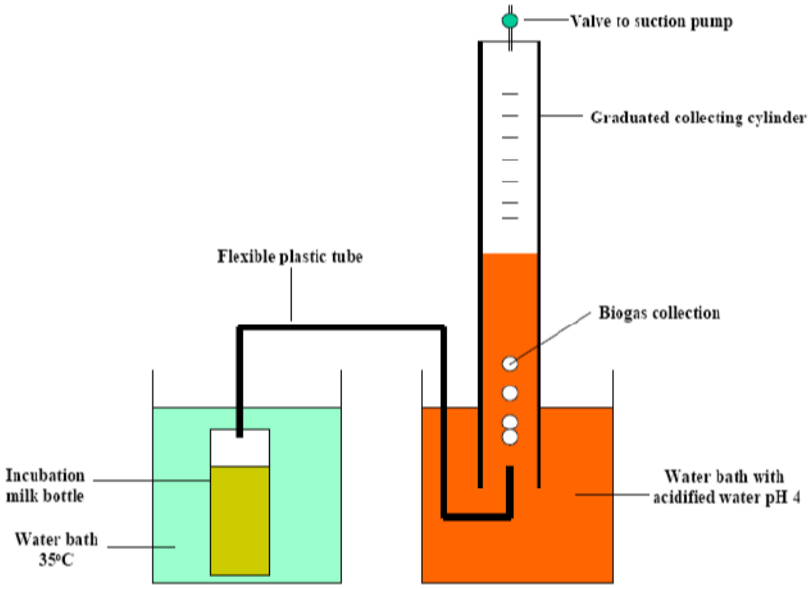

Figure 1: Schematic of BM100 method set up

Dynamic Respiration Rate (DR4)

The dynamic respiration test is an aerobic method of determining organic waste biodegradability based on the standard methods (ASTM D5975-96, ISO 14855:1999). This test method provides a measure of the biodegradability over 4 four days of any solid organic waste whether it is composed of readily biodegradable (raw) organic matter or treated stabilised or poorly bio degradable organic matter.

The DR4 or dynamic respiration index is a reference to the method description where the test is aerated by passing air through the waste. This definition is used to differentiate the method from those where aeration is by diffusion of air into and out of the test material, which are referred to as SRI or static respiration index.

At the beginning of the test, the sample is mixed with a mature compost that provides a good source of microbes (seed) able to degrade the test material. The mixture is incubated under aerobic conditions by aerating the mixture in a vessel through which air is blown. The microbes degrade the test waste producing CO_2 as the decomposition product, which is evolved and found in the exhaust gas stream of the system. The CO_2 production is then measured as a measure of the biodegradability of the test material and converted to oxygen consumption units. The test may also be monitored directly by the consumption of oxygen as an alternative to monitoring CO_2 production (ENVIRONMENT AGENCY, 2005).

Static respiration rate AT4

The static respiration rate was determined according to the method specified in the German *"Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste Treatment Facilities"* which translates the EU landfill directive into German law and specifies the requirements of waste before it can be landfilled.

AT4 is the cumulative oxygen consumption. The evaluation period is 4 days, and it begins following the initial lag phase. The lag phase has ended when the mean oxygen consumption, expressed as a 3-hour mean, reaches 25% of the value that results as the 3-hour mean in the region of the largest increase in the oxygen consumption within the first 4 days.

The weight of the oxygen consumed during the lag phase is subtracted from the weight of the oxygen consumed throughout the entire test (lag phase + 4 days), and it must not be more than 10% of the overall value. If this condition is not fulfilled, determination may not be carried out. Measurements must be recorded on an hourly basis.

Reporting units are on both on a dry matter (DM) and loss on ignition (LOI) basis, i.e. mg O/kg DM and mg O/kg LOI respectively.

Potential Dynamic Respiration Index (PDRI)

The test was conducted according the "Adani" method in the laboratory of Prof. Adani.

The Potential Dynamic Respiration Index (PDRI) is the result of the dynamic respirometric test which is a biological test measuring the hourly consumption of oxygen used in the biochemical oxidation of easily biodegraded compounds contained in an organic matrix by microorganisms, in conditions of forced air insufflation in the sample.
The Potential Dynamic Respiration Index (PDRI) expresses the value of biological stability of the sample standardized according to the main chemical-physical parameters. This standardization guarantees the best aerobic microrganism growth conditions, producing excellent conditions for their activity for the purpose of measuring the potential microrganism activity capable of degrading the organic substance (ADANI, 2004).

ASTM Test Method for Determining the Stability of Compost

The ASTM test was the basis for developing the DR4 test. The key difference is that the DR4 test is operated at 35 °C whereas the ASTM test is conducted at 57 °C.

This test method covers the stability of a compost sample by measuring oxygen consumption after exposure of the test compost to a well-stabilized compost under controlled composting conditions on a laboratory scale involving active aeration. The compost samples are exposed to a well-stabilized compost inoculum that is prepared from municipal solid waste or waste similar to the waste from which the test materials are derived. The aerobic composting takes place in an environment where temperature, aeration and humidity are monitored closely and controlled. This test method yields a cumulative amount of oxygen consumed of volatile solids in the sample over a four day period. The rate of oxygen consumption is monitored as well.

The test method is applicable to different types of compost samples including composts derived from wastes, such as municipal solid waste, yard waste, source-separated organics, biosolids, and other types of organic wastes that do not have toxicity levels that are inhibitory to the microorganisms present in aerobic composting systems (ASTM COMMITTEE ON WASTE MANAGEMENT, 2004).

3 Correlation calculations

The stability test methods employed for this project use different units in terms of the mass base to which the biological activity (gas yield or oxygen consumption) is related to:

- UK tests (BM100 and DR4) results are related to the LOI of the BMW[1] (BM100 = l gas/kg LOI BMW; DR4 = mg O_2/kg LOI BMW)
- SRI/AT4 and ASTM result is related to the dry matter of the whole sample (not BMW) (SRI/AT4 = mg O_2/g DM)
- Italian PDRI result is related to the LOI of the whole sample (not BMW) (PDRi = mg O_2/(kg LOI x h))

This means that the results are related to different parts of the waste that are to be assessed. For the determination of correlations between the different tests all results have to be converted to the same base unit. It was felt that the dry matter of the whole sample was the most suitable base because different types of waste can be directly compared using the same base.

[1] BMW = Biodegradable Municipal Solid Waste

4 Tested MBT plants and sampling

4.1 Overview of tested MBT plants

Over the last 4 years samples were taken from several operational MBT facilities across Europe.

The capacity of the plants ranges from 40,000 to 300,000 tpa. The plants were commissioned between 2001 to 2006 and

The composting technologies employed represent the main relevant processes currently used in MBT facilities:

- tunnel-composting system
- table windrow system (see Figure 3) and
- composting bays (see Figure 3)

Samples from Anaerobic digestion processes were only taken from a few facilities and are not included in this evaluation.

In total 15 plants were tested but not all data are presented in this paper as some of the data are confidential.

In all plants an upfront mechanical treatment is in place prior to the biological treatment process so that only part of the total waste input is biologically treated. The input in the biological treatment was typically less then 80 – 100 mm and the capacity of the biological treatment rages from 25,000 to 150,000 tpa. All processes work with forced aeration and the process time for biological treatment ranges from 10 to 70 days. This wide range is due to the fact that in some tested plants the main focus is on biological drying of the waste, which require shorter process period.

Figure 2: Unloading of a composting tunnel

Figure 3: Table windrow

Figure 4: Composting bays

4.2 Sampling

Samples were taken from different stages in the biological process.

For the actual sampling following procedure was used:

At least 10 sub-samples were taken for each sample. For input samples these samples were taken over a period of several hours to get a representative mixture of the waste of that day. Samples from the composting process were taken during turning or emptying of a tunnel or a batch. This was not always possible for the interim samples for which the outside of a windrow was removed using a front-end loader to reach a representative part of the batch. Samples were then taken randomly from the cross section of the windrow. The sample size depended on the type of waste. For the composting material which is usually sized less than about 80 mm, sub-samples of 10 to 15 ltr were taken.

All sub-samples were then combined and thoroughly mixed. To reduce the volumes for removal to the laboratory, “coning and quartering” was used.

5 Results of correlation tests

In the UK, both the general approach and the parameters used to assess the performance of MBT are different to those used in continental Europe. As there is only little data available for comparison of results from the test requirements in Germany/Austria and the parameters used (mainly SRI - in Germany referred to as AT4, and PDRI in Italy) both the UK parameters and SRI and PDRi have been analysed.

As explained in section 3 all results have been converted to be related to the dry matter content of the total sample.

In Figure 5 to Figure 8 the correlation between the SRI/AT4 (on the x-axis) with the other stability parameters on the y-axis are shown (BM100, DR4, PDRI and ASTM).

The coefficient of determination (R^2) shows a straight forward linear correlation of 0.83 between the SRI and the BM100 and 0.82 between the SRI and the PDRI. The coefficient of determination for the correlation between the SRI and the DR4 and the ASTM are lower at R^2 = 0.68 and 0.56 compared to the parameters listed before.

While there are some differences in the robustness and accuracy of these biological parameters, in general are parameters are suitable to be used to determine the reduction of the biodegradability over the course of a composting process. This means in turn that all these parameters can be used to determine the effect of the MBT process on the biodegradability of the output materials. As a practical consequence an agreement with, for example, a technology supplier could be arrived at where the acceptance of a plant could be based on the SRI/AT4.

What needs to be agreed for any parameter is a sufficient number of samples and test results and a procedure to eliminate outliers (tests which have been failed due to the vulnerability of the test method). For ongoing monitoring, a rolling average of the last 4 results could be a reasonable approach.

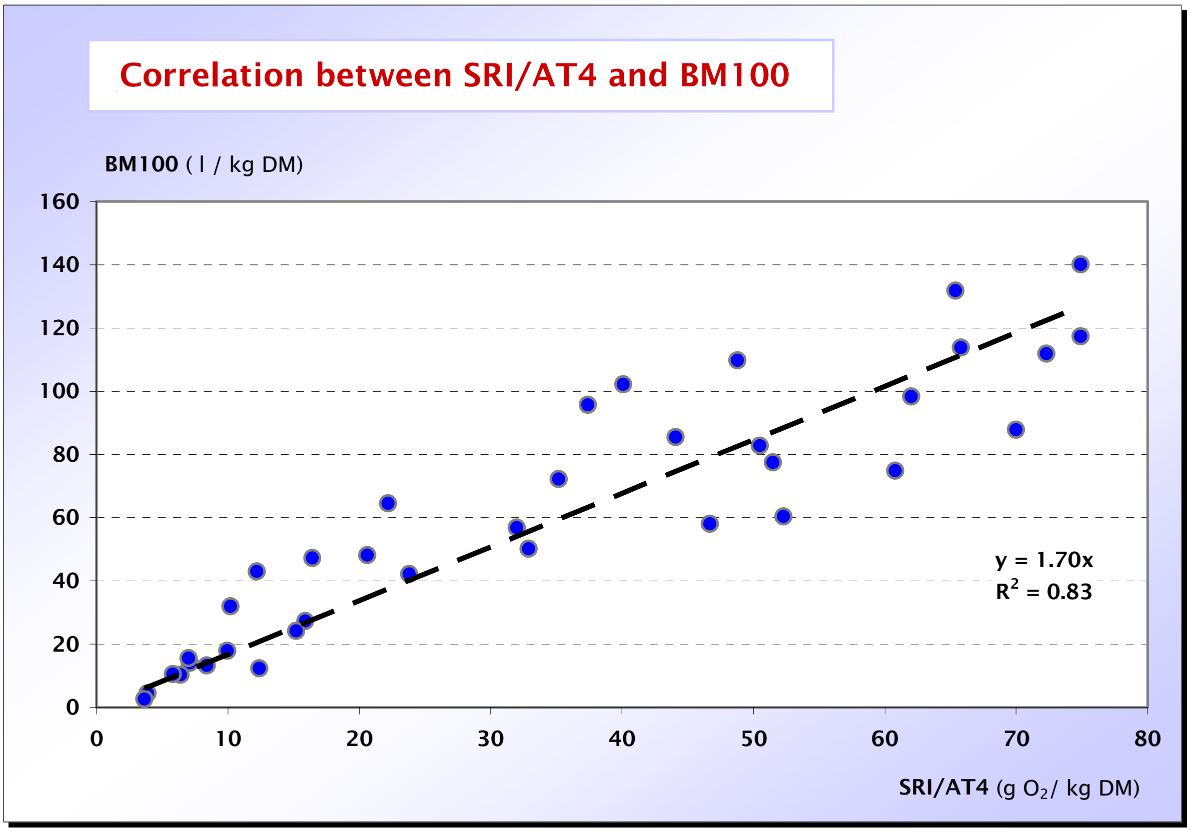

Figure 5: Correlation between SRI/AT4 and BM100

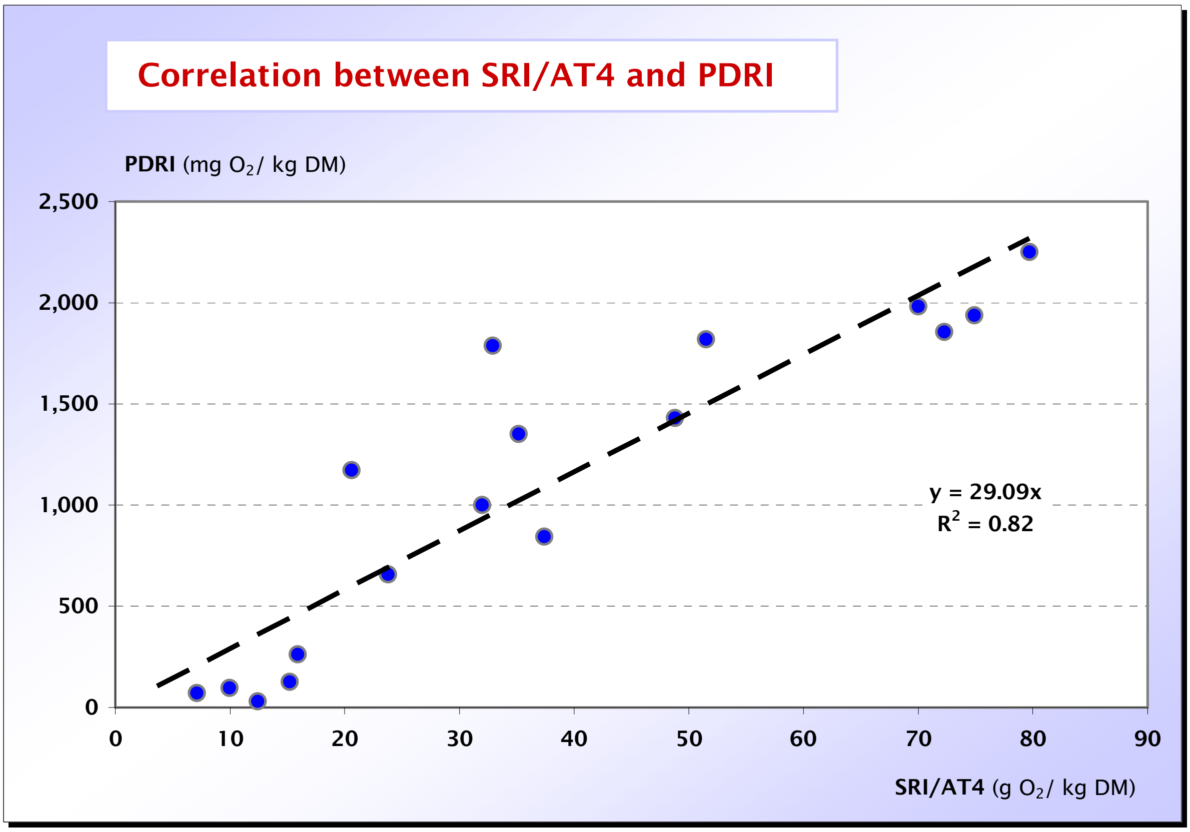

Figure 6: Correlation between SRI/AT4 and PDRI

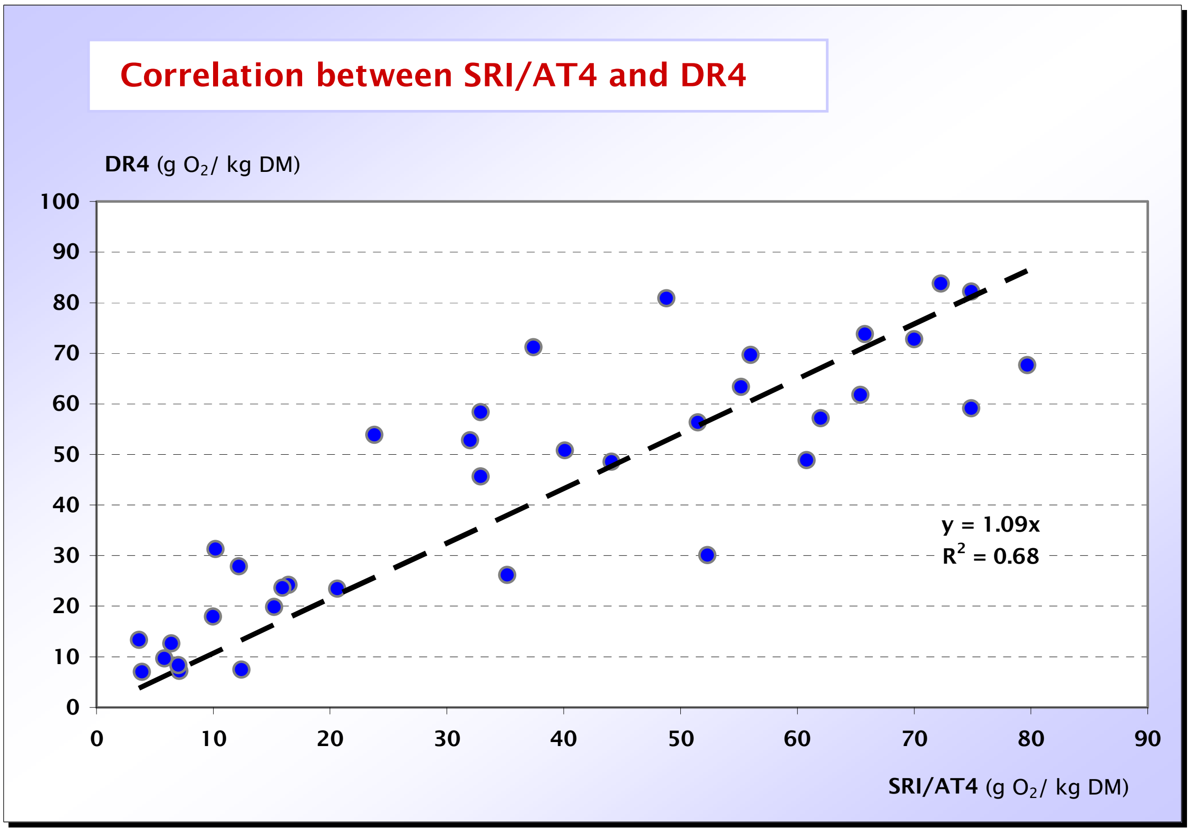

Figure 7: Correlation between SRI/AT4 and DR4

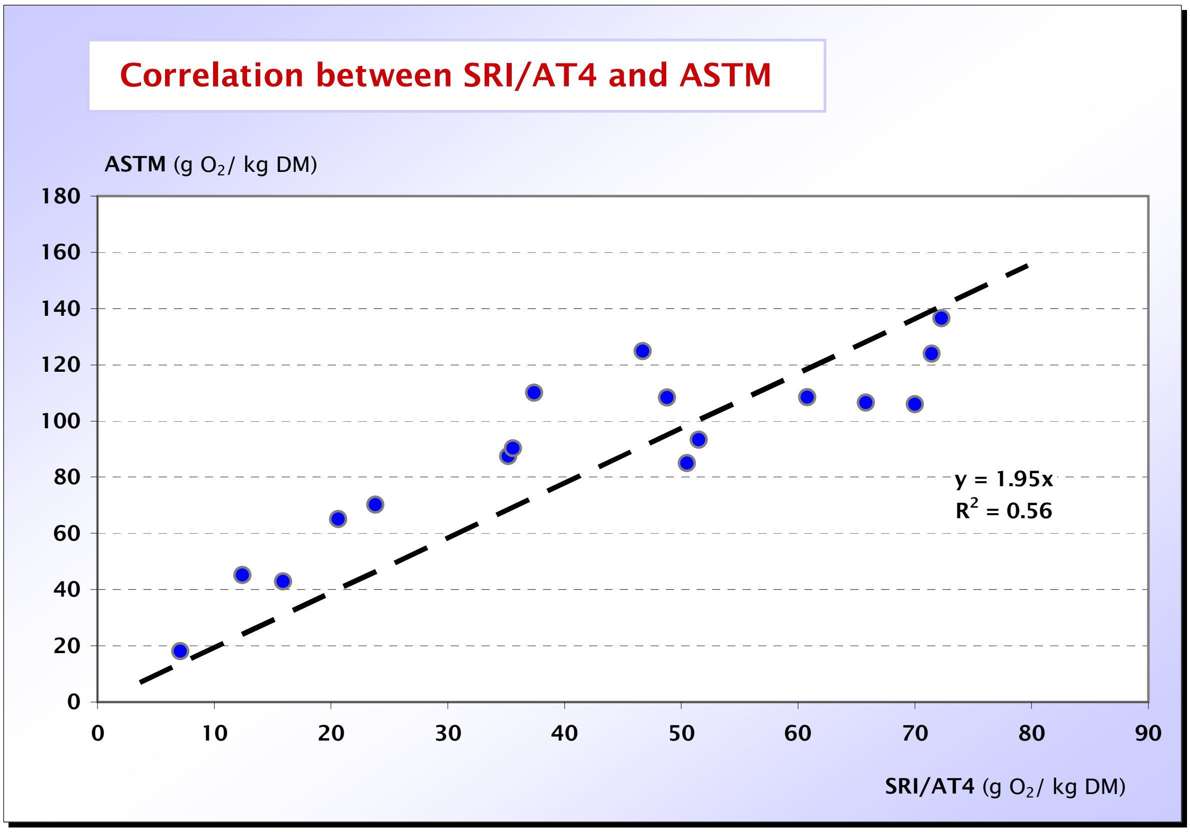

Figure 8: Correlation between SRI/AT4 and ASTM

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Anschrift des Verfassers

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