ANAEROBIC DIGESTION OF WASTE: PROBLEMS WITH CONTRARIES AND INNOVATIVE SOLUTIONS

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SUMMARY: This paper contains an analysis of the inherent reasons for the unsatisfactory performance of most separation technologies currently in use in waste treatment technology. Anaerobic digestion of biowaste and organic fraction from municipal solid waste (OFMSW), containing certain amounts of contraries such as sand, gravel, glass and plastics is a rather young technology. The growing experience with industrial scale implementation shows the necessity of making changes in the overall process. A possible solution is shown, using a much improved wet mechanical separation method for waste material, yielding separated inert and organic fractions that can be used f. ex. as building material, refuse derived fuel (RDF), compost or biogas.

1. INTRODUCTION

Separation of contraries such as sand, gravel, glass and plastics as a pre-treatment for anaerobic digestion (AD) of biowaste and the organic fraction of municipal solid waste (OFMSW) has been chiefly implemented to protect the plant equipment. This applies mainly to wet anaerobic digestion but recently also to dry anaerobic digestion. Scum layers are a yet another common problem in wet anaerobic digestion and recently also for the anaerobic digestion of Renewable Raw Materials. The technology of anaerobic digestion is therefore possibly not appropriate for suspensions containing particulate matter.

The pre-treatment of waste for removal of contraries is generally implemented only for protection of the equipment and has no further purpose as to energy efficiency, waste management or lowering emissions.

After evaluating the experience in anaerobic digestion to date, we have postulated the following requirements for treatment of biomass, regarding energy efficiency, waste management and emissions.

Energy efficiency of biomass treatment

In general the quality of anaerobic digestion of biomass is measured by maximum biogas yields. Economically the separation of materials unsuitable for AD beforehand would be much more sensible, these could be incinerated or recycled .

Most AD processes are designed to treat the largest organic fraction regardless of the anaerobic degradability and regardless of dry matter content. Incineration of dry wood is much more energy efficient than anaerobic digestion of dry wood. Accordingly anaerobic digestion of wet organic industrial waste with high biogas yields is more energy efficient than incineration of this wet material.

Organic matter, once free from contraries, can be dewatered by simple screw presses up to a dry matter content of more than 50 %. This dewatered material is already suitable for energy efficient incineration.

With an anaerobic digestible fraction of less than 50 %, as in f. ex. sewage rakings, thermal treatment like incineration or gasification even without drying is superior to fermentation. This is economically as well as regarding energy recovery the better alternative.

Waste management requirements for biomass treatment

The former three-step hierarchy of waste management has changed into a five-step hierarchy (avoidance – reuse - recycling - energy recovery - disposal) according to the EU Waste Framework Direcitve. Sand, gravel, glass as well as compost or fibres can be recycled from organic waste.

However, recycling of compost and fibres depends on the successful removal of pollutants, contraries and easily degradable organic matter. Pollutants are mostly dissolved in the liquid phase or attached to the fine inert particles, but by aerobic or anaerobic biological treatment they are partly incorporated into organic matter. Therefore composting and most AD processes are not suited for removal of pollutants. Compost should further be free from abrasive materials such as sand to allow pelleting for better logistics and storage properties.

Similar quality standards apply also to incineration in power plants, especially in modern coal fired combustion. Here the content of heavy metals, chlorine and ash has to be quality assured.

Emissions from biomass treatment

Emission reduction is a general concern, also in biomass treatment. CO_2-emission originates from energy consumption for pretreatment as well as from consumption of natural gas for exhaust air treatment and from unrecovered energy from composting. Odour emissions can also be a problem, especially near residential areas.

Following these requirements, we developed a new technology for sustainable biomass treatment. During a research project from 2004 to 2006, sponsored by the “Deutsche Bundesstiftung Umwelt” and scientifically supported by University Duisburg-Essen, and by further research, we could show, that composting as well as anaerobic digestion of suspensions containing particulate matter can become superfluous.

2. OVERVIEW OVER THE DEVELOPMENT OF AD IN GERMANY

The historical overview shows the development of the different AD processes. In Germany, the “Act of Power Input from Renewable Energy” in 1990 brought the breakthrough for anaerobic digestion, but still focused on waste treatment. The substrates were mainly manure and co-substrates such as fodder and spoiled silage, not saleable potatoes, fat etc.

From 1992 to 1995 five anaerobic digestion plants exclusively for separately collected municipal biowaste, without co-fermentation were commissioned. Experiments with anaerobic digestion of OFMSW were conducted in test plants in Quarzbichl (dry AD), Münster (wet AD) and Kahlenberg (percolation). The first industrial scale plant was commissioned in Bassum for dry anaerobic digestion of OFMSW and sewage sludge. The total capacity for AD of OFMSW in

2004 was 35.000 tons per year.

Following the “Renewable Energy Sources Act” in 2000 with an amendment in 2004, concerning specially the advancement of Renewable Raw Materials, the young AD technology has been booming without being prepared to full extent. Between 2005 and 2006 eleven AD plants for MSW with a total capacity of nearly 1 Million tons per year were commissioned.

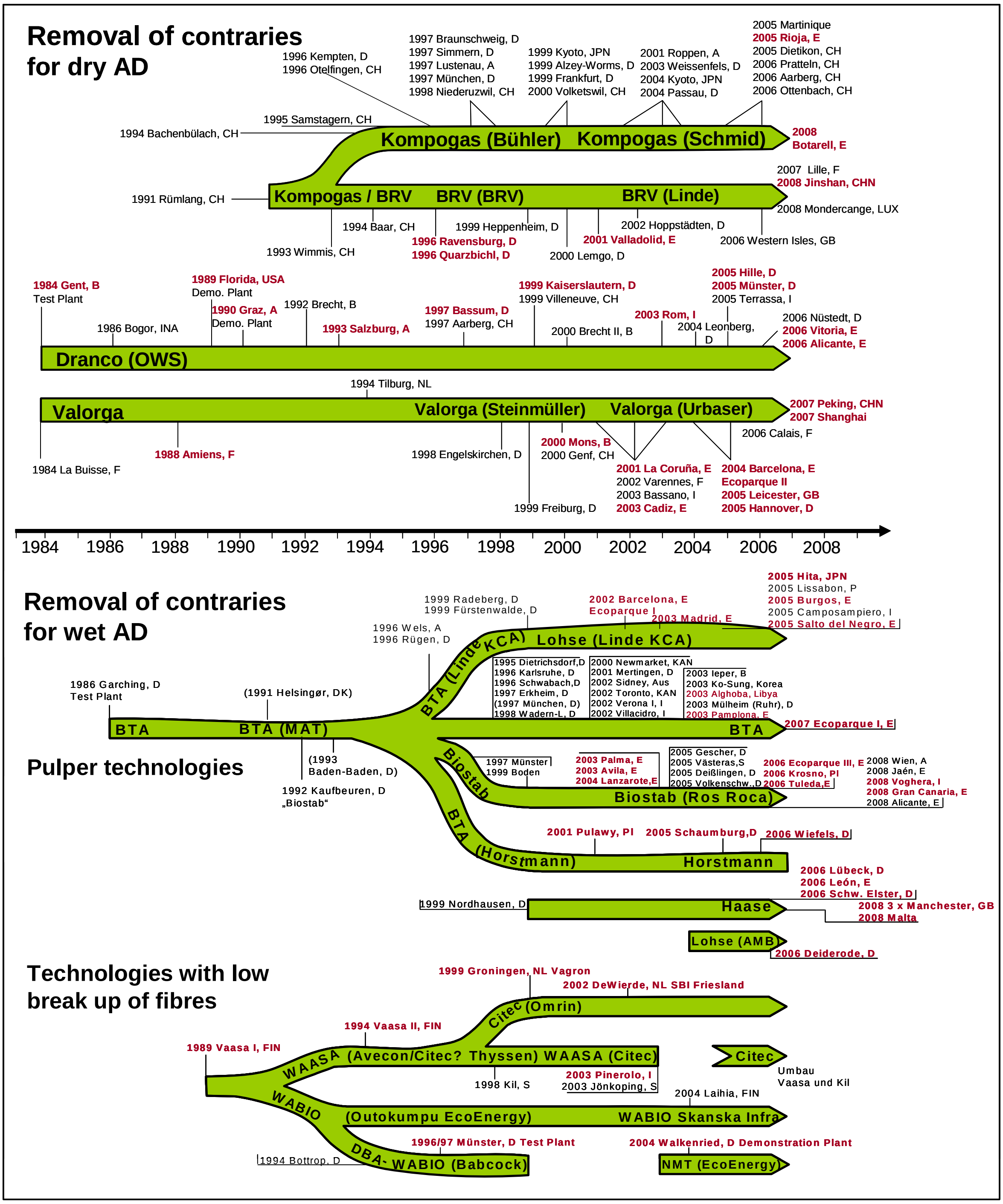

Figure 1. Development of anaerobic digestion (not exhaustive)

3. MECHANICAL TREATMENT AND REMOVAL OF CONTRARIES

For pretreatment, biowaste and MSW are first shredded and screened to particle size of < 40 mm to < 120 mm and metals are separated. Further treatment varies, depending on the AD technology.

Anaerobic digestion processes can be classified into wet and dry processes, where solids are digested, and processes where the waste is washed and only the washwater is put through anaerobic wastewater treatment (wash process). This second type of technologies is including percolation technologies, technologies with hydrolysis and separation processes yielding wastewater enriched with easily biodegradable organic contents.

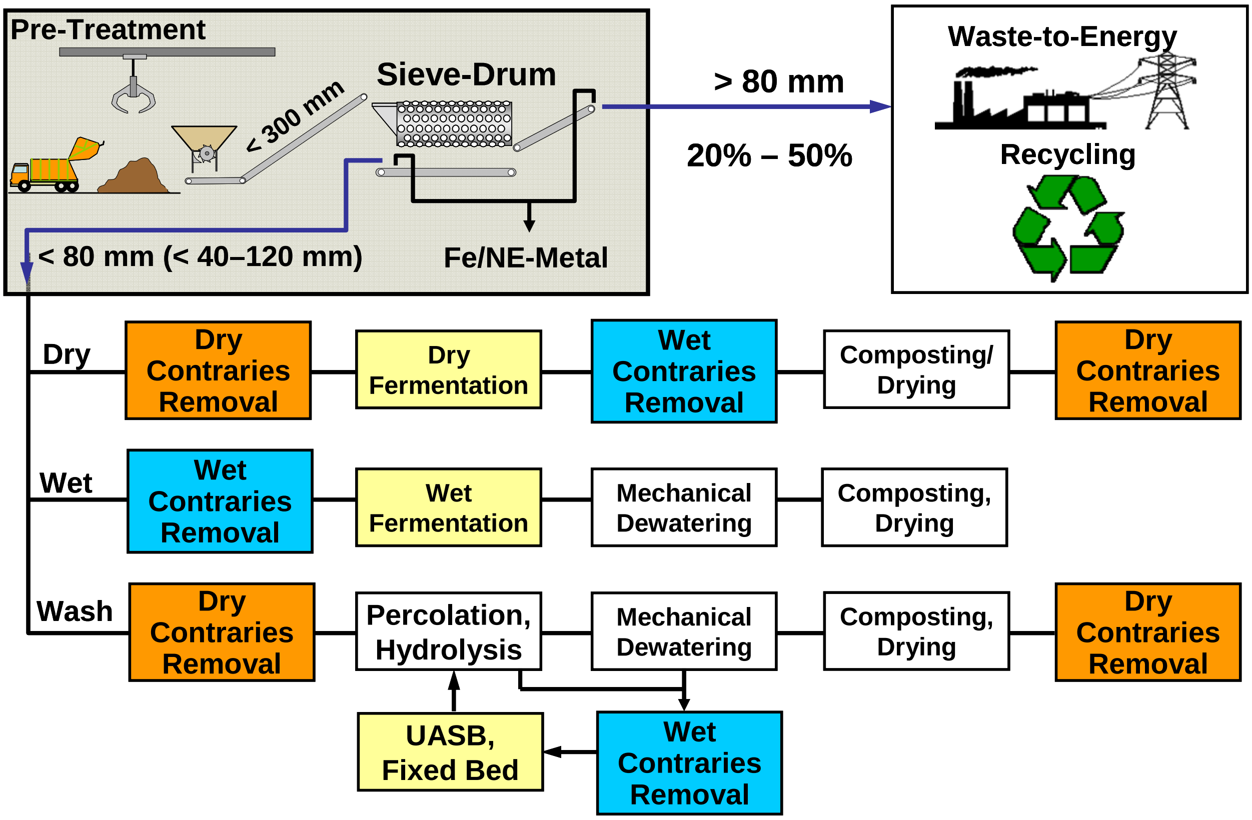

Figure 2. Principle of contraries removal for wet anaerobic digestion

Wet AD (Anaerobic Digestion) technologies usually separate contraries by grinding the material and mixing the material with water in a pulper. Part of the contraries can be separated from this suspension by gravity, but the separation is not complete due to the high viscosity of the suspension. Upon feeding the suspension into the digester the viscosity then drops quickly because of the bacterial digestion of soluble degradable components. For that reason sedimentation of sand in the digester as well as for the development of scum layers is often experienced.

Mechanical separation is more effective in processes without grinding or crushing of the waste material prior to separation. However, due to the low selectivity of the mostly one-stage separation processes the results are also not ideal.

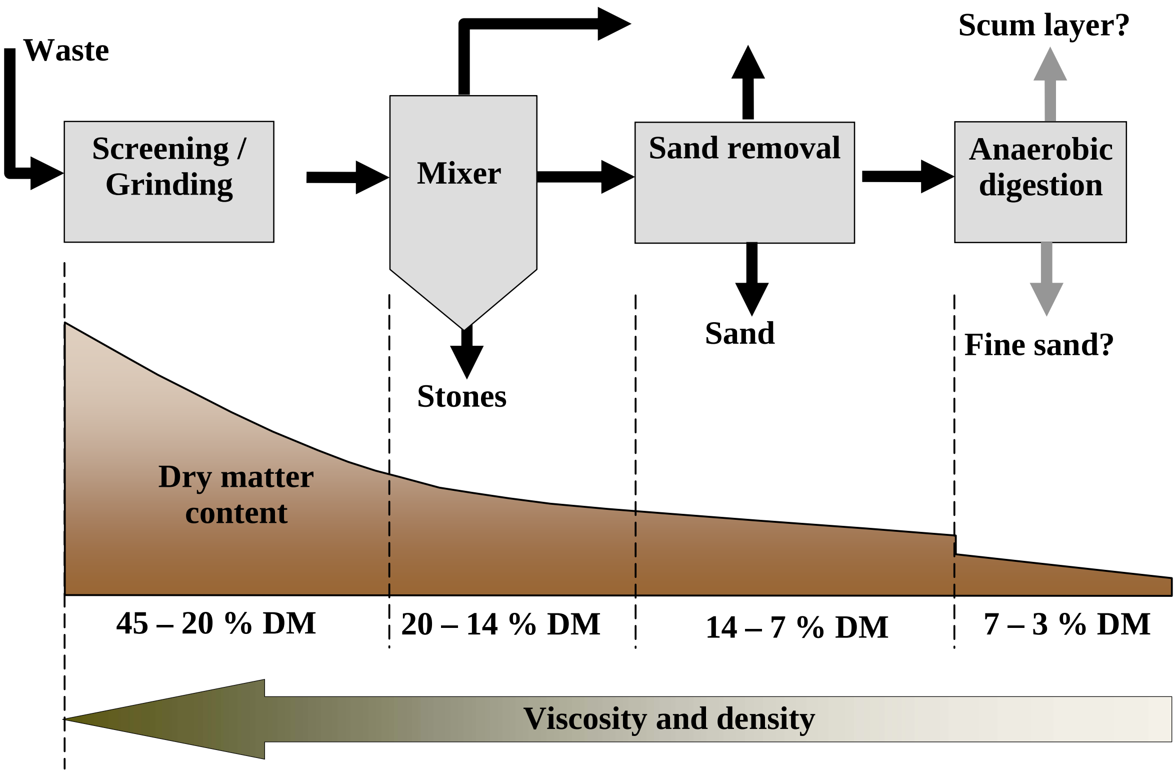

Figure 3. Principle of contraries removal for wet anaerobic digestion

In dry AD plants contraries usually do not interfere with the digestion process itself but are rather impeding dewatering of the digestate and cause similar problems as in wet AD processes.

3. ADVANCEMENT OF WET MECHANICAL TREATMENT

By developing a new, advanced process for wet mechanical treatment of waste (NMT-process), we could demonstrate that composting as well as anaerobic digestion of suspensions with particulate matter are not technically justifiable in the future.

Figure 1 shows the development of contraries removal for anaerobic digestion of solid waste including the DBA-WABIO-process. Babcock dropped the distribution of the process after the merger with Steinmüller in 1999. Our technology is based on the DBA-WABIO-process prinicple avoiding disruption of fibres and we have advanced it into a wash process.

Sand-free organic fractions are produced by a three-stage inert separation and simultaneous production of three organic fractions, washed stepwise with process water. The organic fractions are further separated into particle sizes of 100 µm to 10 mm, 10 mm to 30 mm and 30 mm to 80 mm. The organic fractions are separately dewatered by screw presses. Thus the press force is applied evenly to the material, because no coarser particles are blocking off gaps where the dewatering is hindered.

As an additional distinction of the NMT-process the process water is heated to > 65 °C for destabilising the cell walls and to enable a better cell disruption during dewatering in the screw press. This destabilising effect is due to the structure of the plant cell wall, consisting of not easily biodegradable cellulose fibrils. The fibrils are embedded into a matrix of hemicelluloses, lignin and pectin and are connected by hydrogen bonding. The hydrogen bonds destabilize at a temperature higher than 65 °C so that little shear force is already sufficient for cell disruption.

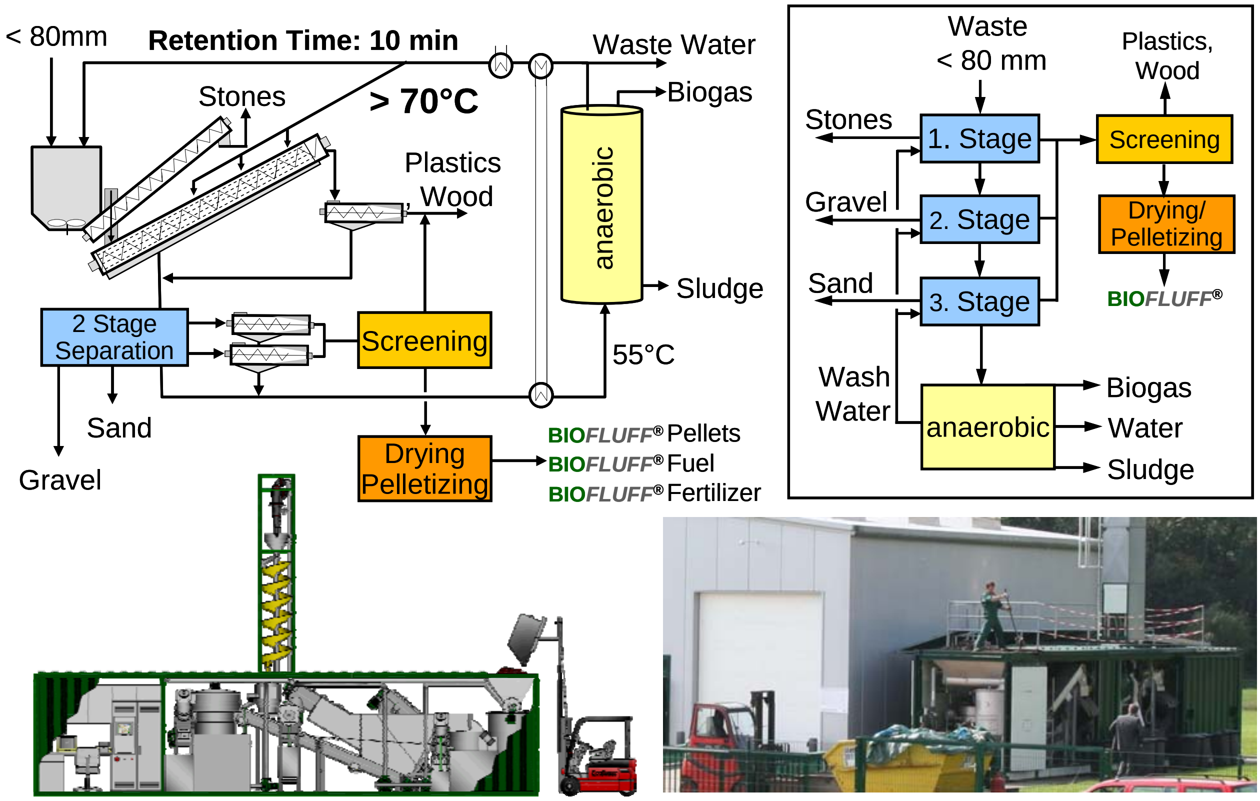

Figure 4. Wet mechanical separation with the NMT-Process

4. RESULTS AND DISCUSSION

With the NMT-Process we have thus achieved dewatering biowaste and MSW to a dry matter content of > 60 % - inert free - using simple screw presses without prior anaerobic digestion, percolation or hydrolysis. The low water content is due to the above described effect of thermo-mechanical-cell lysis (TMZ) since the cell disruption releases the cell water.

A further advantage of the process besides the high yield of easily biodegradable organic compounds is the selective disruption of the native organic fraction by TMZ into particles < 5 mm. The particle size of the fossil organic fraction is not altered by TMZ. The hard plastics and plastic foils can therefore easily be separated from the native organic fraction by screening.

Dewatering of the inert fraction can be achieved without drying. The inert fractions are already dewatered and cleaned in the process with circulating water and fresh water so that they can be recycled.

The process ensures that the native organic fractions contain few pollutants. Chlorine is separated with the fossil organic fraction (PVC) or is present as a soluble salt in the wash water. Dewatering is done without thermal drying so that 50 % to 90 % of the soluble pollutants, depending on the waste water treatment and press adjustment, are removed. The sludge produced from waste water treatment is the pollutant sink of the process and can be disposed.

We could further verify by experiment, that 65 % to 80 % of the biogas production, generated with AD from the total material, would also be yielded using the NMT-process.

The process yields low polluted inert fractions that can be used for construction purposes as well as sand-free organic fractions, containing only low polluted native organic matter, even from the treatment of MSW.

The dried and screened native organic fraction (BioFluff) is then prepared according to the chosen way of recycling or energy recovery. BioFluff can be defined as low polluted, dry stabilised, ravelled out biomass and can be widely used as raw material. For use as fertilizer the material can be pelletised, for use as fuel the material can be pelletised or pressed into briquettes. BioFluff can also be used as raw material for insulation, as building material or filter material or even for ethanol anaerobic digestion. Pelletising or briquetting is recommendable for most applications for logistic reasons since Bio-Fluff has a rather low density.

In the research project “Wet mechanical treatment of waste” (NMT-process), sponsored by “Deutsche Bundesstiftung Umwelt” and scientifically supported by the University Duisburg-Essen, EcoEnergy could demonstrate by the shown biological, physical and mechanical possibilities that composting as well as anaerobic digestion of suspensions with particulate matter in the future are not technically justifiable anymore.

The dried and screened native organic fractions can be defined as low polluted, dry stabilised biomass and can be widely used as raw material, for ethanol production, as fertilizer or biofuel.

New results show that the BioFluff Fractions from separately collected biowaste and from the organic fraction of municipal solid waste show only slight differences in their pollution content.

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