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# Lessons Learnt from the Solid Waste Management Projects in Bangladesh

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## ABSTRACT:

*The inadequate facilities and the organizational set-up city authority for proper addressing the MSW management issue, brings Non-Governmental Organizations (NGOs), Community Based Organizations (CBOs) and Private sectors to think and hence to work in this sector. In Bangladesh, in the early 80's some NGOs and CBOs have been started to formulate some projects for the management of municipal solid waste focusing the improvement of city environment. To materialize the proposed tasks of the project, NGOs have received fund from donor agency, while CBOs raised the fund from its members and also received donation from rich people living in the area. They have started some specific activities for solid waste management incorporation with respective municipality. However, in most of the cases, it was observed that the initiatives either lost the pace or closed. In this paper, the lessons learnt from some solid waste management projects are described.*

## INTRODUCTION

In Bangladesh, urban population mostly concentrated in 10 City Corporation, 318 municipality and around 250 growth center. Presently, urban population is about 30%, which will raise as much as 40% by the year of 2025 as predicted by different international and local organizations (ADB 2010). Moreover, about 60% of urban population and nearly 13% of total population of the country are living in six main cities, these are: Dhaka, Chittagong, Khulna, Rajshahi, Sylhet and Barisal. In addition to urban growth, Bangladesh is currently undergoing a period of unprecedented rapid economic growth. The mirror of a modern society is that it always wanting more, producing more and consuming more. As the wastes generation is an inevitable consequence of production and consumption activities in any society and economy, there is no doubt that the solid waste generation is growing proportionately with the growth of urban population and economy.

Due to inadequate and often inefficient management and visible environmental degradation, the problems associated with solid wastes have acquired an alarming dimension in the urban areas of Bangladesh. City authority is solely responsible for overall management of MSW in urban areas as per the Municipality Act of Bangladesh (WasteSafe 2005). Generally, Conservancy Department is responsible for solid waste management including other utility services. There is no independent wing with sufficient authority to deal the municipal solid waste (MSW) problems in the municipality. It is observed that the attempts taken by city authority do not work well due to severe financial constraints, required infrastructures, absence of appropriate and sustainable technology, lack of motivation, awareness and participation, and the absence of effective legislation, and finally absence of strong commitment and effective initiatives.

The involvement Non-Governmental Organizations (NGOs), Community Based Organizations (CBOs) and Private Sectors in MSW management is mostly due to the failure of city authority for proper addressing of the MSW management issue in the urban areas of Bangladesh. In Bangladesh, in the early 80's some NGOs and CBOs have been started to formulate some projects for the management of MSW focusing the improvement of city environment (Huda 2008) To materialize the proposed tasks of the project, NGOs have received fund from donor agency directly, while CBOs raised the fund from its members and also received donation from rich people living in the area. They have started the works incorporating respective municipality with their activities. Their works are limited to some tiers of the system, not the entire solid waste management system. In Bangladesh, in solid waste management project some international organizations are involved directly and indirectly, those can

be listed as JICA, GIZ, ADB, CIDA, Practical Action, Care, World Vision, WaterAid, European Commission and AusAID, etc..

NGOs, CBOs and are mainly involved in awareness campaign among the city dwellers to aware them about the necessity of solid waste management, collection of solid wastes from household sources through the door to door (DtD) system, composting of organic wastes, recycling and clinical waste management. It is observed that the participation of NGOs and CBOs in MSW management in the major cities of Bangladesh has brought this most striking social and environmental issue to the concerned stakeholders as the matter that needs to address immediately. However, due to inconsistency with the local situation, lack of awareness of the city dwellers shortage of fund specially beyond the project period, in absence of appropriate system and the non-commitment of the local authority, most of the projects either lost their pace or shutdown. The lesson learnt from some SWM projects adopted in Bangladesh in the recent years is described here.

## BASIC FACTS OF MUNICIPAL SOILD WASTE IN BANGLADESH

In Bangladesh MSW are generated at a rate of 0.325-0.485 kg/cap/day, obtained from different source of generation such as 75-85% residential, 11-22% commercial, 1.0-1.5% institutional, 0.50-1.25% municipal services, and 0.4-2.50% others. The composition is 68-81% food & vegetables, 7-11% paper & paper products, 3-5% polythene & plastics, and 9-16% others. The wastes contain high portions of volatile solids (43-71%), while ash residue from 29 to 57% and have high moisture content (56-70%). The bulk density of MSW ranges from 400 to 600 kg/m3. The size of the components of MSW varies from 2 to 200 mm. Other properties are encountered as pH (acidity/alkalinity) from 7.7 to 8.7. Average value of some chemical constituents is 11.50% carbon, 0.91% nitrogen, 0.76% potassium and 0.33% phosphorous. Recent study shows that the generations of hospital waste in four major cities are: Dhaka is 0.22%, Chittagong is 0.20%, Khulna is 0.42% and Sylhet is 1.74% of total generated MSW. Study also shows that the generation rate of hospital waste varies from 0.70 to 1.2 kg/bed/day and the percentage of hazardous portion varies as 10% to 30%. More details can be obtained at WasteSafe (2005) and Alamgir & Ahsan (2007). It is observed due tow collection efficiency and disposal scenario, each day huge amount of MSW is disposed in the dumping sites, which produces significant amount of GHG for emission into the atmosphere (Alamgir 2009).

## EXISTING MANAGEMENT SYSTEM OF MUNICIPAL SOLID IN BANGLADESH

In Bangladesh, the MSW issue was one of the least concerned environmental aspects at the country's highest decision making level. There is no national policy for proper management of MSW and to minimize the adverse environmental impacts on human health and nature. However, in the recent years, the relevant stakeholders, especially the city dwellers and the local city authority gave attention to solve this issue, which exaggerates due to rapid urbanization. The existing management of MSW in Bangladesh is very primeval (WasteSafe 2005). MSW are collected from generation sources by non-governmental organizations (NGOs), community based organizations (CBOs) and city authority by door-to-door collection system, and most of the cases waste generator disposes it to the nearest community bins/ secondary disposal sites (SDS)/ open land/ road sides/ drains. In Bangladesh, city authority is solely responsible for providing SDS; collect wastes from SDS and transfer for final disposal as per existing City Corporation Act. All the ultimate disposal sites (UDS) of MSW in Bangladesh, are uncontrolled crude open dumping site, where even minimum environmental protections are not provided. Composting is one of the common options for treatment and reuse of organic portions of MSW is done in a very small scale by dwellers, NGOs, private sectors and even city authority. Recycling, Reuse and Recovery (3'Rs) are also practices in almost in each tier through individual and/or informal sector. However, major portions of wastes remain unmanaged - throwing them in the adjacent spaces, roadsides and drains etc. A portion of clinical/hospital wastes is managed by NGOs/city authority and the remaining follows the same path of MSW (WasteSafe 2005). The existing management of MSW in the cities of Bangladesh can be characterized as (i) absence of appropriate organizational set-up in the city council and accountability, (ii) significant portions of wastes remain out of any sorts of management, (iii) no special attention to manage hazardous wastes, (iv) recycling, composting and other product oriented management activities are running through informal sectors without any support from government level, and (v) insignificant involvement and participation of local community in the system.

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## BRIEF DESCRIPTIONS OF ININTIATIVES AND LESSON LEARNT

To address the adverse environmental impacts on human and nature, NGOs, CBOs and local authority initiated some projects with help of some donor agencies and the respective city authority starting from early 1980s. In some case, individual also took the personal initiative. The experience learnt through these initiatives for management of MSW is discussed in the followings.

### Source Storage and Primary Collection

In Bangladesh, significant parts of MSW remain unmanaged and hence littered in the close vicinity of the generation points. It is observed that in the urban areas of Bangladesh, more than 40% waste generators do not store, just throw away. People from all cross-section of society used to do it. It occurs in home, office, markets, stations/terminals, recreation place and even in the class room. To address these adverse environmental impacts on human and nature in the urban areas, NGOs, CBOs and the individual person took some initiatives in cooperation with the local authorities receiving financial support of donor agencies for proper source storage and home collection of wastes starting from 1980s. Firstly, they started motivation and awareness campaign to the city dwellers, distributed leaflets and even supplied waste bins for source storage for proper management of household wastes at the source. They also took the necessary initiatives for the collection of wastes through Door-to-Door system against tiny payment from the households. In some cases, MSW was collected free of charge. These types of works have been initiated by the several NGOs and CBOs most in major cities such as Dhaka, Khulna, Rajshahi and Sylhet. Some of these organizations are: Waste Concern, Prodipan, Noujuyan, PRISM, Sylhet Partnership, Muktir Alo, etc.

It is observed that these initiatives did not continue till the full achievement due to discontinue of donor agencies funding and the lack of support from the city authority. Moreover, supply of waste bins among the slum dwellers for the storage and separation of recyclable and rapidly biodegradable wastes do not work due to lack of awareness and effective waste collection. Awareness campaign initially encouraged the people about proper management but to discontinuation of the project and the absence of necessary drive from the local authority, the pace has lost. Due to this in some instants, it is observed that in spite of the presence of bins, people do it from their inherent habits and ignorance. In this backdrop, it can be concluded that the absence of peoples' awareness, commitment and motivation lead to continue such unpleasant and catastrophic habits. Sylhet Partnership in cooperation of Sylhet City Corporation, installed some waste bins in the city area attached with light post so that the people don't through away wastes rather deposited in the bins. But it did not work because due to lack habit and the commitment, they put the wastes outsides of the bins rather out inside. Later, it was observed that the situations were even worst. Sylhet Partnership later removed this bins and project has failed. So, before designing and practicing an approach, all the related issues especially socio-economic conditions and existing practices must be considered.


Figure.1 Failure attempt of the installation of waste bins in street

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Fig.2 Conditions of the Rickshaw Van after the end of project.

Figure 2 show the present conditions of the Rickshaw van which was developed as part of Waste management project. This type of van was handed over to NGO and CBO to help in their services provide to the city dwellers to collect household wastes through DtD collection system. After ethe end of project support, the NGO and CBO failed to even conducting routine maintenance. Conducting physical survey recently, it is observed that the condition is worse than it was before. At the beginning of the project activities, people became aware and cooperative but after a break of follow up all the beneficial outcomes have reached to the brink of its application. So sustainability beyond the project period is one of the main factors to ensure better waste management.

## Composting

Composting is a very old practice both in urban and rural areas of Bangladesh. In this case specific materials such as cow dung, various green wastes, human excreta etc., was used separately or mixing together. However, In Bangladesh, using MSW decentralized compost plant was initiated by Waste Concern 1994. Later several compost plants were established in different cities such as Khulna, Sylhet, Chittagong, Tongi, Jessore, etc. Initially, the plants started with much enthusiasm since MSW in Bangladesh is very much suitable for composting. However, it is observed that most of the plants were shutdown (Fig.3) due to lack of appropriate technology, sustainable supply of MSW, lack of funding and for not getting government permission to sale compost as an organic fertilizer. Waste Concern established the first CDM project in the world in compost near Dhaka. But from the beginning, this plant has been suffering from the sustainable supply of MSW as mentioned in the project, as a result the sustainability of this project is in threat. The compost plant established at personal level and supported by WasteSafe project later closed due to lack of marketing facilities and not getting government permission. The compost plants established PRISM in Khulna, Prodipan in Tongi, Waste Concern in Jessore, Sylhet Partnership in Sylhet, were shut down just after 2 to 3 years of opening of the plant. However, there is success story of compost plant at Munshigonj which was established at personal level, who worked long time in Japan in a compost plant. His product is very much consistent with the requirement of the farmers. It is realized that the entire chain of compost plant starting from the constant supply and quality of compost and its marketing along with government support is necessary for the sustainability of the compost plant.

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Fig.3 Pictorial view of a shut down (left) and a running compost plant (right).

## Hospital Waste Management

The rapid increase in the number of clinics and hospitals in the country has proportionately increased the generation of hospital wastes. Dhaka city is about 1.7 kg/bed/day (Kazi 2004). Study shows that the generation rate varies from 0.70 to 1.2 kg/bed/day and the percentage of hazardous portion varies 10 to 30% (MoHFW 2004, BRAC 2006, Sarkar et al. 2006, Khan et al. 2008 and Fatema et al. 2010). The largest part of this hospital wastes is organic wastes which has not been paid enough attention to segregate it at the source. But very few of the hospitals provides for safe disposal of wastes. In late 1990's and early 2000's, some relevant authorities such as DGHS and NGOs have been started to work on the management of hospital waste at some major cities of Bangladesh. An initiative at small scale level was first taken by Prodipan, a local NGO in Khulna City in 200 in cooperation of Khulna City Corporation, later such activities extended in Dhaka City by PRISM. NGOs are also involved in other cities for hospital waste management taking some collection fees from the clinic and hospitals. The works started from source storage, primary collection, transfer, separation, burning and finally deposition. Except Dhaka, the hospital wastes finally disposed in ultimate open disposal sites. The NGOs started to work in this sector with the help of donor agencies, however, after the end of the funding from donor agencies, financial constraints became the main factors for the sustainability of the services. As a result some important tiers of management were either ignored or closed. Presently, in Khulna, there is no hospital waste management except collecting of waste from some selected clinics and hospital and then dumped in the ultimate disposal site with the MSW (Fig.4).

Figure.4 Pictorial view of shut down burning unit (left) and the disposal of hospital in open

## Sanitary landfill

In Bangladesh, crude open dumping is the common practice for the ultimate disposal of solid wastes except Matuail site of Dhaka. The sites are mainly located in low-lying areas, road, canal and riverside, both in legal and illegal places. Studied revealed that all the sites are posed threat to human health and nature WasteSafe (2005). Dhaka city corporation took the challenges for upgrading a crude dump site namely Matuail, into sanitary landfill with help JICA project (Yousuf 2009). As a result, in Bangladesh, first ever sanitary landfill started its operation at Matuail in October 2007 (Fig.5). This project jointly started by DCC and JICA in 2000. Later Master plan was prepared in 2005 and this landfill was constructed. It is now in a sustainable condition since the responsibility was taken by DCC and necessary organizational reformation is done based on the Master Plan.

As a part of partnership project "WasteSafe II", a pilot scale sanitary landfill having a dimension of 50x50x6m was constructed in Rajbandh at Khulna in 2008 with the collaboration of KUET, KCC, BUW, LUT and AIT co-financing by European Commission (Fig.5). The waste deposition and final covering of this landfill were completed in 2009 and hence its performance has been monitoring (Islam et al. 2009). The specialty of this landfill cell is that local materials and construction techniques have been used. This provided a guideline for the local authority for the construction of full pledged sanitary landfill. With this experience, the KCC has taken the initiatives with Central Government budget to construct its first sanitary landfill in Shailua.

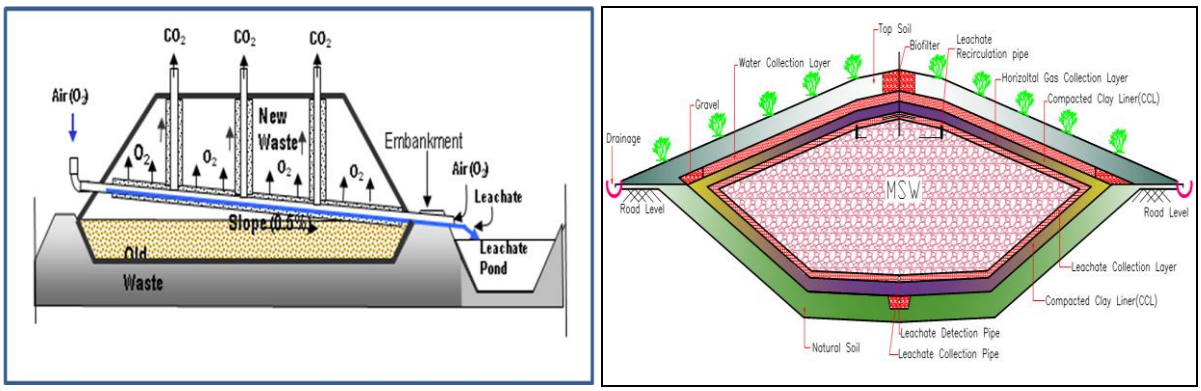


Figure .5 Schematic diagram of Matuail landfill (left) and pilot scale landfill at Rajbandh (right).

## CONCLUSION

Solid waste management is technical issue as well as socio-economic. It is observed that the failure of SWM is very much evident, as a result SWM in Bangladesh has developed in a piecemeal and nonintegrated manner with NGOs, CBOs, informal recyclers and private enterprises being involved along with city authority and fails to bring any sustainable changes. A sustainable system cannot be obtained unless the city dwellers have been realized that they are the waste generator and it is their responsibility to manage it properly for giving a clean, hygiene and environment-friendly city. The realization of the city dwellers must be materialize through a collective efforts taking responsibility by the respective city authority otherwise the initiatives of the NGOs, CBOs and individual will go in vain.

## REFERENCES

Alamgir M. and Ahsan A., 2007. "Characterization of MSW and nutrient contents of organic component in Bangladesh"-*Electronic Journal of Environmental*, Agricultural and Food Chemistry, ISSN: 1573-4377.

ADB 2010. Innovations for Scaling up Organic Waste Management in South Asia. Asian Development Bank Report, RETA No. 6337

Alamgir, M. 2009. Environmental Sustainability of Municipal Solid Waste Management in Bangladesh. Proc. Intl. Conf. on Solid Waste Management: Technical, Environmental and Socio-economical Contexts - WasteSafe 2009, 9-10 Nov. 2009, Khulna, M. Alamgir, et al. (Eds.), Vol.1, pp.1-12.

Akter, J., Alamgir, M and Rafizul, I. M. (2008): Practical Application of WasteSafe Proposal in a Selected Location of Khulna City. Proc. of the National Seminar on Solid Waste Management – WasteSafe 2008, 9-10 February 2008, Khulna, pp 13-24.

BRAC (2006) *Evaluation of public-private partnership model of medical waste management in Rajshahi City Corporation*. BRAC Research Report, IPSU of MoHFW, BRAC, Dhaka.

Khan A.M., Pietroni M., Rahman A.K.S.M. & Salam M.A. (2008) Generation, segregation and management of solid waste at the Dhaka hospital of ICDDR,B. *Proc. of the National Seminar on Solid Waste Management – WasteSafe 2008*, 9-10 February 2008, Khulna, pp. 207-210.

Fatema, Z., Alamgir, M. and Jahan,I. 2010. Organic Waste Management in the Health Care Facilities of Bangladesh Proc. of ORBIT Intl. Conf. 2010 Heraklion, Greece, June 29 to July 03, 2010.

Huda, K.M.N. 2008. Municipal Solid Waste Management: Bangladesh Perspective. Published by Academic Press and Publishers Library, Dhaka.

Islam, M.R., Alamgir, M., Bidlingmaier, W., Stepniewski, W. and Rafizul, I.M. 2009. Field Performance of Compacted Clay Liner Used in a Pilot Scale Sanitary Landfill in Bangladesh. Procs. of the Intl. Conf. on Solid Waste Management Technical, Environmental and Socio-economical Contexts - WasteSafe 2009, 9 to 10 November 2009, Khulna. pp.431-440.

MoHFW (2004) *Environmental assessment and action plan for the HNP sector program (2005-2010).* A document of MoHFW, Government of Bangladesh, November 2004.

Sarkar M.S.K.A., Haque M.A. & Khan T.A. (2006) Hospital waste management in Sylhet city. *ARPN Journal of Engineering and Applied Sciences*. Vol.1, No.2, pp.32-40.

WasteSafe (2005) *Integrated Management and Safe Disposal of Municipal Solid Waste in Least Developed Asian Countries: a feasibility study*. M. Alamgir, C. McDonald, K.E. Roehl and A. Ahsan Edited WasteSafe Report, European Commission's project at KUET, Bangladesh.

Yousuf, T.B. 2009. Construction and Operation of Landfill: Experience of Dhaka City Corporation. Procs. of the Intl. Conf. on Solid Waste Management Technical, Environmental and Socio-economical Contexts - WasteSafe 2009, 9 to 10 November 2009, Khulna, Bangladesh. pp.517-524.

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# How much environmental protection I can get for my mony Design and evaluation of landfill concepts by means of a C-load balance and energy input

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**ABSTRACT:** The deposit of municipal solid waste in low and middle income countries is still affected by arbitrary dumping within and outside of the cities and municipalities as well as missing waste disposal facilities. Due to the economic situation the waste management cannot be transferred to German standard at present. Nevertheless, humans demand is high for a clean and intact environment.
Therefore, a rating system has been developed, which it makes possible to design, compare and evaluate different landfill concept scenarios in regard of the ecological efficiency and the economic effort. It is based on the multi-barrier concept and offers the possibility to generate as well as compare even simple solutions. The existing knowledge of the effectiveness - the protective potential - and of the technical implementation for the establishment of the individual barriers serves as data basis.
The customised landfill concepts are compared to the reference scenario of open dumping which depends on the respective local situation. Thus, an objective assessment is possible. The results form the background for continuative decisions.

**Keywords:** landfill concept rating system, carbon load balance, energy demand, low and middle income countries

## 1. INTRODUCTION AND OBJECTIVE

Illegal or uncontrolled dumping at outskirts and in the city indicates the waste management situation in many low and middle countries. In contrast, technical concepts are developed and implemented for an environmentally sound waste disposal in Germany. However, these concepts require a high technical and economical effort as well as level of knowledge. Germany spends less than one per cent of the gross domestic product for the present waste management. In developing countries, this would be roughly equal to 10 per cent or more if German standards would be adapted one-by-one. Thus, limited financial resources but also the lack of knowledge obstructs a rapid improvement of present situation. A one-by-one implementation of German or European standards would be absurd under the present frame conditions. This applies for landfill concepts as well. Thus, an appropriate standardised rating system to design and evaluate adapted landfill concepts is developed. It is oriented on the exiting guides and programmes acting as a decision support tool. Thus, it has to be seen as supplement to these guides, especially to the technical design of landfill concepts.

## 2. METHODS

The rating system is based on the multibarrier system and combines existing knowledge and experiences to determine the effectiveness of individual landfill barriers and related construction types. The technical complexity is considered on economical side, which is necessary for the implementation of the individual barriers. The underlying rating system supports the generation of different individual landfill concepts and enables its comparison to the reference scenario “open dumping” and among each other.

*The cost-effectiveness-analysis forms the methodological foundation. The effectiveness is described by means of value benefits and mass flow analyses. The technical effort, expressed as non-monetary value, represents the economic aspect. In this sense, it is a modification compared to the general approach of the cost-effectiveness- analysis, but ensures the generality beyond country borders.*
A system of objectives including operationalised objectives has been developed on basis of the local and global emissions in the compartments air and water. It forms the main work base to evaluate objectively the effectiveness of each barrier and/or construction type. The barriers are allocated to the mentioned emissions according to their individual influence. The local waste composition, the climatic conditions in form of precipitation and evapotranspiration as well as the resulting emissions represent the system boundaries.

The evaluation of the effectiveness varies. Local impacts like fire or drift are qualitatively rated, whereas the landfill gas and leachate load emissions are quantitatively assessed by means of a carbon load balance. The individual waste composition forms the foundation for the emission-relevant carbon potential. Thus, a load balancing is possible for the compartments air and water and a quantitative basis of comparison is generated.
The specific direct primary energy and space demand illustrate the technical effort for implementation. The estimation of the energy input is related to the method of the cumulative energy demand.

The carbon emissions and the technical effort refers to a representative element, which is a column of the landfill body with a ground area of one square metre and a landfill height, which has to be specified separately. Thus, a comparison is possible independent from the landfill size. The considered time horizon is set to 100 years. This is the period where most of the biodegradable carbon emissions are released and most technical barriers are evaluated for.

## 3. FINDINGS AND ARGUMENT

The effectiveness of the individual barriers is successfully standardised within this rating system. Now, it can be directly compared to each other next to the technical effort. Furthermore, with the rating system, it is now possible to assess landfill concepts regarding ecological and economical aspects and not only individual barriers.
The carbon load balance clarifies that the emission-relevant carbon in the compartments air and water are present at a ratio of circa 8:1 instead of 19:1 as often published. Thus, the water path is more important than initially thought.
The gained knowledge provides the foundation to illustrate and compare the emission behaviour of different localised landfill concepts. Thus, the results depend on the individual local situations.
The rating system is emphasized by an illustration of the efficiency and the interdependencies between the effectiveness of the individual barriers and the local conditions. Thus, it is possible to evaluate specific barrier variants according to the necessary technical effort against the ecological benefits.
The rating system clarifies also the interdependencies between the individual barriers. For instance, it becomes obvious that the optimal reduction of methane emissions by a surface sealing results in a temporal shift of local leachate emissions into the future.

## 4. CONCLUSION AND SUGGESTION

By means of the rating system, the foundation is given to design stepped, appropriate and professionally assessed landfill concepts. A statement can be made to the question: How much protective potential does one gets for how much economical effort. Hence, one can deduce where available economical resources are used most effectively under ecological aspects. Thus, the results of this efficiency analysis form the foundation for further measures to improve the waste management in low and middle-income countries.

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# The Urban Mining concept in Solid Waste Management

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The passage from a linear to a circular approach characterises either municipal either industrial waste management strategies in last decades.
The linear traditional approach is based on the extraction of raw materials, production, use, wasting and landfilling.

The circular approach primarily arises from the increasing need for primary raw material, as a consequence of the global economic development. Attention is currently moving from the limited and fixed stocks of raw materials to the increasing anthropogenic stocks of materials. This creates the base for the development of the Urban Mining concept.

Urban Mining activities operate in this context, representing actions and technologies finalized towards the recovery of secondary raw materials and energy from products of the urban catabolism (Baccini, Brunner, 2012). Urban Mining therefore provides a systematic management of anthropogenic resources stocks (products and buildings) and waste, in the view of long term environmental protection, resource conservation and economic benefits.

An illustrative example is given by Waste from Electrical and Electronic Equipment (WEEE). Due to their short economic life, the amount of this waste stream is continuously increasing. Currently, their growth can be estimated as being three times faster than the average growth of municipal solid waste. Given that gold concentration in electric and electronic scraps is considerably higher than the amount of gold in gold mines, recovery of gold from WEEE may potentially become result in a more ecologically compatible mining activity.

The Urban Mining principle, for a better understanding of his role and potential, should be considered in the framework of the general matter cycle, including emission control strategies and final materials sink.

A mass balance can then be written:

$$E = \Delta R + \Delta L + \Sigma d_i + I \qquad (1)$$

where:

E: extracted raw material;

ΔR: recycled and reused material (secondary raw materials);

ΔL: recovered material from landfill mining (secondary raw materials);

$d_i$: diffuse mass emissions/loss associated to the specific steps and processes;

I: immobilized material.

The diffuse emissions should be carefully controlled and minimised as they are the cause for the progressive deterioration of the global environmental quality.

How to achieve this (control and minimisation) can be better analysed by rearranging equation (1):

$$\Sigma d_i = E - \Delta R - \Delta L - I \quad (2)$$

In view of controlling emissions, it is thus clear that it is necessary to minimise raw material extraction and to maximize recovery, recycling and reuse of secondary raw materials through urban mining processes and mining of old landfills and to increase the immobilisation of materials in final sinks/geological repositories (Cossu, 2012).

Consequently, recovery, reuse and any material mining activity should be increasingly planned and accomplished with due care and attention to alternative LCA options for emissions minimization, avoiding any demagogical or ideological issues related to the need of treatment and final disposal of the unavoidable waste.

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# Combination of Regenerative Energy and Innovative Resource Management – A Present Challenge

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## ABSTRACT

*The project CYCLE (KREIS*) aims at developing and analysing new concepts and procedures for disposing waste water and waste and at generating power to supply urban city districts. Based on the concept of "supplying by disposing" the project CYCLE covers a multitude of questions on the topic of power and drainage engineering, treating and utilizing residues as well as on the ecological and socio-economic importance. The combination of utilizing new sanitary concepts and generating energy out of renewable resources represents a visionary solution not only for Hamburg. The project is of unique dimensions and represents a valuable practical test that will give important impulses for further developments of urban infrastructure. Therefore, the main objectives of this joint research project are the conduction of preparatory experiments that will support the planning and construction phase as well as the start-up of technical systems and the scientific monitoring of the facilities after their establishment. It is expected that some technical components can be improved after testing in the field. These scientific studies are meant to ensure the overall benefit of the system. The project aims in general at collecting such experience and knowledge that can be directly used in the Jenfelder Au district as well as adapted to similar projects in other regions.*

## INTRODUCTION

The different changing frame conditions on a global and local scale are of increasing importance for the realization of urban areas in conurbations. They demand for a more efficient utilization of resources effects the adaptation of the urban infrastructure. Therefore, new technologies are to be developed which use energy, nutrients and water in a sustainable way. For this purpose HAMBURG WASSER GmbH, the utility provider and waste management company of the city Hamburg, developed HAMBURG WATER CYCLE®, an innovative concept of a combined drainage and power generation system. The concept focuses on a close linking of the infrastructure sectors water and power by using waste water for the production of energy which ensures the preservation of fresh water and closing the material cycles in urban areas. The most important elements of the concept Cycle are the separate collection and treatment of different types of waste water. In contrast to standard drainage systems, in which waste water is mixed and therefore has to be treated expensively, the different types of waste water are split. These streams are "black water" (from toilet, very polluted), "grey water" (from kitchen and bath, low polluted) and rainwater (no pollution). Not all of these waste water streams afford the same effort on cleaning, which saves energy, resources and finally money.


Figure 1: Schematic use of separate collected Waste Water

In the eastern part of Hamburg the new residential quarter Jenfelder Au with 770 living quarters will be constructed on the site of the former Lettow-Vorbeck barrack in the next few years. Additional social, cultural and commercial structures are also part of this new residential quarter. About 610 of these new living quarters will be connected to the innovative drainage system by implementing vacuum toilets that significantly reduce the fresh water demand when flushing the toilet and also provide a low dilution of the black water. By digesting the black water, biogas can be produced that in turn can be converted to heat and power by the combined heat and power unit of the living quarter. This innovative strategy is the foundation of a power supply for living quarters with no impact on climate change and will be supplemented by using geothermal energy, solar heat and photovoltaics. In the end up to 100% of the required heat and 50% of the required power are to be generated using these technologies. Thus, Jenfelder Au comes close to the idea of an energetically self-sufficient city district. Based on the award-winning urbanistic design and according to the maxim “united in diversity”, the residential quarter Jenfelder Au promises an excellent quality of living and working with individual one-story or multi-story buildings, that provide living space for people of different generations, nations and income. From the start, the planning process of the new residential quarter has been focussed on an intensive communication between all interested parties. Interested Citizens were able to participate with their own ideas in a competition for the urbanistic design and landscape architecture of the new residential quarter. The concept of the winner of the competition was widely accepted because of its high quality and awarded with the International Urban Landscape Award. At the moment Jenfelder Au is one of the biggest developing areas of Hamburg and, according to the German Urban Development Policy, a pilot project of the German Federal Ministry of Transport, Building and Urban Affairs and of the German Federal Institute for Research on Building, Urban Affairs and Spatial Development. Additionally, Jenfelder Au is an exemplary project of the International Architecture Exhibition in 2013.

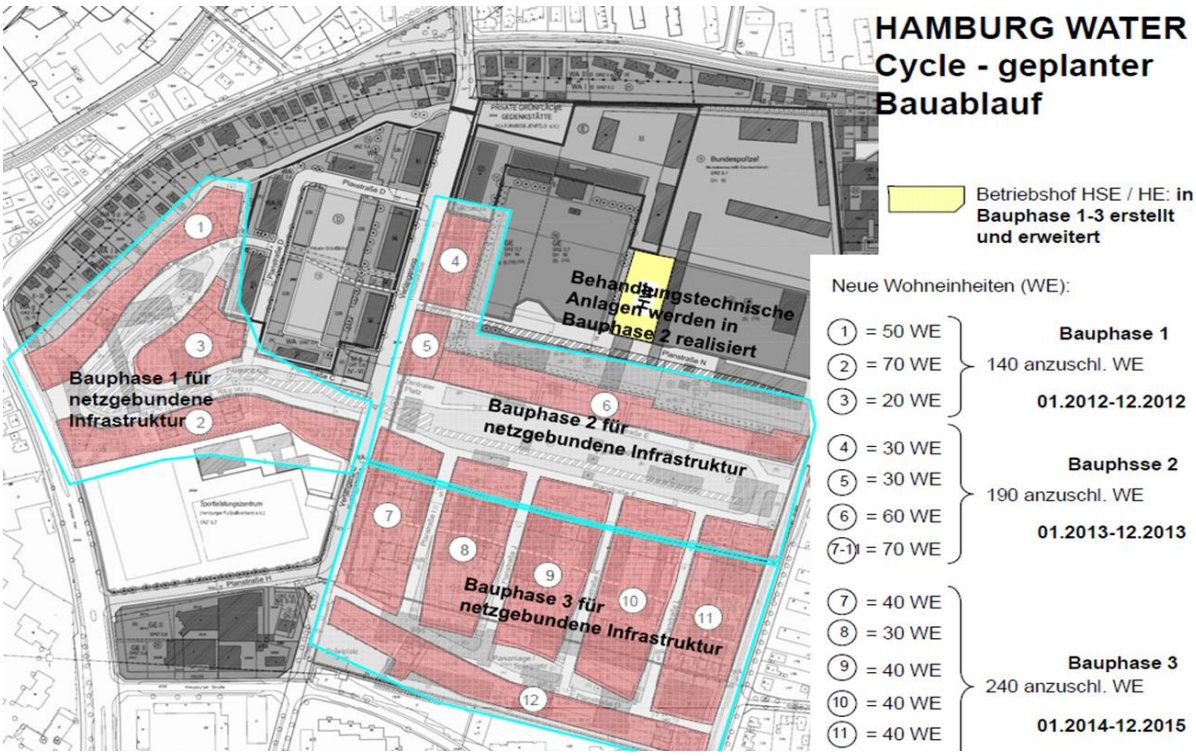


Figure 2: Area of Jenfelder Au

By implementing the concept in the residential quarter Jenfelder Au undiluted toilet waste water is transported by using a vacuum sewer system. Here the operator is faced with a waste water stream that is different from common domestic waste water and is transported through pipes with a relatively small diameter of 50 to 125 mm. Compared to a conventional gravity drainage system, a vacuum sewer system is more vulnerable to clogging in case of incorrect handling because of the small diameter of the pipes. Additionally, the transported blackwater can lead to deposits in the pipeline. Furthermore, local malfunctions caused by clogging can also influence the functionality of the whole system and generate costs of maintenance. Thus, within the project CYCLE different research questions concerning the vacuum sewer system aiming at improving its safety and comfort ability and also at reducing the costs have to be answered. For that purpose, specific methods will be developed and tested to localize and eliminate possible malfunctions in the vacuum sewer system. Using several reference systems as well as a lab-scale pilot plant, the analysis focuses on the formation process of deposits and its dependency on parameters like water hardness, temperature and duration of stagnation. The results of the studies can help to develop procedures and regulations for the operation and maintenance of the vacuum sewer system in the residential quarter Jenfelder Au. Additionally, the researches facilitate the safe operation of the vacuum sewer system which in turn leads to an increased public acceptance of new sanitary concepts and to customer satisfaction with the concept of HAMBURG WATER Cycle®.

## CHALLENGES AND RESEARCH

Blackwater is a mixture of faeces, urine as well as toilet paper and flushing water and therefore contains a specific range of nutrients and possess potential for generating energy (organic components like phosphorus and nitrogen compounds). For this reason, the treatment of blackwater is distributed and, following the HAMBURG WATER Cylce®, combined with an energy production and utilization of nutrients. Every year a human produces 500 liters of urine and 50 litres of faeces. With the implementation of vacuum toilets the amount of flushing water can be reduced from 6 - 8 litres to approximately 1 liter. With this the value adding components can be collected in a concentrated way.

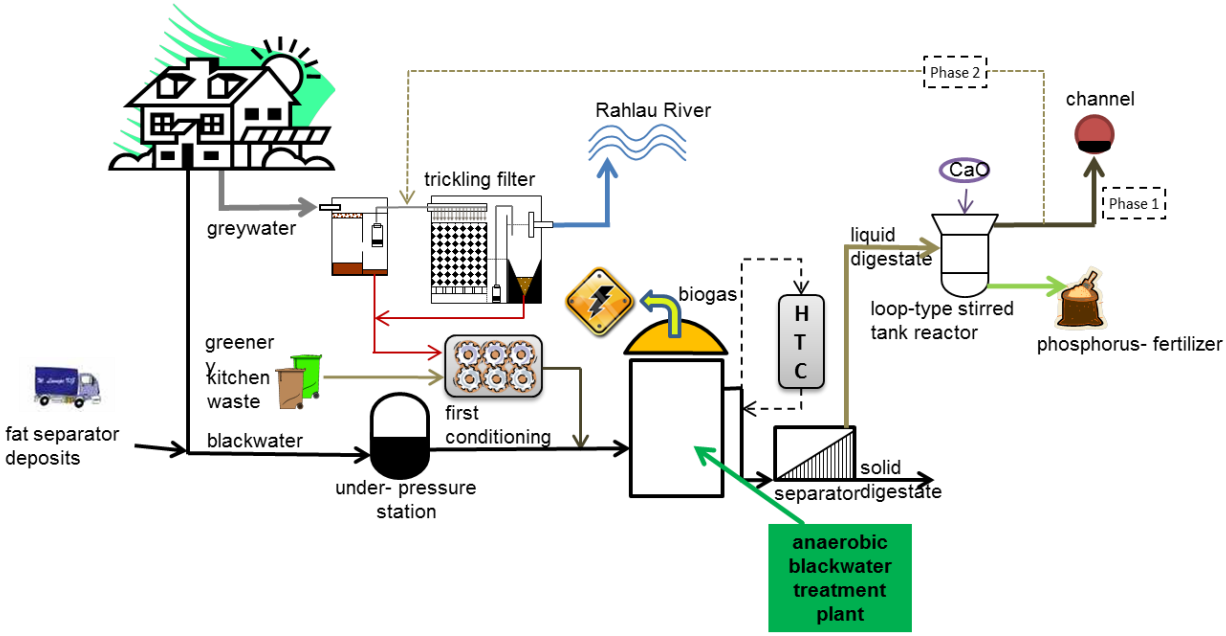


Figure 3: Planned elements of the alternative concept

The blackwater is lead by the vacuum sewer system to the anaerobic treatment plant where biogas is produced that can be used to generate heat and power. The methane content in biogas produced of each litreblackwater is 2 litres. Thus, the project CYCLE aims at analyzing possibilities to efficiently digest blackwater. After the anaerobic treatment of blackwater the digestate still contains valuable compounds. By using different technologies the digestate can be transformed to products which can be used energetically or for the recovery of materials. What products can be generated in the Jenfelder Au depends on many parameters like the used co-substrates, the pollution of the digestate by pharmaceutical residues, the demand for products and the development on the energy and feedstock market. In general the recovery of materials is prior to the energetic reutilization. Especially the elimination of pharmaceutical residues in the digestate is of particular interest. If the elimination is successful by using an anaerobic digestion, a further utilization of the digestate will focus on the production of fertilizer or compost. Otherwise the focus is on the production of solid fuels. The project CYCLE aims at developing a method for an anaerobic degradation of pharmaceutical residues. This method includes optimized operating conditions for continuously stirred tank reactors (CSTR) as well as a special up-flow reactor (UASB). The problem with pharmaceutics in wastewater and environment can be stated as follows:

- antidromic effect; increasing of analytical quality and increasing of pharmaceutical consumption  detection of pharmaceutics and residues in every environmental area (groundwater, surface water, soil etc.)
- insufficient long- time- and big- scale- studies about human- and environmental- toxic effects and result of re- formation and interaction between different substances („World´s self experiment“)
- human- depending loop of pharmaceuticals and residues  direct and indirect intruding into soil and water vs. direct and indirect recovery of freshwater, producing of animals and food plants

The degradation of pharmaceutics focuses on several challenges:

- high stability of these substances depending on the mostly high- complex structure of molecules
- xenobiotic origin of the substances
- “unknown” for native microorganism
- no ability to degrade
- pharmaceutical compounds have the ability to migrate fast between soil and water areas
- not able to fix or bind onto native or technical compounds

Newer studies document that aerobic treatment processes like activated sludge treatment (SBR, MBR, KM) are not able to degraded pharmaceutics in a required rate. Also activated sludge processes require a large content of electrical power and big reactor volume. First, good results for anaerobic

degradation of cycled- based molecules are introduced. Advantages of a highly specialized anaerobic biocenosis with „specialized enzymatic degradation opportunities“ are possibly given.

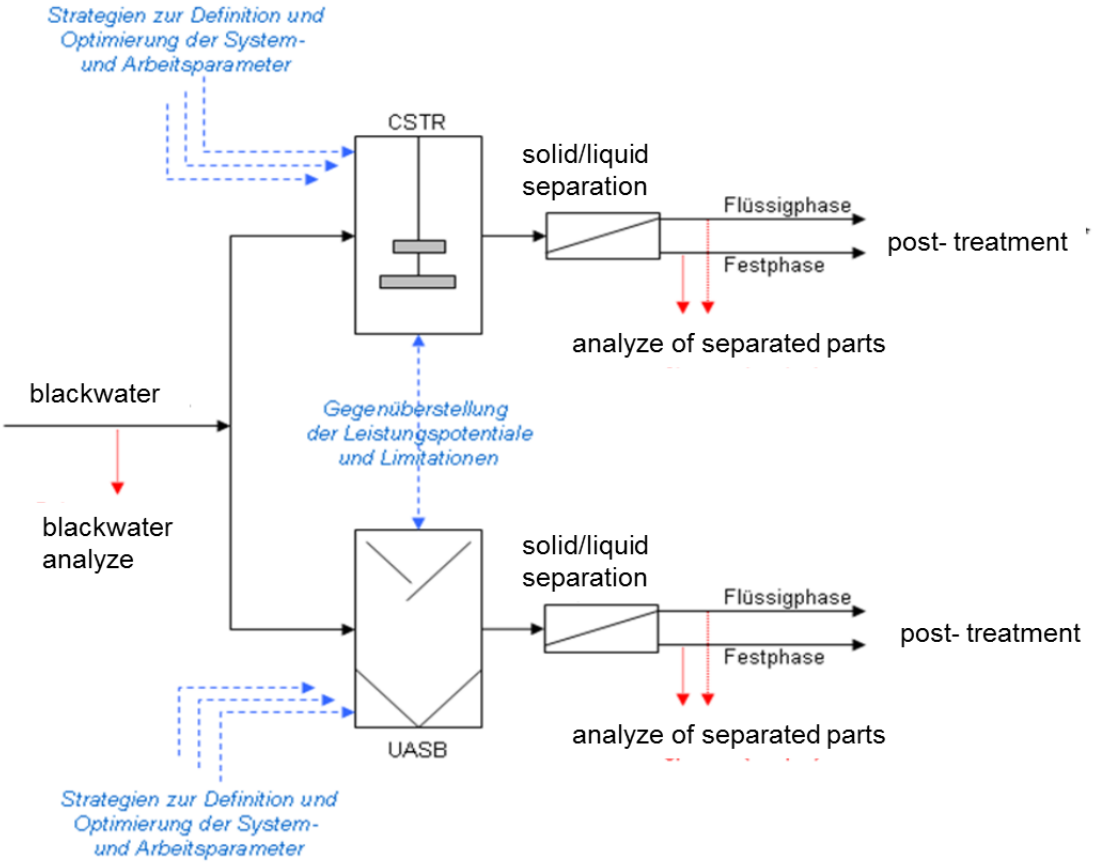


Figure 4: Adequate research on CSTR and UASB for the degradation of pharmaceutics

The pilot plant will be established with CSTR (Continuous stirred tank reactor) and UASB- reactors (Up flow anaerobic sludge blanket).

Advantages of CSTR:

- simple and stable treatment processes are possible,
- funded experience with this technology,
- well optimized technique and
- hydraulic operations with stirrers.

Avantages of UASB:

- degradation of „high- organic- loaded”- wastewaters by usage of passable reactor volumes,
- de- coupling of hydraulic retention time from sludge age and
- Implementation of a high- preformed, xenobiotic- adapted biocenosis?

Planned experiments and analytical procedure will include:

- analysis of physic- chemical parameters for valid the different procedure- configurations and the resulting degradation- performance,
- analytic of degradation- rates of pharmaceutics and pharmaceutical residues (Input vs. Output),
- analytic of physic- chemical process- and environment parameters (pH, T, p, HRT, Input, Output, reactor- loading) and
- Input- variation (different co- products for co- fermentation and different mixtures of these substances).

Table 1 shows the first results of analyses- pharmaceuticals in blackwater.

Table 1: Pharmaceutics in blackwater

| **pharmaceutics** | **detection limit [µg/l]** | **result [µg/l]** |
|---|---|---|
| Carbamazepin | 0,1 | 59,5 |
| Clofibrinsäure | 0,1 | n.n. |
| Bezafibrat | 0,1 | n.n. |
| Diclofenac | 0,1 | 3,9 |
| Fenoprofen | 0,1 | n.n. |
| Ibuprofen | 0,1 | 150 |
| Tetracyclin | 0,1 | n.n. |
| Ethinylestradiol | 1 | <1 |
| Metroprolol | 0,1 | 5,0 |
| Roxithromycin | 0,1 | 2,3 |
| Erythromycin | 0,1 | 0,1 |

| | | |
|---|---|---|
| n.n. = not detectable<br><1 = under detection limit | chosen pharmaceutics | positive match pharmaceutics |

Criteria for selecting a fermentation technology are not only the elimination of pharmaceutical residues but also the biogas yield and the potential for connecting to processes for treating the digestate.

One possibility for an agricultural use of the digestate is the conversion to fertilizer and soil conditioner. For this purpose methods are necessary for eliminating pathogens and pharmaceutical residues. In the district Jenfelder Au only few arable areas are available which can be used for deploying the sanitizeddigestate. The transportation of digestate over a long distance is ecologically and economically not feasible. For that reason methods for conditioning the digestate have to be used. Because of the high water content of the digestate different methods for solid-liquid-separation (filter press, centrifuge) are to be analyzed. In this regard various ways to use the solid and liquid components are to be considered:

- the solid fraction contains organic substances and nutrients. Possible options for the utilization are composting in an existing composting plant or hydrothermal carbonation. The resulting products like compost or biochar can be stored and transported and can be used in agriculture, landscape management and private gardens.

- the liquid fractions contain a large amount of phosphor and nitrogen compounds. For the recycling of these nutrients different approaches are to be tested like the addition of calcium carbonate using a special reactor and sedimentation of calcium carbonate phosphate or the addition of magnesium oxide to produce struvite (magnesium ammonium phosphate) and the following sedimentation. On the other hand nitrogen can be recycled by using stream stripping.

Unpleasant odors must be avoided to ensure the quality of life of the inhabitants in the Jenfelder Au district. In addition the emission of green house gases has to be reduced as far as possible. Within the project two approaches concerning the management of emissions are pursued:

- avoidance of gaseous emissions; methane a green house gas is generated by digestatingblackwater anaerobically and should not escape into the environment non burnt. Using the latest measuring devices leakages can be detected and eliminated.
- purification of exhaust air heavily loaded with harmful substances; the following types of exhaust air should be treated in an optimized purification system before being released into the environment: exhaust air originating from the vacuum sewer system for collecting blackwater as well as air originating from buildings where the greywater treatment takes place.

The slightly polluted greywater can be treated in the district Jenfelder Au using an energy-saving procedure. Afterwards the purified greywater can be discharged into open waters. The treatment requirements are based on the prescriptive limits concerning the discharge of treated greywater (emission standard). Additionally the characteristics of greywater are of importance, i.e. the composition and quantity of greywater have to be known with sufficient accuracy. Therefore two research questions are answered within the project CYCLE:

- How to determine the characteristics (amount and components) of greywater if the assumed load and the loading rate per inhabitant are derived to dimension the greywater treatment plant?
- How to plan, construct and operate a trickling filter for treating greywater if the recycling of greywater is not intended?

To determine the characteristics of greywater, a special technology for taking samples has to be developed and optimized in order to analyzegreywater and the solids it contains. The measuring campaign will start at least on two different sites before it will continue in the Jenfelder Au after the first residents have moved in. Concerning the treatment of greywater it will be assumed that all standard methods for treating municipal waste water are suitable. The research focuses on the utilization of a trickling filter as a simple and efficient purification method. Concerning the suitability and possibility of modifying the trickling filter to treat greywater, no experience is available. Within the project CYCLE the trickling filter has to be adapted for this application. Therefore, two lab-scale trickling filter are tested using different filling materials (plastic bodies, mineral material) and are afterwards implemented and further supported in the residential area Flintenbreite as small sewage works.

After the residents have moved into the new buildings of the Jenfelder Au district, a high flow rate of greywater and blackwater will be generated. For the first time the amount, composition and homogeneity of the grey- and blackwater will constitute a representative cross-section of the urban population. After the implementation of the HAMBURG WATER Cycle® the different wastewater streams are to be recycled in the Jenfelder Au district using a distributed treatment plant. For the treatment of greywater a compact treatment plant will be constructed based on the achieved research results. The implementation of the greywater treatment plant is followed by a scientifically supported test run. The theoretically and in lab-scale acquired rated values will be tested and assessed on real conditions in the Jenfelder Au district. Within the test run operating parameters will be varied to determine the conditions for an optimized operation. Thus, by using a large-scale plant of this scale operational experience with greywater treatment can be gained for the first time. For the treatment and utilization of blackwater a large-scale anaerobic fermentation plant will be constructed in the Jenfelder Au district. Within the test run, blackwater combined with different organic co-substrates will be digested and each fermentation process will be analyzed under real conditions. The test run aims at ensuring a consistently stable, economic and efficient operation of the plant as well as at adjusting an optimized mixture of blackwater and co-substrates. General operating instructions and rated values will be gained by scientifically supporting the test run of this so far unique large-scale blackwater treatment plant.

For the residential quarter visionary solutions are to be found that combine the urban disposal of waste water and waste with a renewable energy supply. Within the project CYCLE an energy concept is to be developed that includes biogas as well as other renewable energy sources. Different innovative technologies are used for the energy supply of the Jenfelder Au district. For this purpose a concept will be developed within the project CYCLE. The cornerstone will be the anaerobic blackwater treatment

plant that is linked to a combined heat and power unit. Beside the collected blackwater additional sources of biomass are used for the production of biogas, e.g. grease separator residues from nearby restaurants, green waste from the district Jenfelder Au and from surrounding residential quarters as well as excess sludge of the greywater treatment plant. In addition to the energetic utilization of biogas other renewable energy sources will be used to satisfy the demand for heat and power. Additional sources to satisfy the heating demand and for heating up the drinking water are solar panels and the use of thermal energy from the groundwater in combination with one or more heat pumps as well as if necessary the thermal utilization of biomass. Renewable energy sources are even meant to satisfy the energy demand as much as possible. In this regard, the use of photovoltaic modules is examined in addition to the generation of electricity by using a combined heat and power unit.

The heat output generated by the different heat sources is fed into the heating system, where it is collected and distributed to the various buildings or building blocks. As greater the distance between the buildings and the heating system is, as greater is the heat loss of the pipeline and the lower the efficiency of the heating network. An alternative to this standard small-district heating system, for buildings, that are located at a great distance to the heat source, are so-called “energy islands”. By using qualitative and quantitative environmental indicators – starting from the fossil energy input to the odor emissions – the sustainability of the concept of a combined drainage and power generation system in the residential district Jenfelder Au can be determined. For a complete assessment of the HAMBURG WATER Cycle®, an environmental evaluation will be performed within the project CYCLE. Within this integrated examination the environmental loads, which are the result of e.g. the production, installation and operation of the innovative partial flow treatment, are assessed in comparison to the positive environmental effects of this system. An exciting research question will be how the utilization of the partial streams of blackwater and greywater, according to the concept of the HAMBURG WATER Cycle®, is affecting the overall ecological balance. Because of the recovery of materials and the energetic reutilization it can be expected that the net energy demand for supplying energy, room heating and process water is reduced. To answer this question a calculation tool will be developed that is fed with all relevant parameters of the examined waste water management systems. With this tool an overall ecological assessment of the waste water cycle in the Jenfelder Au district in comparison with standard (centralised) systems for discharging waste water can be done. The overall ecological assessment is taking into account both quantitative and qualitative environmental indicators. The quantitative indicators are e.g. the cumulative fossil energy demand (CED), the greenhouse gas emissions, the acidification potential and eutrophication potential as well as the total water consumption. Qualitative environmental indicators are parameters that can be described more specifically than measured, e.g. noise and odor emissions or recycling properties of the used materials. In order to assess the sustainability along with the ecological impact, results from different topics like socio-technical analysis and user behavior, economy and transferability are merged in consideration of the ecological results. For this purpose, different existing assessment approaches (such as eco-efficiency analysis, environmental damage costs, Social Life Cycle Assessment) are tested, refined and comparatively applied. To consider the economic aspects within the environmental assessment of projects, the CO2 abatement costs and/ or the environmental damage costs can be used. The aim of this comparative application and optimization of methods for assessing the sustainability is to achieve transferability to other innovative projects in the field of living and infrastructure.

Within the project CYCLE the concept of HAMBURG WATER Cycle® will be analyzed from an economic point of view and will be compared with systems of a centralized waste water infrastructure - also in order to identify potential for a future marketing of the product. By using an economic assessment and decision-making model, systems of a centralized and distributed waste water infrastructure can be compared based on the example of the project CYCLE in the Jenfelder Au district. The model development is carried out on different levels, the micro, meso and macro level. For this, the indicators and economic factors are collected from all sub-projects and fed into the model calculations in order to validate them with the costs actually incurred. Based on the model calculations, the impact of the decentralization will be examined and cost-related variables will be identified among others things.

## EXPECTATIONS

The present infrastructure of urban areas can`t be introduced for further extension. It faces limitations regarding function and economics. The basis of a new concept will be the consequent application of closed material and energy loops. In contradiction to the traditional solution for waste and sewage,

which is strongly disposal oriented, focusses the new one on the use of this urban resources. For the realization new technologies for collection, transportation and treatment are necessary. At least specific adaptations are needed. The resources are sewage or waste, as well as their components itself (like nutritions).As well the content of energy is of strong interest. Aim is the offer of products by waste and sewage. That is for developing countries a short term chance, for Germany –due to present infrastructure- a long-term challenge.

The success of societies will be measured at their efficient use of carbon and nutrition's. With that regard, the importance on research in that area –like composting or anaerobic digestion- is immense. Developing countries do have the possibility due to a "frog leap" to move toward modern concepts instead of the replication of old technologies. That implements the jump via steps of industrialized countries. This realistic view generates naturally a huge number of questions. Some of them are related to technology, but a lot are as well linked to social acceptance, culture and governance. This requires interdisciplinary and intercultural research.

The special challenge is to be seen in realization of closed energy and material loops with the minimization of environmental impact. A field of research, which asks for sustainability, while reducing cost parallel. To reach that aim, new innovative concepts, but already now modern products are requested. The offer of those might induce economic prosperity.

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# "Entrop(h)y - Environment, Art, and Sustainability"

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In this lecture I will present "The Garbage Project: Entrop(h)y" from its conception to its realization over two years (2010-2012) at the Bauhaus-University in Weimar. I propose that collaborative projects between artists and engineers that seek a solution to complex environmental issues is a topical and logical development of the Bauhaus idea today: interdisciplinary, hands-on research directed towards a common theme, leading to complex and multi-facetted interpretations, proposals and solutions.

During my research visits to Bangladesh I discovered this country to be, in many ways, a model for the industrialized world. In comparison to other, less densely populated countries, there is an intensive organization of daily life and a high percentage of recycling and reutilization of material. People in Bangladesh don't waste anything; they use and re-use material and share technology. Though Bangladesh is one of the first countries to ban plastic bags, the federal and local government often fail to provide services. However, as a survival strategy, inventive citizens have created an informal infrastructure for recycling within their neighborhoods. I observed this type of system in motorcycle repair, plastic recycling, paper recycling, human hair recycling and in compost collection.

During my first trip to Bangladesh in 2009 I saw an excellent example of how engineers and artists can collaborate: A new transport bicycle with a tightly-fitting lid was developed for the compost collectors in Khulna, who ride from door to door on a daily basis to collect compost in their neighborhoods. They bring the compost to the new recycling plant that was introduced to us in 2009 at the WasteSafe Conference. Prof. Alamgir and Mr. Roy from the Khulna Art School worked together to promote garbage separation and compost collection in the following way: Children at the art school produced colorful drawings and paintings showing how to separate garbage in the proper manner. These drawings were a didactic tool to teach the children how to deal with waste, but they were also exhibited in the public realm in order to instruct and encourage all citizens to recycle in a responsible way.

**"The Garbage Projekt: Entrop(h)y"** dealt with current global, ecological and economic questions about waste. The title Entrop(h)y is a neologism of the words "entropy" and "trophy". It reminds us that entropic processes cannot be reversed; the amount of energy within a closed system remains the same; the form changes in the direction of chaos and disorder. Elevated to trophy through the implanted h, the title implies that we can benefit from the constant change and transformation of matter.

In dealing with the theme of garbage and entropy, - what prize do we expect to win? If the amount of matter remains the same but the aggregate state is in constant change, it is up to us, as artists, designers, architects and engineers, to bring a new order to chaos, to invent new uses for old materials and to increase public consciousness about our relationship to both the material and the natural world.

The "prize" could be the richness found in the layering of history that occurs through the re-use of objects and materials, much like finding beauty in the wrinkled face of an elderly person. The challenge is to convince the viewer that this face is as beautiful as the blank and flawless visage of an 18-year old in an advertisement.

In short, it is about finding and re-assigning value to materials or processes that, according to current standards, have none. On the one hand, recycling is a lucrative business for some; on the other

hand, developing countries are suffocating under the limitless production of established economies. How can artists bring about changes in attitudes toward waste production through the work we do?

Through avoidance of the production of garbage, or through a re-dedication of material, progressive entropic processes can be slowed down. Only recently have we become aware of such alarming phenomena as the Great Pacific Garbage Patch (a carpet of plastic garbage the size of Central Europe floating in the Pacific Ocean, approximately 1000 km north of Hawaii). It is time to increase our collective ecological awareness.

And as much as we see the globalized world economy as the originator of environmental problems, the globalization of communication systems has also increased our knowledge of environmental damage occurring worldwide. The realization that problems play out within a much larger framework than domestic garbage-separating activities—practiced religiously in Germany—has forced the issue of how each one of us consumes, and deals with the garbage we produce. We need to be thinking about future generations and to find alternatives and solutions to the current destruction of the environment, be aware of the often imperceptible changes in the quality of water, air and soil.

This lecture includes a reflection on the possibility of collaborative projects and research activity between artists and engineers: through careful consideration of the working processes of the other disciplines, valuable insight could be gained. Ideally, artists would leave the ivory tower and confront real-world issues and propose works of art which could initiate a change in individual and public perception of a situation through artistic means. On the other hand, Engineers could assume a more holistic approach to the work they do, by considering the social, political and aesthetic impact of their work in a particular environment rather than simply providing solutions to technical problems.

One role that artists can actively play in collaboration with engineers is in the area of increasing public awareness, both through direct interaction with citizens in participatory works for the public realm as well as well as through the exhibition of art works in galleries and museums. Artists share their point of view with the public in the form of actions, performances and material works of art related to this theme. Both exhibitions and art works in the public realm elicit an individual response from the viewer, encouraging him or her to rethink their personal consumption and deal with their own waste.

Before I go into more detail about the collaboration between artists and engineers in the "Entrop(h)y"-Project, allow me to give you a brief history of the Bauhaus-University: The Bauhaus-University in Weimar, located in former East Germany or the German Democratic Republic (GDR), is at the site of the original Bauhaus founded by Walter Gropius in 1919. Due to the rise to power of the Nazi Party the Bauhaus moved to Dessau in 1925, then on to to Berlin in 1930 and in 1933 it was was completely disbanded. During the GDR years the school was a technical university of architecture and civil engineering, located at the site of the Bauhaus. After the Fall of the Berlin Wall in 1989, it was decided to "bring art and design back to the Bauhaus". There are currently four faculties: Art and Design, Architecture, Media and Civil Engineering, with approximately 4000 students.

I applied for a professorship of sculpture and installation in 1992 in the newly-founded Faculty of Art and Design, and started teaching in 1993. The Faculty of Art and Design is based on the pedagogical concept of interdisciplinary, project-based studies that link theory and practice. For example, as a prelude and as an introduction to the specific artistic investigation of garbage and entrophy, an interdisciplinary symposium took place at the Bauhaus-University, which enabled students to immediately launch into the current discussion of garbage-related themes. Scientific, curatorial and artistic perspectives dealing with the themes of garbage and environmental technology, as well as art and architecture from a recycling perspective, were presented and discussed. Freedom of teaching and research at German universities allows me to design my own curriculum based in part on my own artistic research, often in collaboration with internal and external partners. This is the third "garbage"-project in my teaching career, and the second in collaboration with the Chair for Waste Management, now called Biotechnology in the Resource Economy. There is increasing interest in interdisciplinary projects, for which there is often extra funding. The potential for new forms of research due to the unique combination of the four faculties of the Bauhaus-University, in which related interests come together, is being recognized. Waste management and the associated questions of value relate directly to the use of the found object in contemporary art and in the history of art both as a carrier of memory and as a specific historical and cultural artefact.

In the collaboration with Waste Management engineers, we as artists find ourselves confronted with a situation where the engineers really DO something, working out models for actual solutions to problems, contributing to a direct improvement of the situation. Artists, on the other hand, attempt to find their own meaning through material. They try to transform meaning by altering the viewer's perceptions. The teachers and students of the Faculty of Art and Design therefore have a specific, communicative task: promoting the critical examination of one's own behaviour. The exchange of information about working processes animates creative approaches for both artists and engineers. "The Garbage Project" is, in that sense, a true "Bauhaus Project", investigating the themes garbage and entropy from a technical as well as from an artistic point of view, in order to achieve a complex and multifaceted understanding of the problem.

In this project, we strove to collaborate with other disciplines in such a way that the arts are not only a decorative addition, but complete the meaning. At the same time we attempted to achieve artistic quality. As works of art, each, we hope, can stand on its own.

The artists' various approaches include both ephemeral interventions in the public space and minimalist conceptual works,. The young artists proceeded from their thoughts about entropy to the living objects they transformed. They explored the rich, narrative history of their materials and generated meaning. As they developed alternative strategies and new ways of perceiving, they came to new understandings and actively shaped their world.