Ecological Sanitation and its Relevance for the Concept of Integrated Water Resources Management (IWRM)

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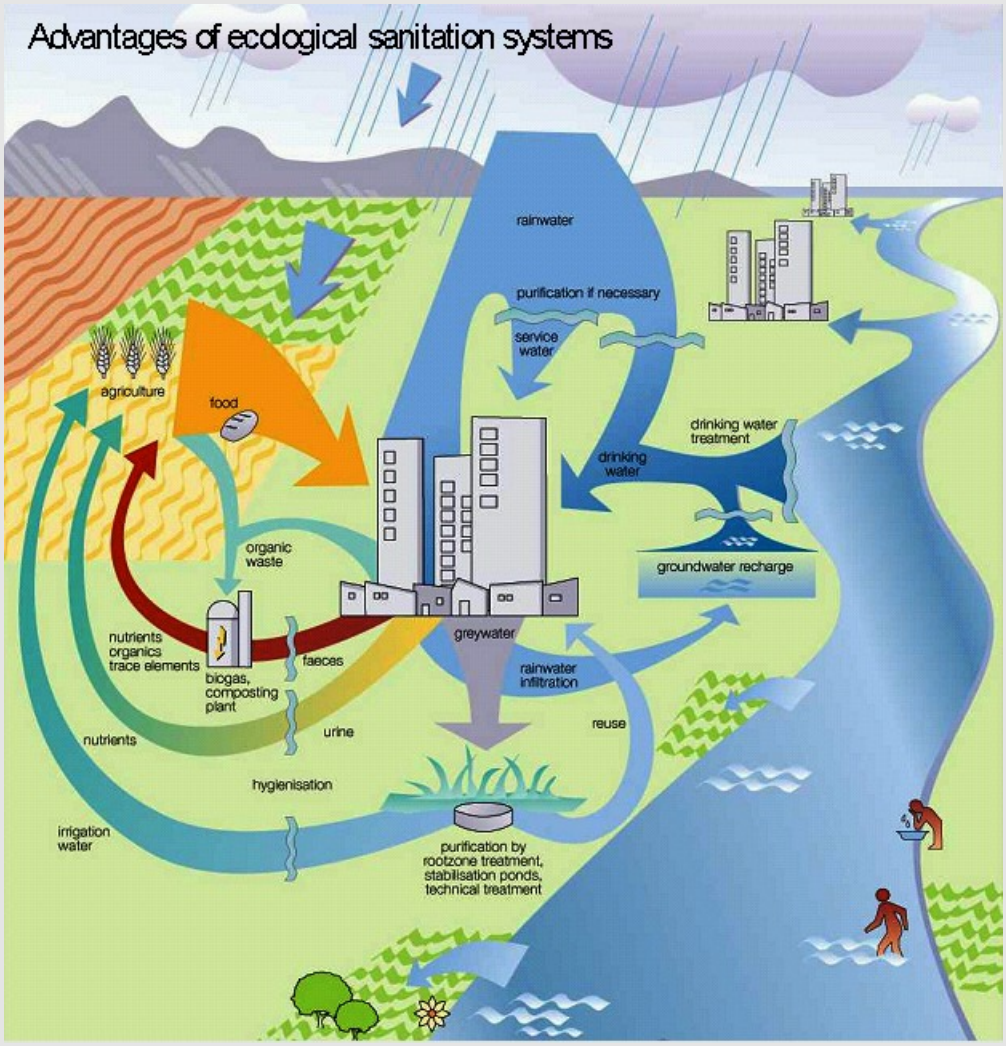
ABSTRACT

This article discusses the concept of 'ecological sanitation' (ecosan) and introduces it as a new, implementation-oriented paradigm for a sustainable water management. While IWRM as it is currently practised is mainly concerned with the development and strengthening of institutions for surface water management, ecosan represents an implementation-oriented approach to a cross-sector resources management concept for the solution of infrastructure problems. The ecosan approach does not promote any particular technology but rather represents a new holistic approach to wastewater and waste management. In fact, ecosan constitutes a change of paradigm from the linear concept of end-of-the-pipe systems to an approach considering ecological systems in a material-flow-oriented recycling (close-loop) process of water, nutrients, organic matters and trace elements. Its multi-sector approach makes ecosan an essential tool for the practical implementation of Integrated Water Resources Management in a broader sense that is integrated resources management. The article will present methods, concepts and practical examples for the implementation of ecosan.

INTRODUCTION TO ECOLOGICAL SANITATION

The modern misconception that human excreta are wastes with no useful purpose has resulted in the end-of-pipe sanitary systems that we have today. In nature however, there is no waste. All products of living things are used as raw materials by others as part of a cycle. Considering the environmental damage, the health risks, and the worsening water crisis, resulting from our present sanitary practices, a revolutionary rethink is urgently needed if we are to correct this misconception and realistically have a chance of achieving the Millennium Development Goals of providing sustainable sanitary services to over 1.2 billion people over the next 11 years. A new paradigm is required in sanitation, based on ecosystem approaches and the closure of material flow cycles rather than on linear, expensive and energy intensive technologies. This paradigm must recognise human excreta and water from households not as a waste but as a resource that should be made available for reuse.
Ecological sanitation is this urgently needed new holistic paradigm in sanitation. It is based on an overall view of material flows as part of an ecologically and economically sustainable wastewater management system tailored to the needs of the users and to the respective local conditions. It does not favour a specific sanitation technology, but is rather a new philosophy

in handling substances that have so far been seen simply as wastewater and water-carried waste for disposal. Ecological sanitation introduces the concept of sustainability and integrated, eco-system oriented water and natural resources management to sanitation.



- Improvement of health by minimising the introduction of pathogens from human excrement into the water cycle
- Promotion of recycling by safe, hygienic recovery and use of nutrients, organics, trace elements, water and energy
- Conservation of resources, through lower water consumption, substitution of chemical fertilisers and minimisation of water pollution
- Preference for modular, decentralised partial-flow systems for more appropriate cost-efficient solutions
- Possibility to integrate on-plot systems into houses, increasing user comfort, and security for women and girls
- Contribution to the preservation of soil fertility
- Improvement of agricultural productivity and hence contributes to food security
- Promotion of a holistic, interdisciplinary approach (hygiene, water supply and sanitation, resource conservation, environmental protection, urban planning, agriculture, irrigation, food security, small-business promotion
- Material-flow cycle instead of disposal

Figure 1. Principles and advantages of ecological sanitation

The basic principle of ecosan is to close the nutrient loop between sanitation and agriculture, with the objectives of:

- providing affordable, safe and appropriate sanitary systems
- reducing the health risks related to sanitation, contaminated water and waste
- improving the quality of surface and groundwater
- improving soil fertility
- optimising the management of nutrients and water resources

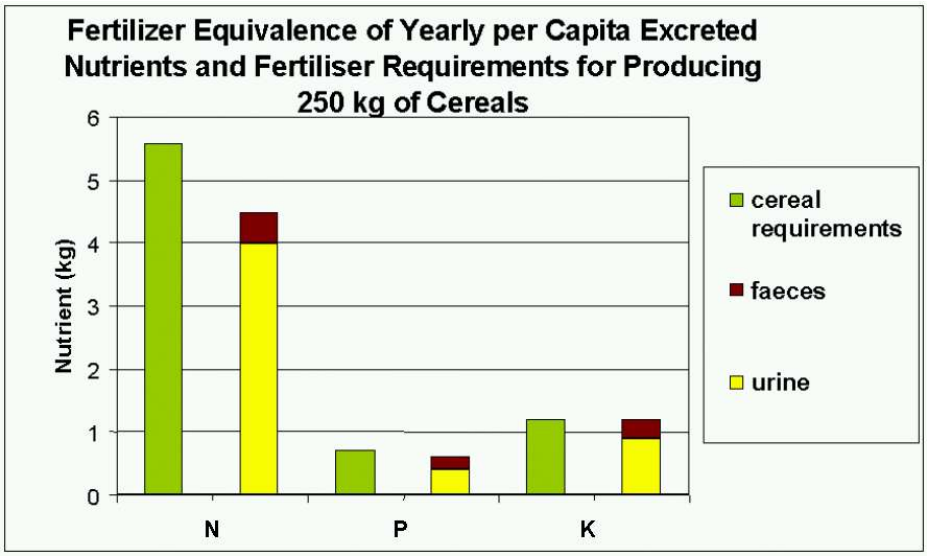


Figure 2. Balance between nutrients excreted by humans and nutrients required for producing their food

Closing the loop enables the recovery of organics, macro and micro nutrients, water, and energy contained in household wastewater and organic waste and their subsequent productive reuse - if necessary after adequate treatment - mainly in agriculture, or for other reuse options. An essential step in this cycle is the appropriate treatment and handling of the materials throughout the entire process, from collection through to reuse, ensuring a series of barriers are erected that will reduce the risk of disease transmission to within acceptable limits, thus providing comprehensive protection of human health.

Ecosan systems restore a remarkable natural balance between the quantity of nutrients excreted by one person in one year and that required to produce their food. It can therefore greatly help to conserve limited resources, preserve soil fertility and safeguard long-term food security. Annually farmers around the world buy and use 135 Mio tons of mineral fertiliser for their crops, while at the same time conventional sanitation dumps 50 Mio tons of potential fertiliser equivalents into our water bodies - nutrients with a market value of around 15 Billion US dollars. Closing local nutrient cycles by recovering and using the nitrogen, phosphorus, potassium, micro nutrients and organics contained in excrement is therefore not only important because it helps minimise the energy and resource intensive production of mineral fertilisers, but also because it makes such agricultural inputs available even to the poorest farmers in developing countries often engaged in subsistence farming.

As an integrated alternative, the implementation of an eco-sanitation project requires an interdisciplinary approach that goes beyond the narrow disciplines and technological aspects of domestic water supply and wastewater management to address issues such as agricultural use, sociological aspects of acceptance and cultural appropriateness, health and hygiene, town planning, economic and small-enterprise promotion, institutional administration, and so on. Such an approach also makes a large contribution to the integrated management of water and other natural resources.

Eco-sanitation opens up a wider range of sanitation options than those currently considered. To optimise cost efficient, high quality treatment and recycling options, two principles are very often applied in ecosan systems:

- Firstly, flow streams with different characteristics, such as faeces, urine and grey water, are often collected separately. This allows the application of specific treatment processes and optimise reuse.
- Secondly, unnecessary dilution of the flow streams is avoided, for example by using dry, low flush or vacuum transport systems. This minimises the consumption of valuable drinking water and produces high concentrations of recyclables.

Rainwater harvesting and the treatment of organic domestic and garden wastes and of animal manure can also be integrated into ecosan-concepts. Such a separation of the flow streams also allows a more active involvement of the solid waste management sector, where there is already a great deal of experience in the logistics, treatment and marketing of discarded resources.

However, whilst often making treatment easier and less expensive, the separate collection and treatment of the flow stream is not a prerequisite in ecosan systems, and ecological sanitation is also possible in centralised and combined flow systems.

Ecosan systems strive for resource efficiency. In reducing unnecessary water consumption and avoiding the contamination of water bodies, ecosan systems can have an impact on reducing the costs of raw water treatment and drinking water supply. Additionally the recovery and agricultural use of the organics and nutrients contained in wastewater improves soil structure and fertility, increasing agricultural productivity and thus contributing to food security. The recovery of energy through the anaerobic digestion of faeces, organic waste and animal manure may also represent a significant step towards energy efficiency, providing biogas for cooking or possibly for electricity generation.

Ecosan approaches very often require marketing strategies for the recovered nutrients, innovative logistics to return them to farmland, and directions for their safe application in agriculture. These requirements often result in new service enterprises being established as a result of new ecosan schemes which can also serve to kick start other income generating measures, for example for the construction and easy and safe operation of the installations.

THE RELEVANCE OF ECOSAN FOR THE CONCEPT OF IWRM

What Is the Relation Between Ecological Sanitation and IWRM?

The term of *Integrated Water Resource Management* (IWRM) as contained in the Dublin principles (1992) and the Agenda 21 (1992) represents a new water policy consensus on the international level. This consensus has since been confirmed in numerous international conferences and various declarations and today constitutes the working base for many organisations concerned with water issues. Yet it is true that different stakeholders use rather different definitions of the concept of IWRM.

As the understanding of IWRM can differ widely depending on the organisation, situation and background, GTZ staff tried to arrange these different concepts in one matrix. This matrix

displays the different levels of decision making, from local to international, on the vertical axis and the degree of integration along the horizontal axis (see Figure.3). Traditional water supply and sanitation approaches are usually only concerned with the management of the resource water and ignore other resources such as nutrients and soil. They should therefore be attributed a small integration degree in the IWRM matrix.

Ecosan approaches on the other hand do not only consider the management of water (in form of wastewater, drinking water, water for industrial use, irrigation water, rainwater, groundwater or surface water) but also the management of additional natural resources such as soil, nutrients, organic matters, energy and trace elements. In addition, ecosan also considers socio-economic resources such as health, employment and food security and links IWRM objectives to objectives of health policy, economy, resources protection, climate protection, soil protection and sustainable agriculture. Ecosan thus represents an approach with a high degree of integration, in which the management of water and numerous other resources is integrated into one holistic concept.[1]

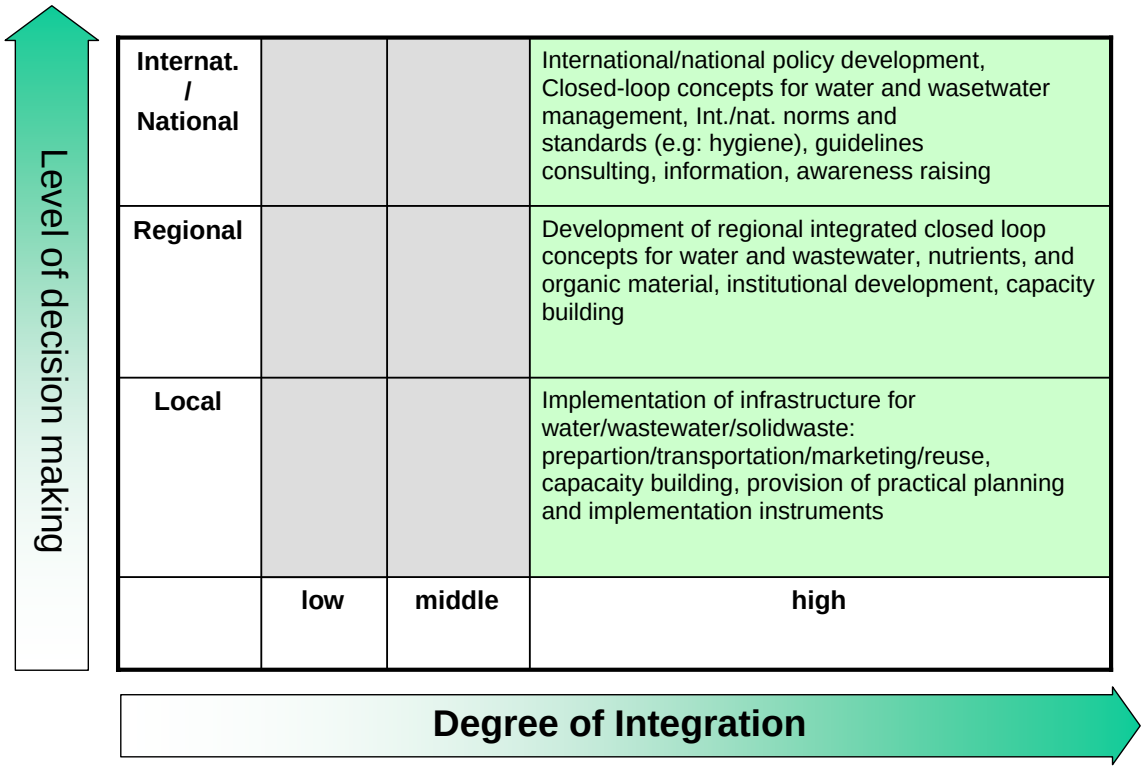


Figure 3. Ecosan within IWRM

Concerning the arrangement of ecosan approaches on the axis of different decision levels, the matrix yields a diversified picture. Ecosan approaches on the one hand foster local solutions of small-scale problems and therefore play an important role on the individual household level, for example when grey water is to be recycled for use in flushing the toilet or watering the garden, when kitchen wastes are composted in the garden or urine is separated and re-used locally. On the local level, particular importance has to be attributed to the realisation of appropriate infrastructure along with the implementation of systems for the collection, treatment, transport, marketing and utilization of the material and substances recycled from

[1] Roediger Vakuumtechnik; vgl. Werner et al. (2000; 2003).

solid waste and wastewater. The preparation of tools for planning and implementation as well as training activities is also very important at the local level.

On the regional level, integrated planning tools, such as integrated closed-loop approaches for water, organic matter, nutrients and energy, can serve as an example for the implementation of ecosan approaches. As a result of the interdisciplinary nature of the ecosan approach, this also necessitates cooperation between relevant institutions as well as reforms that allow for an efficient cooperation between the relevant sectors of water resources management, potable water supply, wastewater disposal, waste management, irrigation, agriculture, soil protection, protection of the environment, power supply and health, which to date have mostly been regarded separately. It is also necessary to anchor closed-loop approaches on the regional level in the curricula of schools, universities and vocational training. It is also recommended that subsidies and funds for research be provided.

The major issue on the national and international levels is the enhancement of framework conditions, including international policy objectives, the formulation of guidelines, norms and standards, internationally accepted technological standards and supra-regional knowledge management. Information dissemination, sensitisation, awareness raising are relevant at all levels in order to make the intended change of paradigm possible and spread the relevant know-how.

Within IWRM, ecosan is thus distinguished by a highly integrative approach relevant to all levels, from local to international.

ECOSAN CONTRIBUTIONS TO SUSTAINABLE INTEGRATED WATER AND RESOURCES MANAGEMENT

As an integrated approach, ecosan links many sectors. Figure 4 illustrates how ecosan touches upon and links sectors such as water resources management, flood protection, sustainable agriculture, soil protection, climate protection, health, resources protection, food security, and even the promotion of economy and employment.
As an example, ecosan significantly contributes to surface water protection as nutrients and organic matters are no longer discharged into the water bodies but are processed and re-fed into the material cycles. Pathogens as well as traces of drugs and hormones contained in urine do also no longer flow into the water body but are separated and, if necessary, can be neutralised more easily by a specific treatment of urine or faeces.

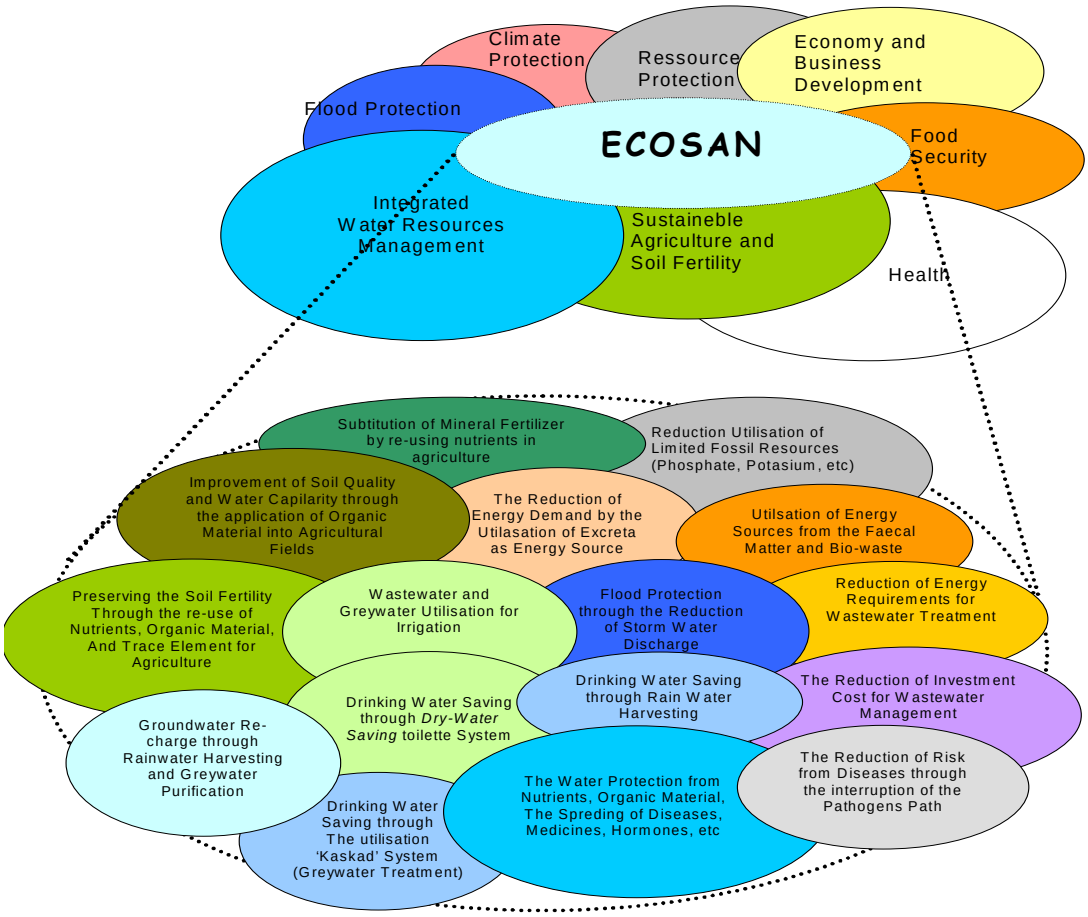


Figure 4. Ecosan Contributions to Sustainable Integrated Water and Resources Management. (Source: GTZ)

As a rule, the high amount of water needed for irrigation agriculture dictates the scarcity of the resource water in arid regions. In this context, however, ecosan can help to mitigate the problems through water saving and recycling. With water-saving or dry toilet systems, drinking water is no longer or only in small amounts used and wasted to flush the toilet and transport faeces. In addition, the multiple use of water, e.g. through grey-water recycling, leads to a significant decrease in fresh water utilisation. The use of wastewater or greywater for the irrigation of agricultural areas, gardens or recreation areas also increases the efficiency of water utilisation and mitigates the competition of different forms of water use. Rainwater harvesting can similarly help saving potable water and, in combination with on-site infiltration, furthermore has a positive impact on flood protection as it reduces the amounts of drainage. The local infiltration of rainwater or treated greywater into the soil also contributes to groundwater recharge and an increase in the water resources available. In addition, the re-use of organic matters improves the water storage capacity of the soil and natural infiltration.
Crucial is the ecosan approach with respect to the solution of qualitative water resources problems because it prevents the contamination of surface water and groundwater and thus safeguards the quality of the existing resources for various utilisation purposes.

The increased re-use of nutrients can substitute significant amounts of mineral fertilizer for agricultural purposes. This would offer great economic advantage for many developing countries because fewer amounts of expensive mineral fertilizers have to be bought from foreign countries. In addition, it will lead to a reduction in the global consumption of energy (for nitrogen production) and finite resources (phosphorus, potassium). Important energy-saving potential also arises from the reduced energy demand in wastewater treatment. Furthermore, the energy production from faecal matter and organic waste can help to conserve fossil fuels. The re-use of the organic materials, nutrients and trace elements in agriculture constitutes an important contribution to the safeguarding of soil quality, fertility and capillarity.

A major advantage of ecosan is that the systems entail significantly lower investment cost in comparison to conventional wastewater technology, which means that more people can benefit from the funds earmarked for wastewater management. Increased access to orderly waste and wastewater disposal will thus also improve public health in developing countries. This improvement will also be due to the reduction in groundwater and surface water pollution, incl. the contamination with pathogens.

Above examples illustrate that ecosan approaches can in a very diversified manner contribute to an efficient and sustainable water resources management. In fact, ecosan constitutes a change of paradigm from the linear concept of end-of-the-pipe systems to an approach considering ecological systems in a material-flow-oriented recycling (close-loop) process of water, nutrients, organic matters and trace elements. The resulting multi-sector approach makes ecosan an essential tool for the practical implementation of Integrated Water Resources Management in a broader sense that is integrated resources management.

THE IMPLEMENTATION OF ECOLOGICAL SANITATION

The utilisation of human faeces for agricultural purposes is a millennium-old tradition in many countries. Even today, it is still practiced e.g. in a large parts of Asia, in particular in rural and peri-urban areas. Ecosan approaches are, however, increasingly discovered for other countries as well, where the solutions are adapted to the local situation and then implemented. Ecosan approaches have already been implemented in numerous projects in both developing and industrialised countries. Nevertheless, the change to ecosan needs time.

Centralised end-of-the-pipe systems have been used and optimised for more than a hundred years. Their weaknesses were not realised for a long time or were accepted as part of the system. Only in recent years have successful ecosan projects demonstrated how sustainable infrastructure projects in the water sector can be and slowly the awareness settles in that they can serve to solve a whole bunch of problems. Numerous and diversified ecosan approaches have already been implemented but compared to the spread of conventional wastewater technology, the spread of ecosan (as expected) is very limited.

The span of the major obstacles in the promotion of ecosan ranges from the lifetime of the existing end-of-the-pipe systems (the investment cost of which are not yet written off) over the water supply and sanitation industry well-adapted to this structure (which would need a restructuring if the material flows are changed) to the legal framework, which does not consider or sometimes even hinders the new options (e.g. legal requirement to connect to and use the system), new technological and logistic challenges and last but not least a lack of

acceptance on part of the people in handling the products which are considered harmful or disgusting.

Adjustment of Traditional Instruments to a Holistic Approach

The instruments most frequently used in the preparation and planning of infrastructure projects are pre-feasibility and feasibility studies. These studies generally encompass a survey and assessment of the existing situation, the strategic planning, elaboration of feasible solutions, technical design, cost estimates, financial planning as well as environmental and socio-economic impact assessment, including an assessment of potential risks and are followed by a time schedule for construction works, the elaboration of an operation concept, detailed design, tendering and eventually the construction and commissioning of the system.
These instruments can and should also be appropriately used for the planning and implementation of ecosan projects. They have to consider a broader scope of ecosan-specific issues and aspects, however, and be adjusted in a differentiated manner. This adjustment relates to the following aspects in particular:

- **The integration of the closed-loop approach into the analysis of the initial situation and in all concepts and planning phases:**

The basic principle of ecosan is to close the loop between wastewater management and agriculture and prioritise re-use and recycling as opposed to disposal. In comparison to the planning of conventional wastewater disposal systems, more aspects must be considered for the implementation of ecosan, such as a survey of the situation in agriculture in view of soil fertility, the kind of crops cultivated, the agricultural methods, water and fertilizer requirements, the type of agricultural equipment used, irrigation practices, the quality of water for irrigation, animal husbandry, the existing situation as to the handling and re-use of animal manure, current and traditional methods of fertilization and soil protection, productivity, costs and yields, attitudes of the farmers towards artificial fertilizer, dung, wastewater and human excrement, etc. In this context it should also be noted that in the ecosan approach, the utilisation for agricultural purposes is generally not limited to the recycling of nutrients, organic matter, water and energy for traditional agricultural purposes. Utilisation in agriculture in the broader sense also includes forestry, fish farming and hydro-culture as well as gardening and landscaping. Therefore, numerous options should be considered during the investigation of re-use potentials of nutrients from faecal matter and urine in agriculture.

- **The integration of drinking water supply aspects:**

As ecosan solutions also aim at reducing water requirements and integrating rainwater collecting systems and greywater treatment and re-use, the water supply system should as a rule also be examined and modified.

- **The integration of town planning aspects:**

Ecosan solutions ideally close the loop of local material and energy cycles. To minimise the need for transport and to avoid just a relocation of problems to other and more distant areas, the place of re-use should, if possible, be in the vicinity of the source. For this reason, a consideration of urban planning aspects might be necessary (for instance in order to create room for the integration of a constructed wetland in a green city or find a location where small service providers can treat and temporarily store ecosan products in the vicinity).

- **The integration of solid-waste management aspects:**

Apart from solutions for wastewater problems, ecosan also offers solutions for integrating the treatment and re-use of organic waste from the household.

- **The consideration of many more sanitary engineering solutions (centralised/decentralised, conventional/cycle-orientated, high-tech/low-tech, conventional/new, material flow separation/mixture, etc.):**

In this context, it should be noted that the numerous thinkable combinations of technologies and fields of application of ecosan pose a substantial challenge to the planners. The development of suitable ecosan wastewater concepts requires a lot of know-how and experience. On the one hand, it should be avoided that innovative and feasible technical solutions and service options are rejected at the beginning of the planning process; on the other hand, the planning process should not be overloaded with too many different and maybe far-fetched combination options.

- **The application of new and holistic criteria for the assessment of water and sanitary systems.**

Through the productive re-use of excreta and wastewater, the ecosan approach aims at reducing the environmental pollution and health risks. Accordingly, the traditional assessment criteria currently used in wastewater infrastructure projects, e.g. discharge limits for receiving water bodies, are no longer appropriate for the assessment of individual options. For this reason, new criteria have to be developed and applied to the wastewater disposal systems, e.g. resources efficiency, energy requirements, degree of re-use, health risks, environmental risks, life-cycle analyses, self-help criteria, factors concerning job creation, total cost and benefit analysis, etc.

- **Intensified use of participatory assessment methods in the preparation and implementation of ecosan projects, in particular to enable the stakeholders to make informed choices.**

- **The analysis of stakeholder needs, in particular of the users of the sanitary facilities, the service providers and the potential users of the recycling products.**

- **The consideration of smaller planning units and a larger number of decentralised options.**

- **The integration of education, institutional development, education and training aspects into the project planning.**

For above reasons, the preparation and planning process of ecosan projects is much more intricate and demanding as in traditional infrastructure projects. Therefore, several organisations have developed or are currently developing tools and guidelines for such projects. As a rule, they concentrate on one or some of the specific points above and try to explain how the holistic approach can be realised in the preparation and implementation of ecosan projects.

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