sustainable sanitation alliance

Case study of sustainable sanitation projects

Humification of sewage sludge El-Minia and Nawaq, Egypt (draft)

Fig. 1: Project location

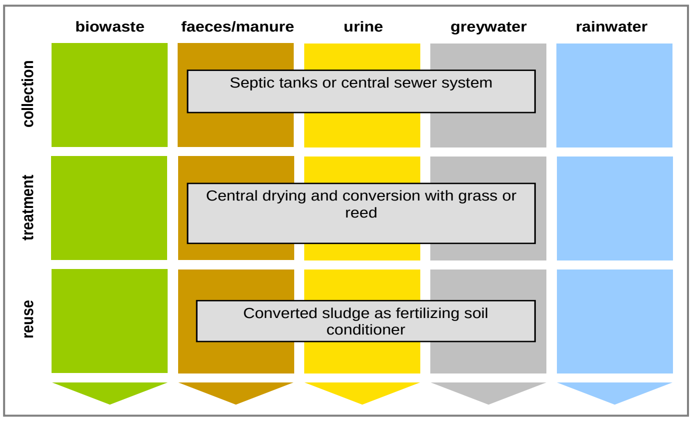


Fig. 2: Applied sanitation components in this project

1 General data

Type of project:
Technical pilot project and study

Project period:
March 2001 – August 2002

Project scale:
Appr. 220,000 EUR

Address of project location:
Sewage treatment plants Nawaq and El Minia, Egypt

Planning institution:
IPP Consult, Hildesheim

Executing institution:
IPP Consult, Hildesheim, Germany
University of Mansoura, Egypt
USDC, Mansoura, Egypt

Supporting agency:
BMZ, IPP Consult

2 Objectives and motivation of the project

The main goals of the project were:

- Evaluation of methods to convert sewage sludge from waste water treatment plants in different climatic regions in Egypt to a product of high quality, which can be applied in a safe and effective way in agriculture, public gardening and landscaping as well as for wood production.
- Dissemination of the useful results and information about sludge conversion in the framework of a closed loop system to treatment plant operators, authorities, farmers etc.

3 Location and conditions

Most cities in Egypt have been treating their municipal sewage by technological treatment methods partially since the 1980's. Today, many small towns and municipalities in Egypt already have or plan their own sewage treatment plants.

One aspect often neglected is the amount of sewage sludge produced and to be disposed or reused respectively. There is an annual amount of 12–15 kg of solid matter in the sewage sludge per inhabitant in Egypt, which corresponds to a daily production of 35–40 g.

A local survey was conducted at six treatment plants in the Mansoura and Damietta Governorates in order to assess the related problems of sludge treatment and handling. The method of treatment adopted in all of the treatment plants is thickening followed by drying. All the interviewed plant operators complained about the large amounts of produced dry sludge together with its too low market value and demand. In Egypt the use of sewage sludge is legally restricted by very complicate regulations that can hardly be observed under the local conditions. Nevertheless its use is common in Egypt and the demand is increasing.

The fast drying of sewage sludge in hot and dry climates has the disadvantage that the hydrolytic and microbiological decomposition as well as the microbiological conversion of organic and inorganic substances is minimized. After a few days, the humidity is not sufficient for the survival or the reproduction of microorganisms. If the dried product is applied in agriculture offensive odours may occur.
Disadvantages are often the big size and hardness of the lumps, the low water storage capacity, the low hygienisation rate and the low microbiological conversion of the organic substances during the short drying period.

Fig. 1: Sludge conversion polder planted with grass in Nawaq (source: IPP)

Fig. 2: Large lumps in overfilled drying beds (source: IPP)

The agricultural experiments with dried sludge in El Minia and Nawag showed that the product has high contents of substances which have harmful effects on plants. This substances lead to lower germination rates and to a slower development of the plants. The hygienic analysis showed a general decrease of pathogenic germs, but after a drying period of some months the product still contains a high risk potential with respect to salmonellae and Helminths. All these disadvantages can be avoided with a well operated sludge conversion system.

The treatment plant in Nawaq is situated in the Nile delta a 100 km north of Kairo with temperatures between 20 and 35° C between winter and summer. It is dimensioned for 17.000 inhabitants and consists of an oxidation pond with rotating aeration and a post treatment plus chlorination of the effluent before leading it into a receiving ditch. The sludge is to be dried in stabilization ponds, but since the plant does not operate at full capacity the ponds could be used for the sludge conversion project.
El Minia is located in upper Egypt approximately 260 km south of Kairo and has more or less a desert climate with rather extreme temperature differences. The treatment plant is constructed for the city of 200.000 inhabitants and has got a similar technical system as Nawaq, but the stabilization ponds are not constructed in an appropriate manner, which leads to a highly loaded effluent.

4 Project history

The project „Sewage Sludge Conversion in Egypt“ was initiated and financed by GTZ (German Society for Technical Co-operation) and the private company ipp Consult from Germany as PPP project. For technical, scientific and management support ipp Consult established a Cooperation with the Egyptian Consulting Enterprise USDC (Urban Study and Design Centre) in close relation with the National Academy for Scientific Research and Technology.

It was divided in 4 phases:

I (3,5 months): organisational tasks and first large scale experiments
II (3,5 months): After first dissatisfying results the experiments were continued in a bigger small scale programme in Nawaq to determine the adequate plant species and operation methods.
III (6 months): large scale experiments in Nawaq and El Minia
IV (4 months): agricultural experiments, socioeconomic field study, presentations, information campaign.

5 Technologies applied

The principle of sewage sludge conversion is mainly based on the development of a soillike environment in the sludge by its cultivation with plants. The plants and their roots penetrating the sludge lead to the establishment of different micro- and macro-organisms in it and its aeration and slacking. After a conversion process of 2,5 months the product is similar to earth in structure, odour and colour, hygienically safe and has got a high fertilization value.
The main project activities took place in the two treatment plants and were:

- To test and to compare sludge conversion with grasses and reed – well known low cost methods in Europe – under Egyptian conditions
- To apply the gained sludge product in agricultural experiments to observe its qualities as fertiliser and soil conditioner.

6 Design information

1. Conversion with grass
Sewage sludge is filled in layers of 20–30 cm into so called conversion polders with a usable depth of approximately 1 m. A minimum filter layer of 20 cm of sand above 20 cm of gravel should be provided. Between the filling of each layer the sludge should dewater through air-drying and drainage for at least some days. The seeding can take place when a filling of appr. 10 cm of stabilized earth moist sludge (content of dry substance 30-40 kg/m²) is left over and first drying cracks have appeared on its surface.

After the complete development of the grass and the conversion of the first layer, the next layer of sludge can be filled in. With each further layer, the above described process will be re-peated until the polder is filled (40 – 50 cm). The already developed environment in the lower layers and the grass, which is not harvested, have an important influence on the upper layers, for example by providing a structure and additionnal aeration of the fresh sludge after the filling.

After the completing of 4–5 cycles, the product can be used (after approxi-mately 2,5 months). In hot climates the regular irrigation of the sludge with treated waste water or liquid sludge turned out to be indispensable for the germination and develop-ment of the grasses especially during the first two weeks of growth. Use of pregerminated seeds as well as the covering of the surface with straw is recommendable to support the germination.

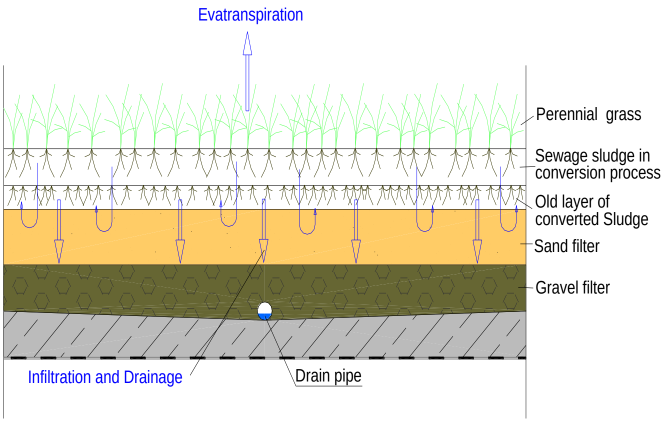


Fig. 6: Scheme of a sludge conversion plant (source: IPP Consult)

2. Conversion with reed

In contrast to the conversion with grass, the reed species “Phragmites australis” is planted in polders with depths of 1 m – 1.5 m. For a better development, the filter layer (compared to the filter layer of the grass conversion polders) is covered with a 20 cm layer of sand of the quality of 0/2. At first, the reed develops a complex root system; after that, with the increasing height of the sludge, a rhizome system is developing. Through the metabolism of the reed, the organic substance in the sludge is mineralised.

The processes are comparable to the conversion with grass. The difference is that reed can grow also in anaerobic environments, because reed can transport oxygen from the green parts of the plant to the root zone.

The filling can be carried out in relatively short intervals. Normally the polders are used for 5 up to 10 years without emptying, depending on volume reduction, depth of the polder and surface pressure. Therefore, the method is continuously in contrary to the discontinuous conversion with grass. However the product contains a lot of reed roots and straw is only partly decayed.

3. Agricultural field tests:

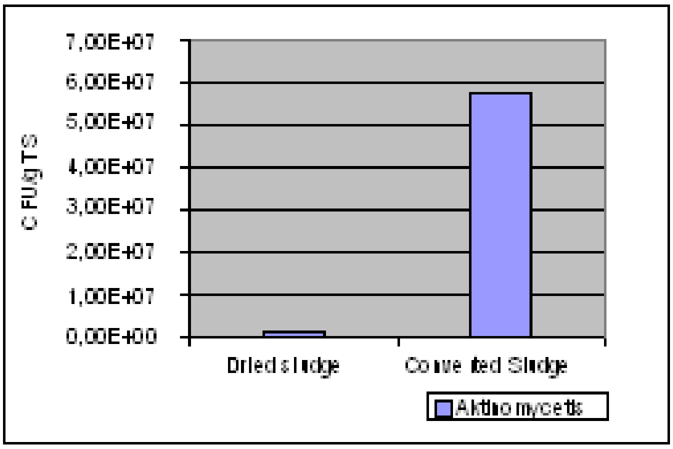
The experiments compared an application of converted sludge and air dried sludge on heavy soil from the Nile Delta and pure sand under cultivation of several domestic crops.

They show evidently that with respect to both objectives of examination (germination rate and yield) the application of converted sludge is preferable. Plants develop faster in soil fertilized with converted sludge. Especially the results on pure sand in Nawaq obviously indicate that the availability of nutrients in converted sludge is adapted to the demand of the plants compared to the instantly available nutrients in dried sludge.

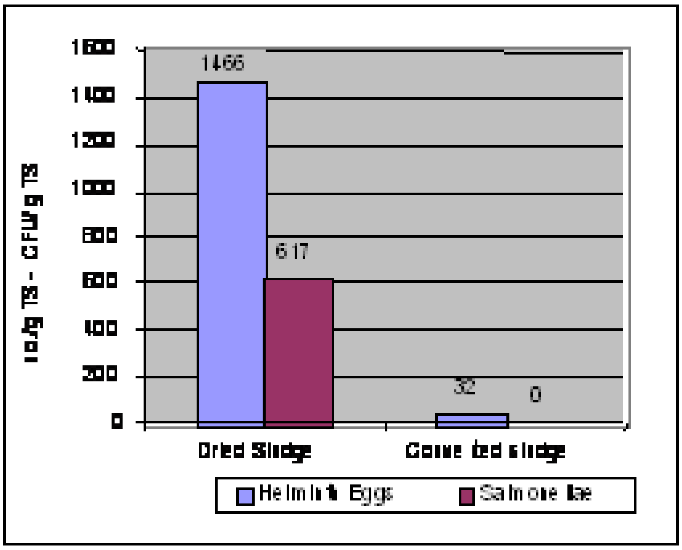
Plants in sand fertilized with converted sludge developed the same height and thickness as in the Nile Delta soil, which shows the large ability of converted sludge to adopt and to store water. Even high concentrations had nearly no negative impact on the vegetation, but enable a long term soil improvement by the accumulation of organic substances, which reduces the demand for fertilizer and irrigation water.

7 Type of reuse

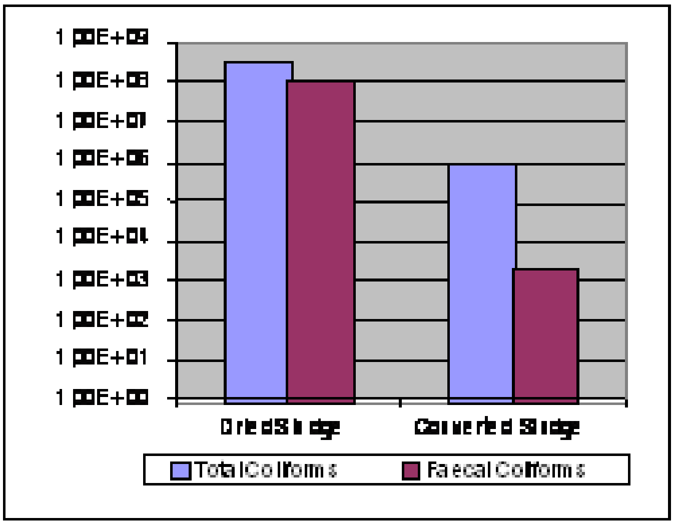
Since the soil suffers from degradation and salinization and artificial fertilizers are expensive a high demand for natural fertilizers exists: The converted sludge is to be used as hygienical safe and efficient fertilizing soil conditioner in agriculture.
The reed has to be harvested about once a year. Its reuse options are limited because of the high risk of unwanted re-thriving of the material and hygienical hazards



Graph1: Contents of Actinomycetis, (source: IPP)



Graph2: Contents of Helminths and Salmonellae, (source: IPP)



Graph3: Contents of total coliforms and faecal coliforms, (source: IPP)

Fig. 3: Converted sludge at use for building purpose, (source: IPP)

The safest options are its use as organic material for anaerobic digestion and biogas production or as fire material.

To provide the safe and efficient application in agriculture, the converted sludge-product has to fulfil the following requirements:

- Safe handling during operation and transport
- Minimization of health risks for farmers
- High fertilising value High acceptance by the users
- Efficient and easy application in agriculture.

The converted sludge proved to be adequate to fulfill these conditions. It was analyzed with regard to its hygienic and fertilizing qualities:

Parameter	Dried product	Conv. sludge
Total Nitrogen	2,4 %	2,9 %
Total Phosphorous	0,5 %	0,6 %
Potassium	0,2 %	0,4 %
Magnesium	0,3 %	0,8 %

Table 1: Average concentrations of plant nutrients (source: IPP)

Parameter	Dried product	Conv. sludge
pH-Value	6-7	5,8–7,18
Chloride	1,94 %	0,435 %
Sulphate	2,09 %	0,378 %
Electrical Conduc¬tivity. mS/cm	9,15	0,99
Volatile Solids	52-75 %	36-46 %

Table 2: Average pH-value, content of salt, organic substance (Navaq) (source: IPP)

A socio economic field study was carried out in cooperation with the University of Mansoura to evaluate the existing agricultural practises regarding sewage sludge, the acceptability and possible marketing of the new product. It showed that the use of sewage sludge is common, but that there is no reliable information for the farmers how to handle it and no quality or hygienic controls are carried out. In the treatment plants and on the fields it is handled without any protecting clothes etc.

Fig. 4: Current transport and handling of dried sludge (source: IPP)

Also chemical fertilizer is applied inappropriately. The interviews showed a high demand for converted sludge and a broad willingness to take part in experiments and activities with this concern, because the existing quantity, prices, quality and handling of anthropogenic fertilizers (dried sludge) are unsatisfying.

8 Further project components

A socio economic field study (quoted in chapter 5) was carried out in cooperation with the University of Mansoura.

An information campaign about the project covering the local region as well as the governmental level was carried out and showed positive results.

9 Costs and economics

As a comparative basis prices for prevalent fertilizers (in L.E.) were evaluated:

Nitrogen: appr. 27-32 /50 kg
Superphosphate: appr. 15-20 /50 kg

Potassium Sulphate: appr. 45-57 /50 kg
Manure: appr. 8-20 / m³
Dried sludge: appr. 10-41 / m³

Regarding dried sludge the current practise is the supply directly from the treatment plant or from the transport enterprises, while prices vary signifycantly depending on the region and seller.

Approximate costs for the production of converted sludge can be estimated as follows:
Seeds: 250 L.E. /year/1000m² surface
Irrigation:

- Investment: 1500 €/100m²
- Operation costs for pumping: 500€ /year/1000m²

Fig. 5: Conversion work in Navaq (source: IPP)

O&M:

- Personnel : 1750€ /year/1000m²
- Maitenance material: 600€/y/1000m²

Estimated total investment costs for 1000 m2: 60.000 €
Estimated yearly operational costs for 1000 m2: 3.023 € (durability of constructions: 20 years, machines: 15 years)
Suggested sales price for converted sludge: 4-10 €/m³.

10 Operation and maintenance

Attendance of the process described in chapter 10 by skilled personnel on a regular basis is necessary. During the project personnel from the treatment plants was permanently involved in all tasks and trained to be capable to plan and operate a sludge conversion plant after the project.

11 Practical experience and lessons learnt

- Sewage sludge conversion can be applied in semi-arid and arid regions. A stabile operation could be established.
- Chemical and microbiologic as well as agricultural analyses proved the hygienic safety and the high fertiliz-ing value of the product, which is moreover esthetical acceptable and easy to apply. This enables the commercialization of an attractive product, which could even be packed in sacks, barely reminding of its origin.
- The results of the agricultural experiments have attracted a lot of attention and the interest of national and local authorities as well as of farmers.
- The reed is less affected by the stabilisation grade of the liquid sewage sludge than grass, so a lower stabilization is acceptable. Nevertheless it is necessary to work with lower loads in case of a low biological stability, which results in a reduction of the possible annual load. As the reed reacts very sensitive to overloads the necessary and strict fulfilment of the loadings is a disadvantage of this method.
- Another drawback of reed conversion is the necessity to chop up the final product to prevent the development of reed plants after the application on the field. This is especially dangerous in Egypt, because the agricultural fields are mostly irrigated by flooding, which is an optimum condition for reed to sprout again.
- For grass conversion a detailed schedule of operation (filling, drying, seeding, irrigation) is required to guarantee the successful operation and maintenance of the polders. Hence the personnel must be very well trained and instructed. The necessary irrigation causes additional technical effort at the plant.

Fig. 8: Public presentation, Navaq (source: IPP)

12 Sustainability of the system components

Table 1: Relative sustainability of system components

	collection and transport			treatment			transport and reuse		
Sustainability criteria:	+	o	-	+	o	-	+	o	-
• health and hygiene									
• environmental and natural resources									
• technology and operation									
• finance and economics									
• sociocultural and institutional									

13 Available documents and references

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GTZ-IPP Consult, 2002: Klärschlammvererdung in Ägypten, Abschlussbericht über die PPP-Massnahme (German only).

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