CASE STUDY

SEWAGE SLUDGE CONVERSION IN EGYPT

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GTZ

German development agency http://www.gtz.de

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1. Introduction

The involvement of ipp-Consult regarding the introduction of an innovation to improve the quality of sewage sludge in Egypt lasted for a period of one and a half years and was initiated as a PPP-measure (Public Private Partnership), which was equally financed, by GTZ (Gesellschaft für Technische Zusammenarbeit) and ipp Consult. For the realisation of the project in Egypt, the University of Mansura, Egypt, as well as the staff of the private enterprise USDC of Mansoura became involved.

2. Current situation

Most cities in Egypt have treated 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 of or re-used 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. The share of solid matter (organic and inorganic material produced within the sewage treatment process) depends on the pollution of the raw sewage and on the respective sewage treatment and sludge drainage system and is usually between 1 % and 3 %. Higher amounts of solid matter (4 – 10%) may be achieved by thickeners, which pre-drain the sludge mechanically and partially stabilise it.

3. Local Examples

A Local survey was conducted on 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 plant operators that were interviewed complained of the large amounts of dry sludge produced together with its low market value and demand. The following pictures show the situation in plants that were visited.

Photo 1: Dried sludge stored besides the drying beds

Photo 2: Large lumps in overfilled drying beds

4. General Information about the project

The project „Sewage Sludge Conversion in Egypt“ was initiated and financed by the GTZ (German Society for Technical Co-operation) and the private firm ipp Consult from Germany. For technical, scientific and management support ipp Consult established a Co-operation with the Egyptian Consulting Enterprise USDC (Urban Study and Design Centre) in close relation with the National Academy for Scientific Research and Technology. The project was carried out from March 2001 to July 2002.

5. Background of Investigation

The contents of nutrients in the sewage sludge are considerably high and if treated in an adequate manner, the product can be used as a hygienically safe fertiliser of high quality. The main goals of the experiments was to find 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.

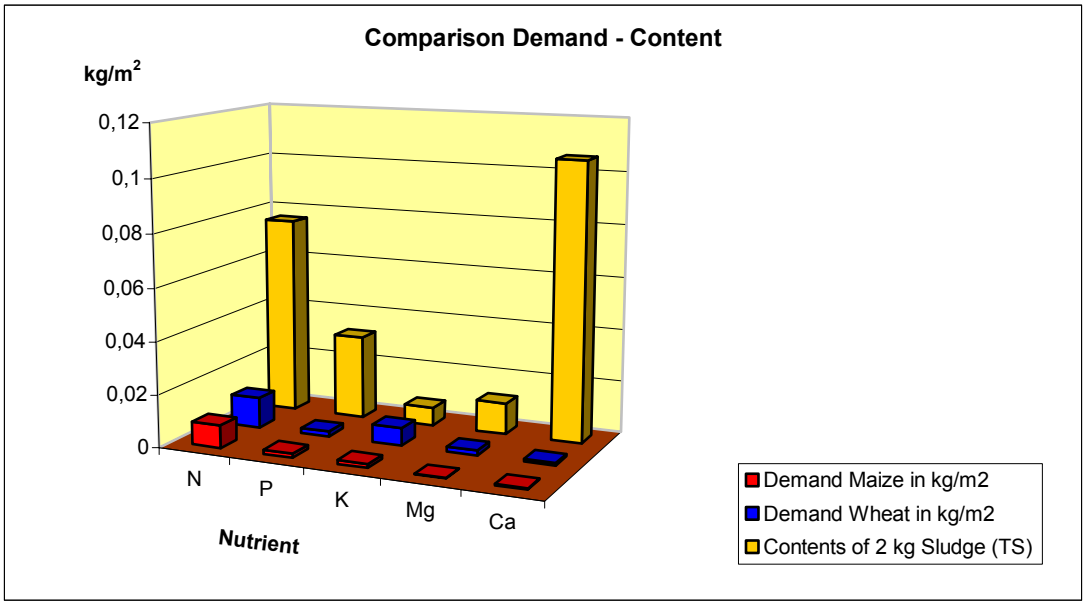

Fig.1: Comparison between the nutrient-demand of certain plants and average nutrient contents of sewage sludge

6. Sludge Product Requirements

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

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

7. Sludge Quality Considerations

To cover these requirements the sludge has to be evaluated considering its morphological, hygienic, chemical and physical as well as its aesthetical characteristics

- **Chemical-physical qualities**

  The physical-chemical qualities are important parameters for the evaluation of the fertilising value and the value of the sludge product as soil improver. Especially the fertilising value is important for the estimation of possible hazards in its application.

  The most important nutrients, which can be found in sewage sludge, are nitrogen, phosphorous and potassium. Especially in Egypt the contents of micronutrients like manganese, iron and zinc are of high importance because of the deficiencies of these compounds in soils in the new reclaimed lands as well as in the Nile Delta. Also the water storage capacity plays an important role in the sandy soils in the new lands.

  Too high or too low pH-values as well as too high contents of salts, expressed by the contents of chloride and sulphate lead to negative results in agriculture. The accumulation of heavy metals like lead, cadmium and chrome in soils and plants are potential hazards for the health of plants, animals and men.

- **Hygienic Characteristics**

  With the analysis of the concentration and presence of pathogenic germs and parasites in the product it is possible to make statements according to the hygienic safety of the product. The hygienic safety of the product is required above all during the emptying of the drying plants, the transport, and the distribution on the field as well as during the seeding and planting phase when humans are exposed to the product. A direct hazard for the consumer of agricultural goods does not exist because of the effect of auto-purification by the soil. The quality of the irrigation water plays in this case a role far more important.

- **Morphological quality**

  The morphological quality is an important criteria for the handling of sludge during the application on the field, especially the mixing with the soil. Large, hard lumps make it difficult to distribute and to mix the sludge-product in a homogenous manner. This can lead to negative effects according to the germination and growth of plants. Therefore the structure of the product should be crumbly and easy to break.

- **Aesthetical quality**

  The aesthetical quality is an important criteria for the successful sales management and advertisement of the product. A product that has excellent chemical-physical and hygienic qualities is often hard to promote if it shows bad aesthetical qualities (odour, consistence, colour).

8. Activities

The experiments were carried out in the wastewater treatment plants of Nawag (a village near Tanta) and El Minia in Upper Egypt to apply the methods under different climatic conditions. The main activities were to test different methods to convert sewage sludge and to apply the hereby-gained sludge-product in agricultural experiments to observe its qualities as fertiliser and soil conditioner.

Photo 3: Waste water treatment plant Nawag

Photo 4: Waste water treatment plant El Minia

Photo 5: Agricultural Research field with Sand in Nawag

Photo 6: Agricultural Research field with Sand in Nawag

The tested methods of sludge conversion were:

- Sludge conversion with grasses
- Sludge conversion with reed

Photo 7: Conversion with reed in Nawag

Photo 8: Grass conversion in Nawag

Both methods are acknowledged and applied in several European Countries and are considered as low-cost processes. Because of the different climate in Egypt according to temperature, Humidity and evaporation, it was necessary to examine the two processes according to their functionality and with respect to the operation and maintenance.

9. General information about the methods

The idea of sludge conversion

The principle of the Sewage Sludge Conversion is based mainly on the development of a different environment in the sludge. This shall be reached by the cultivation of certain plants, which create conditions, which facilitate the establishment of a soil-like environment. The metabolism of the micro- and macro-organisms leads to decomposition processes, which are comparable to the humification processes of compost.

Biochemical Background:

The cultivation of grass and reed on the sludge and the penetration of roots leads to the establishment of different groups of micro- as well as macro-organisms in comparison with the normal air drying of sewage sludge. It leads also to the additional aeration of the sludge. Beside the aeration effects, the penetration of roots has the effect of slacking of the sludge, which provides the crumbly structure of the product.

Photo 9: Decomposed Sludge from Nawag

Quality of the product

The product of both methods can be described as soil-like according to its structure, odour and colour. Analyses in Germany have shown that the product is hygienically safe and provides a high fertilising value.

10. Results of Investigation

The tests according to the methods of sewage sludge conversion in Nawag and El Minia have shown that both methods are applicable and can be operated successfully in Egypt although they have to be operated in a different way compared to the operation in Europe because of the climatic conditions in Egypt. Operational aspects have been investigated but not yet definitely determined to create an overall manual for the application of these methods.

The sludge product gained from the experiments showed mainly the same characteristics as in Europe. The agricultural experiments in both project locations have shown, that the biologically converted product has several decisive advantages in comparison to air-dried sludge.

Specific differences of Operation in Egypt

- **Sludge Conversion with grass**

After the first phase of the project it was clear, that the method couldn't be applied and operated like in Germany. The limiting factor is the moisture and this has to be provided by irrigation. It is not necessary and it would not be economic to use fresh water.

Photo 10: Drainage water from the drying beds Nawag

Photo 11: Improvised irrigation facility

The polders can be irrigated with sludge water from the thickeners or sedimentation tanks as well as from the effluent or the drainage water from the polder itself. The polders have to be irrigated regularly especially in the first weeks of the grass development. False operation leads to negative results.

- **Sludge conversion with reed**

Until now not many differences could be observed. In very dry periods it can be expected that the reed needs water to recover from the charges. The reed reacts very sensitive to overcharging. The fillings have to be carried out very careful. Layers above 20 cm are not required and can be harmful for the plants. Careful observation of the reed plants is required. The reed polder can be operated constantly without change of operation until the polder is filled and can be emptied after a certain retention time.

Photo 12: Reed after overcharging

Photo 13: Reed bed after overcharging

<u>Main requirements of application in Egypt</u>

- **Sludge conversion with grass**
  - The existence or the installation of irrigation facilities according to the water, which will be used for irrigation. It is generally recommendable to install a system, which provides the irrigation form both sides of the polders. The irrigation by sprinkling has certain advantages but its application is more time and cost-intensive than the simple flooding of the polders.

- A detailed schedule of operation (Filling, Drying, Seeding, Irrigation) is required to guarantee the successful operation and maintenance of the polders
- The quality of the sludge charges should be homogenous, especially the age of the sludge as well as the degree of stabilisation
- The operation personnel has to be trained and instructed in an adequate manner

- **Sludge conversion with reed**
  - The requirements are similar to the conversion with grass, but an irrigation facility is not required, although water has to be provided for the cultivation phase and temporary flooding.

Quality of the product

The quality of the product of both methods is considered to be similar although only the product of the grass conversion could be analysed sufficiently. The analysis of the lower layer of sludge in the reed bed have shown that the morphological, chemical-physical, hygienic and aesthetical quality of the product can be expected to be similar to the product gained from the method of grass conversion.

Photo 14: Decomposed sludge in Nawag

The sludge product produced by the process in the period from September 2001 to June was analysed according to its morphological, chemical-physical, hygienic and aesthetical characteristics. It was found that the product fulfilled the requirements mentioned before:

- Morphology: "Soil-like", crumbly, the decayed grass provides structure
- Esthetical Characteristics: brown colour, earthy smell, no offensive odours
- Chemical and physical characteristics: neutral pH-value, high contents of organic material and macro-nutrients (nitrogen, phosphorous, potassium), considerable contents of micronutrients like zinc and iron as well as a good water storage capacity, and low concentrations of heavy metals (cadmium, copper, lead)
- Hygienic characteristics: low concentration of coliform germs directly after the finishing of decomposition, absence of Salmonellae and worm-eggs

The microbiological analysis has shown that the concentration of faecal coliforms, worm eggs and Salmonellae have decreased considerably after a conversion time of 2 month with a resting period of 2 weeks. Salmonellae could not be found in the sample of converted sludge whereas the dried sludge (drying time: more than 4 months) still has dangerous contents of this germ.

11. Comparison of the methods

Conversion with grass	Conversion with reed
Advantages	**Advantages**
- Production of a save and valuable sludge product which can be used for fertilising and soil improving - Low cost method - Flexible in operation according to operational errors	- Production of a save and valuable sludge product which can be used for fertilising and soil improving - Low cost method - Relatively easy to operate
Disadvantages	**Disadvantages**
- Necessity of providing an irrigation facility - Necessity of daily control and operation	- Low flexibility of the method according to operational errors - The reed reacts to overcharging very sensitive and can be affected by plagues - Remaining rhizomes in the product can cause growing of reed on the field after application. Reed is considered as a plague by the farmers and therefore the product can get discredited

The advantage of the sludge conversion with reed is the easier operation. Nevertheless the main disadvantages are putting the applicability of the method in question. The main problem is the fact that the replanting of reed is more difficult and time intensive than the re-seeding of grass.

The replanting of reed could become necessary because:

- The reed reacts to overcharging very sensitive and it is difficult to plant new reed on the polders while the process is not finished. Therefore it is necessary to be very careful during fillings because layers above 20 cm are not required and can be harmful for the plants
- The reed can be affected by certain plagues like the Stemdriller which causes the dying of the plant

Another problem are the remains of the roots respectively rhizomes in the sludge product. This can have negative effects affect in agriculture because new plants can develop from these remaining rhizomes. The farmers consider Reed as a plague and therefore the product can get discredited. The only way to eliminate the rhizomes in an effective and ecological way is to destroy them mechanically by chafcutters.

12. Agricultural Research

The agricultural research was carried out in Nawag and El Minia during June and July with the sludge product converted by grass as well as with air-dried sludge for comparison. The experiments were focused on the quality of the substrates as fertilisers in heavy soil from the Nile Delta in Nawag as well as pure sand in both locations.

Already the pre-investigation experiments in buckets have shown that the efficiency of even the only partly converted product, as fertiliser is considerably higher than the efficiency of the dry sludge. In the same time crops developed faster and more biomass in the soil mixed with converted sludge than in soil where the dried product was applied.

Photo 15: Results of the pre-investigation with barley in substrates of soil mixed with different percentages of sludge

Experiments with pepper weed have shown furthermore that the dried sludge contains considerable high concentrations of compounds, which are affecting the plants negatively whereas the tests with the converted product proved the absence of such compounds.

The results of the field tests have lead to similar conclusions. Of the 4 tested crops Maize (Durra), Millet (Durra Sucari), Ladyfinger (Okra, Bamia) and Garghir only Maize is developing similar in soils fertilised with converted and dried sludge although negative effects produced by high concentrations of air dried sludge can be also noticed. All other tested plants are developing slower in soil fertilised with dried sludge. In the plots with high concentrations of dried sludge, Ladyfinger, Sorghum and Garghir nearly have not developed at all.

Photo 16: Maize and Ladyfinger in Nawag after 4 weeks

Photo 17: Soghum and Ghargir in Nawag after 4 weeks

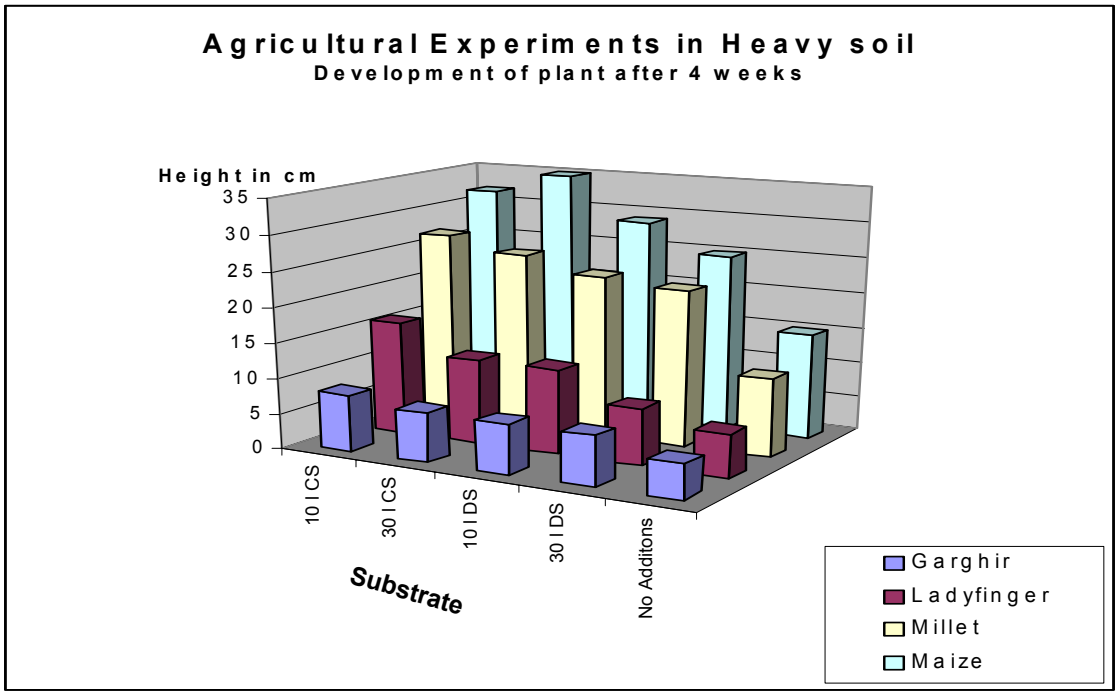

Fig. 2: Development of plants in Delta soil with various concentrations of dried and decomposed sludge after 4 weeks

Especially in the sand the converted product demonstrates its quality as soil conditioner because the plants have developed the same height and thickness as in the heavier soil from the Delta, in case of Okra even more. This shows that the converted product has a large ability to adopt and to store water

Photo 18: Development of Garghir (from left to right: Sand with 30 l dried sludge, Sand with 10 l dried sludge, Sand with 30 l converted sludge, Sand with 10 l converted sludge, Sand without additions)

Photo 19: Development of Ladyfinger (from left to right: Sand with 30 l dried sludge, Sand with 10 l dried sludge, Sand with 30 l converted sludge, Sand with 10 l converted sludge, Sand without additions)

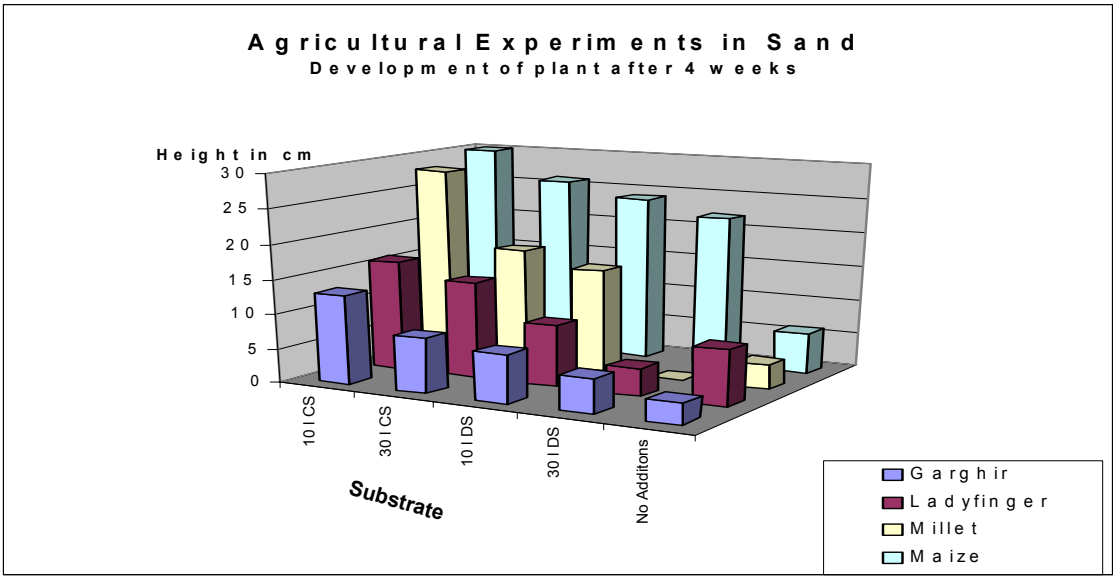

Fig. 3: Development of plants in sand with various concentrations of dried and decomposed sludge after 4 weeks

A meeting with local farmers on Tuesday 9th of June has shown that they are very interested in the product which the consultant presented in Nawag.

Photo 20 - 22: Presentation of the results to the Farmers in Nawag

13. Conclusions and Outlook

The experiments carried out in Nawag and El Minia have shown that it is possible to convert sewage sludge to a bio solid product of high fertilising value which can be applied in agriculture in a safe way.

As treatment method for sewage sludge, the consultant favours the conversion with grass although the operation requires more time and investments in comparison to the conversion with reed. The aspects that the product of the conversion method with reed will possibly be rejected by the farmers because of the contents of rhizomes in the reed as well as the lack of flexibility of this process in case of operational mistakes have led to this conclusion. Nevertheless it is recommendable to continue the investigation of the feasibility of this method in Egypt because it needs nearly no additional investments compared to sludge drying beds.

The results of the agricultural experiments are encouraging because the product, gained from the conversion polders showed the characteristics of a high quality fertiliser. If the process of grass conversion is operated in an adequate and effective way, the product could be a great benefit for the agriculture especially in the poor soils in the new reclaimed lands. Besides that, the method can be described as an important tool to close further the ecological circle of matter respectively the chain of nutrients.

If the product is promoted and can be sold for a reasonable prize, the necessary inversions and operation and maintenance cost can be amortised in short place.

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