

# Additional poster presentations

## Poster presentations

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## Wastewater - management, reclaiming and reuse

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### Keywords

Education, energy, recycling, sanitation

### Abstract

This paper is a review of the wastewater treatment and reclaiming technologies being implemented by our private company, PEMAGI ENERGY LTD. PEMAGI Energy Limited is a Renewable Energy (RE) Technology enterprise committed to development and diffusion of renewable energy and waste management technologies in East African region and beyond.

### Introduction

We implement our wastewater treatment systems in collaboration with our clients, local and foreign experts. We have several objectives in our work. The main ones are:

- To improve sanitation
- To reclaim wastewater for re-uses in agriculture
- To conserve clean water
- To recycle nutrients
- To recover biogas from the wastewater, which is used as a fuel, which saves on the use of firewood. Reduced use of firewood helps to reduce in-door air pollution
- To educate communities on the need to re-cycle waste which is normally discarded and forgotten etc.

The idea of reclaiming wastewater has been used by our company to counter demand for fresh water and fertilisers for our clients. Thus PEMAGI Energy Ltd views wastewater as not just another waste but as a useful resource.

The initiative of PEMAGI Energy Ltd has been first to provide practical solutions in wastewater management for institutions that have realised that wastewater is a problem to them. For such institutions, we design systems to fit under their circumstances. Usually, this group of institutions is the main clientele of PEMAGI. They are the easier to work with since these institutions have already acknowledged that wastewater is a problem that needs to be addressed. Wastewater management is thus prioritised highly in the development programmes of such institutions. The second approach by PEMAGI has been to create awareness among institutions on the need to incorporate wastewater management systems in their development programmes. The key issue is to sensitise the heads of institutions to realise that wastewater is an issue to be thought about early enough before it presents itself as a problem to the institution. In the view of PEMAGI, it is an issue that should be considered at the earliest planning stage of institutions. In our experience, we have come across many situations where land that could best be utilised for wastewater treatment facilities being occupied by other

infrastructure. Under such circumstances, there are several limitations, which present themselves in the course of planning of wastewater treatment facilities. Examples of such limitations are limited connectivity to the wastewater facility, limitation in re-use and re-cycling have treated effluent, limitation in the use of gravity flow etc. The worst scenario is where the institution has covered all its land with buildings and non at all has been spared for wastewater treatment facility.

## Methods

The projects we propose to our clients are driven by the needs of the clients. The primary need among them is usually the need to improve the sanitary conditions in the environment of the client. So we design our projects to target this primary need. We then apply anaerobic wastewater treatment technologies adapted to the local site conditions. With consultation with the client we integrate wastewater disposal-by-reuse methods either in agriculture, tree growing, fish farming or a combination of all of them.

The biogas generated from the anaerobic process is usually collected and used in the clients' kitchen where it replaces firewood. Thus we focus on wastewater management solutions that are ecologically, economically and socially sustainable with no additional waste output.

## Results

Since the founding of our company in 1993, we have built bio-latrines for 100 families and three schools. These are modified pit latrines where we have the ordinary cubical on top of anaerobic digester, which is built in place of the ordinary pit. This set up is usable for unlimited time without filling unlike the pit latrines: The biogas generated in the digestion process exerts pressure, which cause continuous discharge of the decomposed waste into an adjoining compost pit. The effluent is used as organic fertiliser.

We have also installed anaerobic wastewater treatment systems for the following: Two hospitals each with above 200 beds, one agricultural training college, one boarding school with about 250 students and two church institutions. These wastewater treatment facilities consist of a number of digesters for the primary treatment and biogas recovery, depending on the volume of wastewater available. Down stream of the digesters we may have conventional wastewater stabilisation ponds, biological filters consisting of sand-ballast- water plants zone for post treatment. The combined digester capacity for the six installations above is about 900M<sup>3</sup>. The volume of wastewater treated and reclaimed ranges from 40M<sup>3</sup> to 100M<sup>3</sup> per day for individual systems.

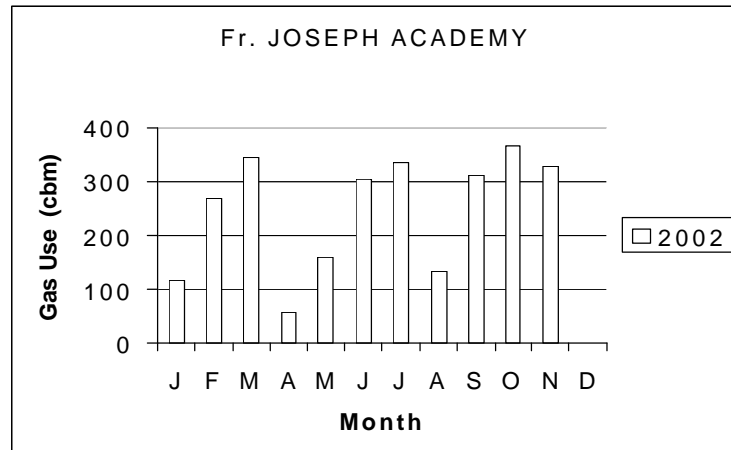
The installation of our wastewater disposal and re-claim systems has led to dramatic improvement of the sanitation conditions in the premises of our clients. In some situations the systems have saved some institutions from eminent closure by public health authorities. We have transformed the swampy smelly corners of our clients' compounds into dry and clean environments. These had previously attracted the wrath of public health officials and neighbours. After satisfying our clients with this primary objective, there is biogas, organic fertiliser and reclaimed water suitable for agriculture for our client to use as extra bonus from the treatment facility. Our unique projects have thus played a significant demonstration role for those who would like to improve their wastewater management practices.

Here below are just three examples of our projects:

One 220 bed rural hospital has used our system for the last four years. The organic manure is spread in the farm where fodder is grown with better results and more sustainable supply. (See photo above) Biogas is used to cook for the patients where about 9 M<sup>3</sup> is used daily for the last three years. As the treatment process includes ponds for improved quality of effluent, we have introduced fish in the ponds primarily to control mosquitoes; but the community around is gradually accepting that the fish could also be eaten.

Our clients are using the re-claimed wastewater from one of our systems in Nairobi to grow bananas. After only 18 months, the client has begun to harvest the bananas. Previously the raw wastewater effluent had generated animosity between our clients and the neighbours.

In a boarding school with 250 pupils the biogas generated from the wastewater is used to cook some of the meals for the pupils (See graph). Some of the reclaimed water is applied in a pasture area where goat and cows graze. More is being applied in an oats field by sprinkler irrigation. Another smaller portion of the water is used on a lawn through some underground sprinklers.



## Conclusions

The need for wastewater management systems will continue to increase as the demand for fresh water supply increases. The increasing awareness on the need to control the pollution of our environments and the increase in awareness of people's rights is other factors that will accelerate demand for the systems. As the population continues to increase, there will be less and less space to freely dump our wastewater. These circumstances will call for the need to re-use wastewater after treatment to decrease the demand on fresh supplies. The anaerobic systems also offer a chance to generate some biogas, which can be used as a fuel in the institutions. With this background PEMAGI ENERGY LTD is hopeful for improved business in the future and an improved product quality for our clients.



## Ecological sanitation: Bangladesh perspective

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### Keywords

Worst sanitation, piles of wastes and water born diseases.

### Abstract

Bangladesh has not yet been able to provide safe drinking water and sanitation facilities to its entire people. According to a WHO report 50% of Bangladesh people do not have hygienic sanitation facility. The sanitation condition in the rural areas is worse than it is in urban areas. People without sanitary latrines in the villages still use the hedges behind their house, river, ponds or open space to defecate.

The condition of sanitation in the urban slums is the worst. The unimaginable density of population in the slums has compelled their residents to sleep, cook and excrete almost at the same place. In many cases all of the dwellers of the slum have to use only one latrine.

The houses in cities, particularly in Dhaka are being constructed without proper planning. As a result, the sewerage system is breaking down. Piles of wastes are seen on the streets, which often overflow through the broken, or stolen sewerage leads in the cities. Living with waste ultimately causes various diseases and epidemics. Diarrhoeal diseases and other water-born diseases are caused largely for poor sanitation facilities. Oral saline provides immediate relief to Diarrhoeal diseases, but the problem of underweight, the poor physical and mental growth of the children persists.

The sanitation problem extends to the work places also. Most of the offices do not have adequate latrine facilities. The few lavatories that the offices have are rarely cleaned. The women personnel suffer most from the ill sanitation system. The sanitary condition in the Educational institutions also raises concern. A UNICEF survey reveals that sanitation in schools is in the worst condition in Bangladesh, Nepal and the Maldives among the world countries. In rural Bangladesh there is only one latrine for every 90 students, and most of these are unhygienic. Forty percent of these toilets are not cleaned regularly.

The sewerage and sanitation systems in the urban areas of Bangladesh are far short of modern standards and even where in modern systems of sewerage has been established, it is at best, inadequate in coverage. The human waste disposal system is a mixture of several modes, including the traditional mode of bucket latrines. Even in Dhaka city only about 35 percent of households have access to the sewerage lines and a very large percentage of the capital city's population do not have access to any sanitary latrines. In Chittagong, only 38 percent of the populations were served by septic tanks in 1985, 4 percent by pit latrines and almost 30 percent relied on bucket latrines, 5 percent used communal latrines, 19 percent used open latrines, while 4 percent had no specific sanitary facilities at all.

The conditions in district and Upazila towns are even worse. According to the Department of Public Health Engineering, no water-born sewerage system existed in any of the district towns in 1983. According to the department, only 12 percent of the people of district towns use septic tanks, 10 percent use pit latrines, and 5 percent use bucket latrines, while 68 percent use either

surface latrines or no specific facility. In the Upazila centres, only 4 percent have access to septic tanks, 5 percent to water seal latrines, 56 percent use surface latrine and 35 percent have no specific facility.

The high cost of installation of proper sanitary facilities, the cost of maintenance, lack of adequate space for installation and other factors stand in the way of improvement of the sanitary environment in urban and also rural areas.

## Reference

IEDS Data Base

## The impact of urbanization on sanitary conveyances and sewage treatment facilities in the city of Lusaka, Zambia

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### Keywords

Conveyances: sanitary drains and sewerage that convey soil, waste and storm.

Sanitary facilities: conveyances and treatment systems.

Waste stabilization ponds: which includes facultative anaerobic and maturation ponds they are biological treatment plant.

### Abstract

The overall aim is to promote ecological and sustainable management of sanitation systems in urban settlements of Lusaka, induce economic growth, health and environmental protection. The paper brings out information on the status of systems of sanitary conveyances and Waste treatment facilities. It highlights the impact of urbanization to sanitary infrastructure and the urban environment. It also shows how poor sanitation has contributed to outbreaks of most human infections. The paper points out how inadequate design and maintenance of drains causes rainwater stagnation leading to road damage and breeding grounds for malaria carrying mosquitoes.

Urban sanitation is a world wide common failure to regard disposal problem as less important than the consideration of portable water supply. Without effective community-wide method to contain excremental, the full health impacts of a plentiful water supply will not be appreciated. The key issues to achieve ecological sanitation are: - political recognition of the importance of sanitation, poverty alleviation, capacity building, rural economic development (ruralisation) and the development of policies. Ecological sanitation is eco integration through total cooperation among decision makers, researchers and the public. It requires systematic planning, adequate organisation and recycling of urban wastes to prevent environmental damage and health risks.

### Introduction

The increasing and fast growing urban population of Lusaka, Zambia has brought about a number of adverse effects on the public amenities and environment. At independence (1964) the population of Lusaka was 195,700. The Population of Lusaka is now estimated at 2 million, (Central Statistical Office 2000). The sewer network and sewage treatment plants were built in the late 1950s, with the most development being in 1980 when an extension was made to the Manchinchi sewage plant.

Despite Lusaka experiencing a rapid growth of population over the last 25 years, no study has been conducted to determine the effective operation of the sanitary conveyances and sewage treatment plants (Wamukwamba and Share 2001). These facilities were designed using the population at that timeserving. Manchinchi and Chunga sewage works design capacity 36,000 and 9,000m<sup>3</sup>/day, Matero ponds 7,100m<sup>3</sup>/day, Ngwerere 8,350m<sup>3</sup>/day, Kaunda square 3,600m<sup>3</sup>/day, Chelstone 2,700m<sup>3</sup>/day and Garden maturation ponds 36,000m<sup>3</sup>/day.

The increasing pressure on existing sanitary systems is reflected in the break down of conventional treatment plants. Leakages, over loading and choked sanitary facilities have resulted into the production of offensive odours (air pollution), contamination of ground and surface water bodies by spilled un-treated (raw) sewage that poses a health hazard and degradation of the environment. The city of Lusaka sewer network covers a total length of about 450 kilometres with about 10,000 manholes and seven pumping stations in the serviced areas, which include high, medium and low cost.

The prevailing poor sanitation caused by unsatisfactory operation of sanitary systems has led to outbreaks of most human infections such as water borne, water based and water related diseases. These include diseases whose transmission will be reduced following an increase in the volume of water used for hygienic purposes, like diarrhoeal diseases an example is cholera. Water related diseases are these diseases spread by insects which either breed in water or bite near water, and an example is Malaria.

The poor design and maintenance of the drains (underground and surface) results in stagnation of rainwater, which contributes to road damage and creates nuisance in the city as well as creating breeding grounds for malaria carrying mosquitoes. See table 1 showing the top 5 cases of morbidity in Lusaka in 2001.

No	Causes	Cases	Incident
1	Malaria	32,699	285
2	Diarrhoea	16,534	144
3	Respiratory	13,861	121
4	Pneumonia	7,105	62
5	Intestinal worms	3,171	27

**Table 1:** Top 5 cases of Morbidity overall in 2001. LDHMT/JICA-PHC April 2002

The conceptual framework in (Diagram.1) shows the importance of collecting data on the status, the effective operation of sanitary systems and calculated capacities of sanitary infrastructure. This could be a possible and participatory way of improving sanitation in urban communities and promoting wastewater reuse, hence, will positively trigger development in various aspects of the environment. It is clear from the framework that effective operation of sanitary facilities can with little doubt lead to: - Improved Sanitation in Urban Communities, Integrating the Environment to insure the right of citizens to clean and health environment, Poverty reduction through increasing food production by the use of wastewater by small-scale farmers and creating employment during maintenance of sanitary facilities. To increase the effectiveness in the enforcement, there is need to review existing sanitary legislations and intervention strategies. It also gives a clear understanding of sanitary systems suitable to local conditions (separate, combine and partially combined systems).

With the framework in mind and the reality of the sanitation situation in the city, it would be fair to conclude that the effective operation of sanitary facilities can partially, if not wholly prevent adverse effects brought by poor sanitation in urban serviced communities.

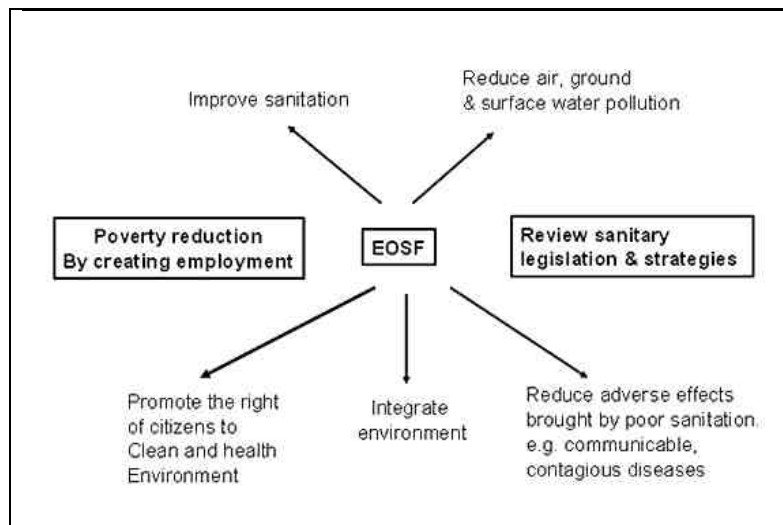


Figure 1

### Justification

The study assessed capacities of sanitary systems and gathered information on status and satisfactory operation of private and public sanitary conveyances, Waste stabilization ponds and Conventional treatment plants in relation to the population it is serving. It also assessed the possible utilisation of wastewater in small-scale farming. Potential risks likely to affect the communities were analysed too. The data will be useful in improving sanitation in urban settlements and review of existing legislation on sanitation. The study is in line with the overall objective of the National Environmental Action Plan (NEAP): to gather data, which will help to integrate the environmental concerns into social, economic development and planning process of the Country. In addition, it is within one of the three fundamental principles of the NEAP " the right of citizens to clean and health environment (NEAP 1994).

Zambia is one of the developing Countries of the World. Developing Countries of the World are those, that are poor and behind in many things, such as level of education, health service provision, inadequate sanitation and wholesome water supply to their population. They have high death rates and high birth rates and their population often increases at such a rapid rate that they can hardly keep up with new jobs. (Monica and Bennett1986).

UNESCO-UNEP, give a world- wide overview on water and sanitation. Lack of safe drinking water and adequate sanitation for a great number of people in the world is one of today's most critical environmental problems. While the estimated water and sanitation coverage is close to 100% in industrialized countries, the situation in the poor developing countries is far from satisfactory (Egil 1998).

In 1980, the General Assembly of the United Nations declared the period 1980 – 1990 as the International Drinking Water Supply and Sanitation Decade. The global target " Safe drinking water and adequate sanitation for all people in 1990" was widely published and a mood of enthusiasm and high expectation was generated. It soon became obvious that the goal of the decade was unrealistic. However, increased efforts during the decade created awareness about the sector and more systematic approach to the problems. Even the goal of the Decade was clearly unrealistic; two factors particularly had a negative impact on the development. Firstly, the world population continued to grow rapidly, from about 4.5 billion in 1980 to 5.3 billion in 1990, with most of the increase (about 614 million) in the developing countries, particularly in urban areas. Secondly, the downturn in the world economy made fewer funds available for the sector

in many countries. In the early 1970s it was estimated that only one third of the people in the developing world had access to safe drinking water and adequate sanitary excreta disposal.

Furthermore, population growth and increasing urbanization make the prospects of the decade target grim. Inadequate Urban Sanitation, Urbanization is often the major source of pollution of ground and surface water bodies (Egil 1998). This may be through leaks from sewer pipelines and sewage treatment facilities.

Inadequate urban Sanitation is worldwide common failure in regard to excremental disposal problems, which in the developing world the situation is more serious, Zambia inclusive. To solve these environmental health problems, the Government of the republic of Zambia has embarked on Environmental Support Program (ESP), which is a long-term commitment to stimulate the interest and investment in environmental and natural resources management with the framework of the economic growth. The NEAP has identified five major environmental issues water pollution and inadequate sanitation, soil degradation, air pollution wildlife depletion and deforestation. The NEAP is founded on three fundamental principles that is the right of citizen to a clean and health environmental. Local community and private sector participation in natural resources Management. Obligatory Environmental Impact Assessment (EIAs) of major development in all sectors.

The rapid demographic changes especially in urban cities, such as Lusaka are caused by an annual population growth rate of 3.5%, urbanization, industrialization, increased social amenities demand and general economic decline, pose a threat to sustainable use of the natural resources which, in return threatens economic, social and environmental sustainability in the long run (Central Statistical Office 1990).

The city of Lusaka attracts numerous migrations because of its various small-scale businesses and both formal and informal employment. However, since the mid 1990s when the country began to experience serious economic downturns job opportunities became very limited and most migrations ended up in the informal sector. The high level of urbanization taking place in Lusaka and the constant lack of adequate management of the city have constrained the city authorities in providing basic services such as adequate road drainage, sanitation, water and many other public amenities.

A survey conducted by (CSO and University of Zambia 1992), on country profiles identified that Government has recognized the need to promote and maintain the welfare of the people by adopting sustainable policies, for the benefit of both the present and the future populations. An implementation program to achieve these goals regimes appropriate policies, incentives, guidelines and public awareness at local, provincial and national levels could be done by carrying studies and provide information in order to promote citizens right to clean and health environment and for policy formulation. On urbanization it reported that the high population concentration in urban centres have put pressure on meagre urban resources especially sanitary facilities. Most urban municipalities have failed to provide social services such as clean water, adequate sanitation and waste disposal. Migration into urban centres has lead to the sprouting of unplanned settlement areas (shantytowns). Inadequate sanitation and lack of clean water supply pose great health dangers and environmental hazardous. Out breaks of diseases formerly rare in Zambia such as cholera have now become endemic problems.

(Bland and Kilama 1985) conducted a study to determine the causes of most infectious diseases; the investigation identified that poor sanitation is the major cause of most human infections. Infections spread through inadequate sanitation include: viral diseases like cholera, typhoid, paratyphoid and bacillary dysentery; protozoal diseases like amoebic dysentery and worm infections like ascariasis, pinworm spread through direct contact, indirect via water, soil and food or via carriers. The study further finds that; without effective community-wide method to contain excremental, the full health impacts of a plentiful water supply will not be appreciated.

The major sources of water supply for the city of Lusaka are derived from two sources, ground

water 53 boreholes around the city and surface water from Kafue River. The average annual production of water is 200, 000 cubic meter with each source accounting for 50% of the production quantity. Further more, the paper states that the water borne sewerage systems cover about 30% of the area to which the company has water supply services and the total length of about 450 kilometres with about 10,000 manhole. These are usually poorly constructed or located, posing a risk of contaminating ground water. The areas, which are serviced, include high cost and medium cost areas (Mtine 2000).

From the foregoing review of literature, it is evident that a number of studies have been conducted in Lusaka. Most of these have concentrated in the water supply, water quality and solid waste management. The reviewed studies also show that there are a number of water projects under taken in Lusaka and elsewhere in Zambia. Therefore, the importance of conducting this study cannot be over emphasized, if the trend cannot be reversed the quality of the ground and surface water could be effected and bring about adverse effects to the environment and human life.

The literature cited indicates that there has been no detailed study to review the status and satisfactory operation of sanitary Conveyances both (under ground and surface drains) and sewage treatment facilities in relation to population growth. Therefore the importance of this proposed study cannot be over emphasized and it requires support, in order to meet the national goals to integrate the degrading environment.

## Methods

Data collection involved review of literature; stakeholder interviews using questionnaires (10 institutions and 300 household core informants), focus group discussions and inspection (observation) of sanitary systems. Both qualitative and quantitative data was collected. The 30 wards in Lusaka urban were stratified and a sample of 6 wards was selected representing two (2) wards from each residential category namely high, medium and low-density areas. The circular systematic sampling method was used in the selection of wards, which assumes the following relationship: Let  $N = nK$

Where  $N$  = total Number of wards assigned sampling serial numbers in the case  $30$   $n$  = The sample size of wards i.e. the required number of wards, which in this case was 6.

$$K = \text{The Sampling Interval calculated as } K = \frac{N}{n} \\ = \frac{30}{6} = 5$$

A random Number was obtained from a table of random numbers. This number was between 1 and  $N$  (both inclusive). In this case, the  $N$  was 30, as there were a total of 30 words. The sample interval  $K = \frac{N}{n}$  was calculated. In this case was  $K = \frac{30}{5} = 6$ . The sampled numbers of wards required were then selected using the circular systematic sampling method. The ward whose sampling serial number corresponded to the random start was the first selected ward. Then the  $K$ , i.e. the sampling interval was applied by adding  $K$  to each selected wards, serial number until the required sample size ( $n = 6 \text{ wards}$ ) was achieved. In all, 6 wards were selected.

## Results

It is evident that Lusaka is the most urbanised, populated city in Zambia and one of the urbanised in sub Saharan Africa. The public sanitary facilities are overloaded because they were designed with the capacity follow of 36,000 m<sup>3</sup>/day in 1950s but currently they are serving more people. The service providers' are strained due to limited capacity to maintain the existing

sanitary systems in the city. It was found that extensions are made in private cartilages with or without permission from the local authorities, especially in low and medium cost areas, see figure 1. Showing a housing structure extension within a yard, drains and sewer are connected illegally.



**Figure 2:** Building extensions, source: field data 2002

It was evident that the socio-economic and practices of urban communities have contributed to unsatisfactory operation of sanitary infrastructure in the city. The street vendors use drains to dispose solid waste most of which are Inorganic nature. The Inorganic substances are trapped as screens before entering the waste treatment plants. These inorganic materials are usually block and damage the drains. There are no source separation of solid waste in the city of Lusaka and most waste generated are indiscriminate damped, especially in low and medium cost areas. In some case vendors remove lids from the manhole and inorganic waste materials are found into sewer lines up to the screen. See figure 2, showing inorganic screens.



**Figure 3:** Screens out for sewer, source: field data 2002

Most infectious diseases common in Lusaka are spread through inadequate sanitation. Especially malaria, cholera, dysentery, and typhoid have become endemic in urban settlements. In 1997/1998-rain season, the Central Board of Health reported that by February 19, 1999 there were 1,540 cases of cholera in 14 districts countrywide. There were 43 deaths, 19 of them from Lusaka alone. Urbanisation has contributed greatly to poor sanitation, which is often the major source of pollution of the ground and surface water. This is through leaks from sewer pipes, waste stabilisation ponds and discharge of raw sewage from dilapidated sewer system into water bodies' figure 3, showing ponds of sewage fro dilapidated manhole and figure 4 showing dry up waste stabilisation ponds.



**Figure 4:** Dilapidated manhole, source: field data 2002



**Figure 5:** Dilapidated manhole, source: field data 2002

## Conclusion

The conclusions drawn are that urban sanitation is a common failure especially in developing countries like Zambia. The disposal problem of solid and wastewater are regarded as less important than the consideration of portable water supply. The fact is that without effective community-wide method to contain excremental, the full health impacts of a plentiful water supply will not be appreciated. The historical roots of such an assumption originated in times when it was acceptable to pour the wastewater into the nearest watercourse. Urbanisation is often the major problem in Lusaka and other cities in developing countries. The concept of ruralisation is not fully implemented so as to control urban drift. Capacity building and political will can contribute to improve sanitation situation in urban settlements where leaks from sewer pipes, waste stabilisation ponds and illegal sewer connections are common.

Regarding developing countries, the key issues to achieve ecological sanitation are: - political recognition of the importance of sanitation, poverty alleviation and rural economic development (ruralisation), recycling of urban wastes and the development of adequate policies. Ecological sanitation is eco integration through total cooperation among decision makers, researchers and the general public. It requires systematic planning, adequate organisation and recycling of urban wastes and wastewater to prevent environmental damage and health risks. Efficiency, equity and vitality are the three dominating agents in ecological sanitation. Ecological sanitation requires totally functioning design, management and help local people through capacity building.

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## Study on ecological sanitation and anaerobic digestion process models in China (2000-2003)

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### Abstract

This paper presented the study on the Chinese explorative research and successive design and anaerobic digestion process models as well as the various case examples, research activities of anaerobic digestion projects for environmental protection in China during 2000 to 2003. The illustrated wastewater treated anaerobically are organic industrial wastewater, hard to biodegrade, hazardous, non-hygienic and chemical, covered the mixed domestic wastewater discharged from large sized steel and iron enterprises; and industrial wastewater from chemical plants, soybean source factory; black liquor from paper mills; industrial wastewater from textile and dyeing industry, antibiotics production, Coca-Cola drinks production, pharmaceutical industry, fiber production etc. In addition, the newest research, design and applied results in the circle of anaerobic digestion were briefly highlighted, including the optimization of industry practice and experience as well as operational management ability, e.g. alkali method straw pulp and chemical pulp-paper making wastewater, wastewater from medical industry, biopharmaceutical production, antibiotics as penicillin, erythromycin etc. Chinese medicinal herbs processing, antibiotics, tanning, brewery, distillery, agricultural chemicals, pesticide and insecticide, animal medicine, dyeing production, textile and printing industry, petroleum-chemical processing (PTA-phenyl terephthalic acid), coke processing, explosive production as RDX, hospitals, can and food processing, sugar-processing, municipal sewage with mixed industrial and domestic wastewater etc. All the mentioned research and practice show that both Chinese people and Chinese government have made great efforts in the last two decades in purifying the environment of water, soil and atmosphere via combining good understanding and application of anaerobic digestion with the local environment and economic development conditions. In addition, some theoretical treatment principles, bio-reaction types, and biodegradation pathways are briefed as the fundamental knowledge and expertise for the anaerobic digestion.

### Keywords

Ecological sanitation, sustainable development, anaerobic digestion, process

### Introduction

Ecological sanitation alike ecological safety is very important issue in sustainable development for developing countries and even developed countries concerned by the international society. Ecological sanitation covers many fields such as water ecological sanitation, plant ecological sanitation etc. If something wrong with the water ecology sanitation, it will impact the other ecological sanitation as soil, plant and animals even the food ecological chain of human beings and animals, which has been well known by many people.

If a water body either a river, lake, sea or a reservoir, pond, well etc. is polluted by some hazardous, non-hygienic, and/or chemical industrial wastewater, some pollutants are hard to biodegrade, which can go into the food chain of human and livestock resulting in diseases of poisoning, cancer and malformation, and viscera malfunction. Additionally, the increasing use of pesticides, chemical fertilizers, and various agrochemicals has no doubt left hazardous substances on grains, vegetables, fruits, eggs and meat, and even in honey products which have affected on people's health and export of agricultural products into the world markets. Though Chinese government issued regulations in the early 1984 on the use of quality, high efficient, and low remnant pesticide, the estimated annual pesticide consumption still increases by 7-8%. In accordance with the statistic report done by the Ministry of Public Health, P.R. China, in last two years, the poisoning event caused by agricultural chemical remains in food poisoning occupied greatly, and the rate of disabling and death were higher. The same astonishment was shown for the impact from the animal medicine remains or animal feed additives. Some animal feed additives could influence the standard of meat quality, and even cause diseases of human body. The Chinese government again and again bans to adopt hormone, antibiotics and some chemically the synthesized drugs to stipulate the growth of animals. It was reported by China National Environment Agency that the annual output quantity of wastewater discharged in China reached by 62 billion ton, which greatly polluted 25% of big rivers, lakes, off-shore marine water impacting the quality of water and soil in the irrigating areas along a few rivers.

In the Chinese State Council issued "Some decisions concerning environment protection", it is clearly stated that as a target up to 2000, all the pollutant discharge in the country must meet the national or local standards. This target involves in many important industries such as chemicals, light industry, leather product industry, food, pharmaceuticals, petroleum-chemical processing industry, and etc. which are backbone industries in national economy in one hand, and produce large amount and various kinds of industrial wastewater on the other hand due to their multiple sources of raw materials, complicated processing techniques. Processing of this wastewater for the purpose of water environmental improvement and wastewater reuse is a difficult task and requires advanced technology on anaerobic digestion and environmental protection. For instance, in harnessing papermaking wastewater by anaerobic digestion, core technologies will include dealing with paper pulp wastewater, organic phosphorous wastewater and organic chloride in insecticide production, naphthalene and benzene and high concentration colored wastewater in dyeing production. Therefore optimal biological processing techniques of anaerobic digestion, anaerobic-aerobic technique, and high efficient typical anaerobic digestion facilities combined with pretreatment and post-treatment processing technologies can be used to process effectively various hard-to-biodegrade organic industrial wastewater in order to improve and purify water, soil, and atmospheric environment.

### Organic pollutants in industrial wastewater, which China's government will control

The names of organic pollutants that China's government would like to control firstly are briefed as follows:

No.	Name	No.	Name	No.	Name
1	Dichloromethane	21	Polychlorinated biphenyls	41	Benz[k]fluoroanthene
2	Trichloromethane	22	Phenol	42	Benzo[a]pyrene
3	Carbontetrachloride	23	m-Cresol	43	Indeno[1,2,3-c,d]pyrene
4	1,2,-Dichloroethane	24	2,4-Dichlorophenol	44	Benzo[g,h,i]perylene
5	1,1,1-Trichloromethane	25	2,4,6-Trichlorophenol	45	Dimethylphthalate
6	1,1,2-Trichloromethane	26	Pentachlorophenol	46	Di-n-butylphthalate
7	Syrn-Tetrachloroethane	27	p-Nitrophenol	47	Diocetylphthalate
8	Trichloroethylene	28	Nitrobenzene	48	Hexachlorocyclohexanes
9	Tetrachloroethylene	29	p-Nitrotoluene	49	DDT
10	Bromoform	30	2,4,-Dinitrotoluene	50	DDV
11	Benzene	31	Trinitrotoluene	51	Dimethhoate
12	Toluene	32	p-Nitrochlorobenzene	52	Parathion
13	Ethlbbenzne	33	2,4-Dinitro-1-chlorobenzene	53	Parathion-methyl
14	o-Xylene	34	Ariline	54	Nithofen
15	m-Xylene	35	Dinitroaniline	55	Trichlorofon
16	p-Xylene	36	p-Nitroaniline	56	Acrylonitrile
17	Chlorobenzene	37	2,6-Dichloro-1-nitroaniline	57	N-Nitrosodimethylamine
18	o-Dichlorobenzene	38	Naphthalene	58	N-Nitrosodi-n-propylamine
19	p-Dichlorobenzene	39	Fluoroanthene		
20	Hexachlorobenezene	40	Benio[b]fluoroanthene		

**Table 1:** Organic pollutants in industrial wastewater.

### Processing technique models and experience for anaerobic digestion of several typical industrial wastewaters in China

1. Shanghai Baoshan Steel and Iron Group (Large State-owned Enterprise) SBR Domestic Wastewater Treatment and Reuse Project.

Process Flow:

Wastewater → Screen Bar → De-silting (sludge transportation) / Sludge storage → Regulating → Pump for Influent → SBR → Intermediate → Pump → Filtration → Biocarbon → Measurement → Adding NaClO → Contact → Medal Water → Reuse

2. Anhui “Mini-electrolysis-UASB-PACT” Process Treating High Concentration Wastewater of Nitrobenzene.

Process Flow:

Wastewater →Regulating →Pump →Mini-electrolysis with addition of  $H_2SO_4$ , activated carbon, Fe powders and air → Water-collecting → centralization with addition of lime water plus PAC and PAM →UASB in addition with one time dilution water and discharging sludge →Retarding with addition of 1 time dilution water →PACT →Effluent discharge →Sludge Storage →Compress and Filtration →Sludge

3. Chongqing Soybean Source Plant “Anaerobically Acidification Hydraulysis-Activated Sludge” to Treat Soybean Source Wastewater Project.

Process Flow:

Wastewater →Screen Bar and Screen Net → Regulating → Pump → Anaerobically-Hydraulysis-Acidification → Pumping → Aeration → Sedimentation →Filtration with Coal Dust →Discharge

4. Shenzheng Jiede Textile ( Joint Venture with Hong Kong ) Wastewater Anaerobic Treatment Project.

Process Flow:

Wastewater → Adding  $FeSO_4$  → Regulating → Contact Aeration → Sedimentation → Coagulation Floatation →Effluent

## Sewerage management at Delhi, India

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### Keywords

Sanitation, wastewater, water drainage system

### Abstract

The population growth and rapid urbanization in Delhi has led to immense pressure on basic amenities such as water supply, wastewater collection and treatment. River Yamuna the second largest river in India having length 1376 km, having catchments of the basin 10% of the total; landmass of country is highly polluted within 22 km stretch along Delhi (70% pollution is discharged) and unfit for designated water uses. High organic and pathogen levels in all the urban surface water have resulted from huge discharges of municipal wastewater (sewage and industrial wastewater) and urban drainage into the river. Average annual BOD and total coliform in river at downstream of Delhi are in the range of 30-40 mg/l and  $10^4$  -  $10^6$  MPN/100ml respectively. Thus river stretch along Delhi is most critical segment from pollution angle. All environmental aspects were considered in Yamuna Action Plan of Indian Govt that support an immediate progress and a long range plan to create improvement in sanitation, public health and quality of the people of Delhi with the affordable solution to the problems of sewage collection, treatment and disposal, including the improving to the quality of river Yamuna. This paper describes the present sewerage and sanitation condition of Delhi.

### Introduction

Population of Delhi has grown to around 14 million in year 2001. Delhi as a state comprises urban and rural segment. The growth of population has mainly been in the urban sector. The average density of population per square km was 12361 in urban area as against only 1190 in the rural sector. The rural sector has been shrinking rapidly and green area of Delhi is under considerable pressure of habitation on account of population influx and urban push. Over 45% of population of Delhi today live in slums, JJ clusters and unauthorized colonies where practically no sewerage system exists.

#### *Sanitation and wastewater condition in Delhi*

The principal of Public Health Engg demands that satisfactory wastewater disposal arrangements should be provided along with the water supply to every citizen. However, during earlier five year plans in India the emphasis was mainly on the provision of drinking water to both urban and rural areas. As a result, sewerage facilities commensurate with the sewerage generation did not develop. Even today only 55% of population of Delhi is served by sewerage system. Existing sanitation conditions vary widely throughout the Delhi. The habitation in the Delhi is in the following categories:

1. Planned developed- approved colonies
2. Un- authorized - regularised colonies
3. Resettlement colonies

4. Urban village
5. Rural village
6. Un authorized non regularized colonies
7. Slums and JJ clusters

According to the present policy of Delhi Water Board, sewerage system is provided or to be provided in all the categories from no 1 to 4 above. The existing un- sewerred parts in these colonies are being attended to in a phased manner depending upon the response of the residents towards payment of development charges. Nearly 45% of the population of Delhi live in UN authorized colonies, JJ clusters and rural villages and presently their population do not have access to sewerage system. As per the present policy of Water Board, sewerage system is not to be provided in these colonies in the near future. Therefore, these areas will remain un-sewerred till the present policy is amended. Most of the households in the unauthorized colonies have constructed septic tanks. Overflow from such tanks are connected to surface drains, which finally find way to the Yamuna River. There are total of 219 rural villages with an estimated population of about 0.6 million, where the rate of water supply is only 50 lcpd. No sewerage system has been provided in these villages because of dense population and it is technically not feasible unless the water supply is increased to a minimum of 135 lcpd. The wastewater generated in the area finds its way into river Yamuna either through open drain. There are total of 1080 identified JJ clusters in Delhi. In these clusters, a family of 4 to 5 persons live in one hutment about 150 sq ft without any access to sanitation facilities. In JJ clusters low cost toilet facilities are provided. Under such facilities community toilet complexes are constructed near the clusters. However, many hutment dwellers do not use these toilets and prefer to defecate in the open area around the clusters creating the health hazards. Human wastes that are not properly treated and disposed off pose parasitic infection through contamination of water and foods. Sewerage overflow from such complexes are generally let off into the nearby surface drain and ultimately pollute the river. Based on the water quality modelling analysis, by Central pollution Control Board it is estimated that slum clusters along the river banks of Yamuna within its reach passing through Delhi, contribute approx 5% of pollution as a non point source load. Additional non-point source from slum clusters on banks of drains flowing into Yamuna contribute additional non point source pollution load. Sewerage facilities have been extended to all the planned developed and approved colonies of Delhi.

In the 22 km stretch along Delhi between Wazirabad and Okhla, the entire sewerage of Delhi, in partly treated and mostly untreated condition is discharged into river from both banks. In addition, industrial effluents from 30 odd industrial estates of Delhi also flow into the river through sewers or directly in untreated condition. The total quantity of wastewater received by river in Delhi is of the order of 2870 MLD comprising 2670 MLD of sewerage and 200 MLD of industrial effluents. The present sewerage treatment capacity in Delhi is about 2145 MLD. Due to silting and settling of sewerage system at many places only 950 MLD of sewerage reach the Sewerage Treatment Plants. There are a number of sewerage treatment plants around the city most of which are based on Activated sludge process. At present 15 STPs are under operation, their existing capacity is 2145 MLD and 3 are under construction with the capacity of 135 MLD. There are 77 numbers of main and intermediate pumping stations. About 15% of the trunk sewers are functioning satisfactory. The remaining sewers are affected by accumulation of silt. The level of silt deposition ranges from 30-60% of the capacity. The sewers are silted due to insufficient velocity in sewers, flooding of sewers, blockage of sewers with floating matter/debris, surcharging of sewers due to power cuts and open manholes. At least 10% of sewers are affected by settlement or structural weakness.

#### *Storm water drainage system*

There are 19 storm water drains in Delhi which outfall into Yamuna River downstream of Wazirabad. (Table: 1)

No	Description of Drain	Discharge (m <sup>3</sup> /d)	BOD (mg/l)	Total BOD (t/day)	Drainage (sewerage) zone
01	Supplementary drain	180	22	4	Out of Delhi
02	Najafgarh drain	1,180	125	147.5	Rithala, C. pillar, Keshopur
03	Magazine road drain	4	190	0.8	Okhla
04	Sweepers colony drain	27	88	2.4	Okhla
05	Kheybar pass drain	23	65	1.5	Okhla
06	Metcalf house drain	11	85	0.9	Okhla
07	Quadsia Bagh	24	155	3.7	Okhla
80	Mori gate drain	24	85	2	Okhla
09	Moat drain	2	195	0.4	Okhla
10	Civil mill drain	55	180	9.9	Okhla
11	Rajghat/Delhi gate drain	43	190	8.2	Okhla
12	Sen-Nursing home	100	280	28	Okhla
13	Drain no.14	153	320	49	Okhla
14	Bara pula drain	255	165	42.1	Okhla
15	Maharani Bagh drain	64	370	23.7	Okhla
16	Kalkaji drain	11	210	2.3	Okhla
17	Tehkhand drain	34	310	10.5	Okhla
18	Tuglakabad drain	8	150	1.2	Okhla
19	Trans Yamuna	672	240	161.3	Trans Yamuna
	Total (Average)	2,870	174	499.4	

**Table 1:** Observed discharge, BOD levels and total BOD in storm water drains of Delhi during April 2002

Out of these 19 drains, 15 drains (no1-15) outfall into the Yamuna between Wazirabad and Okhla barrage along its right bank. These drains are now carrying untreated sewage from entire Delhi and finally discharge it into the Yamuna.

The Najafgarh drain is the largest drain carrying nearly 1200 MLd of combined sludge into the Yamuna. This drain has 38 tributary drains, which carry domestic and industrial wastewater from its command area.

#### *River water quality*

The desired water quality according to "Designated Best Use " criteria of Central Pollution Control Board is of "Bathing Class" along the city limit of Delhi. This require inter alia, a BOD of 3 mg/l (maximum), Dissolved oxygen 5 mg/l (minimum) and total coliform count of 500 0/100 ml. Poor waste water collection, treatment and disposal system in Delhi, inadequate solid waste handling system and discharge of untreated or partially treated wastewater into Yamuna have resulted in deteriorating water quality in river Yamuna. (As shown in table 2) In the 22 km stretch along Delhi, with practically no perennial flow of its own is the most critical segment from pollution angle.

Parameter	Water quality standards	Current status in Delhi stretch
Total coliform MPS/100 ml	5000	$1.9 \times 10^6$
pH	6-9	6-9
Dissolved Oxygen	5	0
BOD <sub>5</sub> mg/l	3	36

**Table 2:** Present water quality of river Yamuna – source CPCB annual report 2002

Hence in order to keep BOD<sub>5</sub> values of river water 3 mg/l all the wastewater generated in Delhi and reaching the river needs treatment up to the tertiary level with BOD<sub>5</sub> up to 3mg /l. One may examine the technical and financial feasibility to achieve the limits or look for some alternate solution such as land treatment of municipal wastewater and augmentation of minimum freshwater flow through the river.

#### *Low cost sanitation community toilet complexes*

Delhi has certain areas along river banks/drains occupied by slums dwellers belonging to economically weaker sections of the society. These people do not have toilets in their houses. Therefore, they defecate in open, which in turn deteriorate environmental sanitation and consequently lead to water pollution through surface runoff. As these slums are too congested to have a sewerage system, proper sanitation facilities in the form of LCS/CTC are proposed to be provided with the community to provide the sanitation .A large number of LCS/CTS facilities have been created under Yamuna Action Plan, but it has been felt in due course that there is no or very little acceptance of these facilities by people. We may list various possible reasons for under utilization of different facilities. Some of them are given below.

1. Lack of people involvement in earlier stage of planning of the project
2. Non-Cooperation of urban local bodies of the town
3. Lack of socially motivated O&M operators
4. Improper site selection like distant location of toilets from the habitation, in appropriate approach to the toilets etc.
5. Lack of intensity towards gender, age, disability and dignity related issues while designing the toilets
6. Improper supply of water and intermittent supply of electricity
7. Non- willingness of users to pay the fees

#### **Conclusion**

Economically weaker sections of the society living in Delhi do not have toilets and defecate in the open area. This leads to in sanitary living conditions in the city and runoff after a rain carry waste into the river which has adverse impact on the river water quality during dry season as when very little fresh water flow exists in the river .By addressing the slum settlements sanitation problems, direct benefit would be a significant reduction of the estimated daily average pollution load on the river.

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 Acknowledgement Mrs. Mehvish and Aamir

## Decentralized wastewater treatment in Lesotho

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### Keywords

Sanitation problems

### Abstract

Lesotho is a poor, mountainous country, surrounded by South Africa, with 2.2 million inhabitants, mainly in rural areas.

### Sanitation in Lesotho

VIP-latrines are widely spread.

Modern houses are equipped with septic tanks, mainly in urban areas.

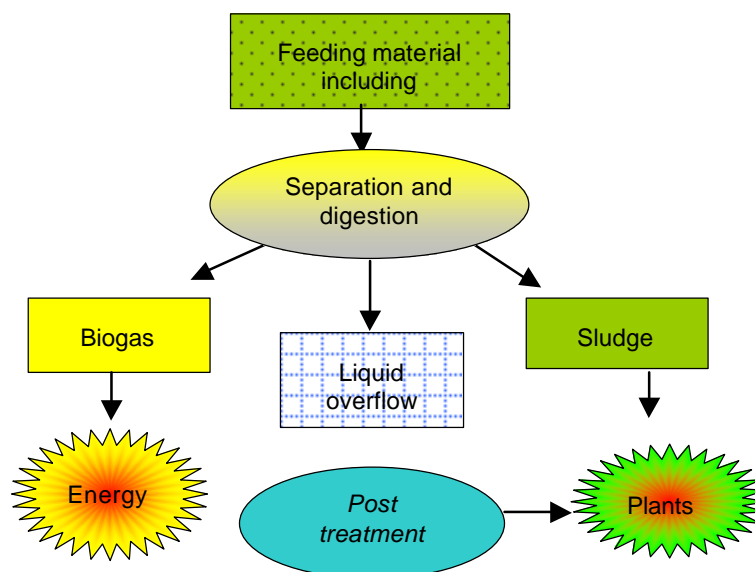
Many houses have both, a flush latrine inside the house and a pit latrine outside the house.

Emptying of septic tanks is a big problem for the house owners (costly).

### Closed loop sanitation

The idea of closed loop sanitation does not exist.

- The authors have started an extension programme for Bio digester Septic Tanks, connected to constructed wetlands, irrigation and fertilization of vegetable plots.



## Principle of extension

Commercial Approach (Minimized subsidies)

## Creating demand

The first system was established close to town, where many visitors have the chance to see this in operation.

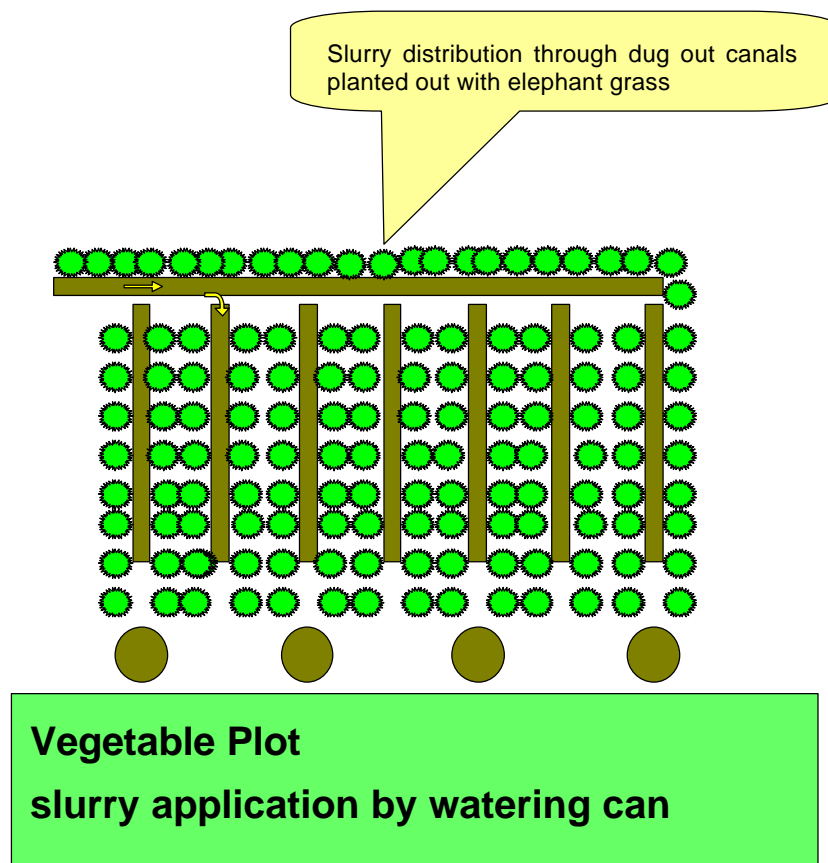
Convinced customers demand the technology. Best conditions are for those who are constructing a septic tank in their yard but for those who already have a septic tank, the system can be constructed aside.

## Creating supply

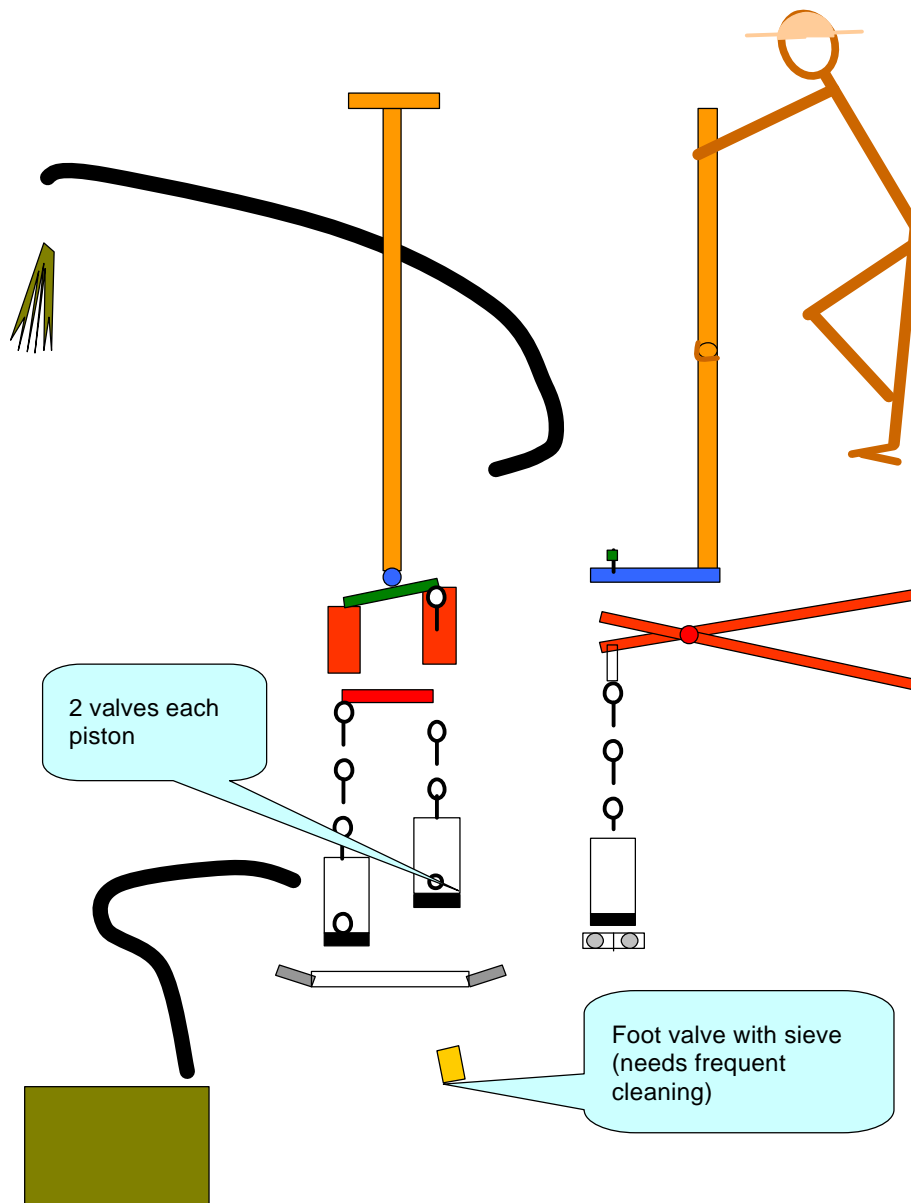
Seven trainees, who are potentially unemployed, have been identified and learn enthusiastically all aspects of the technology on the job. Part of the training is to equip the trainees with a tool set each.

The training costs 10 000 Euro. Transport and engineering supervision is covered by DED.

Since January 2003, 3 systems have been completed and 4 are under construction. The customer covers work and material expenses.



**Figure 1:** Example for the distribution of slurry through dug out canals



**Figure 2:** Sketch of a pedal pump, sucking and pushing liquid slurry. (*Super Money Maker*) produced at Selam Technical and Vocational Centre, Ethiopia

**References**

Bio Digester, Constructed Wetland, Gravity Irrigation, Grey water Separation, Use of Plastic Waste as Fixed Film Aerobic Treatment, Vegetable Production

Additional poster



