# Biological Sewage Treatment Systems

## Design and Implementation

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# Wastewater Management in Urban Areas - Own Sewage Treatment Systems

**Keywords:** Wastewater, Own sewage treatment systems, Environmental, Financial burden.

## Abstract

Despite the impacts of rising energy costs as major challenge facing water and wastewater utilities there are many opportunities to save money and help the environment by focusing on energy efficient techniques. Wastewater utilities offer innovative approaches for maximizing the sustainable use of energy, water, and waste and improving performance. The planning of sewage treatment systems involves the selection of a satisfactory method of treatment from the available treatment processes at a reasonable or a minimum cost. Every engineer confronted with a design problem is aware that it can usually be solved in a number of different ways. The rapid development of the urbanization is creating problems for the satisfactory treatment of sewage. Buildings have their own disposal systems but much waste is discharged to aquifer after little treatment and not at sufficient quality. Although buildings are now beginning to install their plants which are theoretically capable of producing an acceptable effluent, wide fluctuations of the loading of them do not make for efficiency. The aquifer is endangered as a result.

## Introduction

Only a few decades have passed since mankind have become aware of threats to the environment and environmental degradation due to their own waste products. The first progress in wastewater management was realizing the connection between wastewater - and possibility of spreading epidemics which led to attempts to centrally convey the sewage into surface waters.

In the past, the sources of drinking water were mainly wells, i.e. groundwater, and therefore the discharge of sewage into surface waters was at such situation the simplest. The second important step in the wastewater management was seeking the solution how to treat the waste water and than return it to nature. Discovering the principle of biological wastewater purification and determining the limit values for discharge into surface waters can be considered as a breaking point in the wastewater treatment development [1].

Necessity to treat the wastewater is really an essential part of a comprehensive environmental protection and improvement of the environment. If the wastewater is not properly disposed of, or if it is more neglected, the groundwaters and surface waters would not be protected which may lead to gradual devastation of the environment to irreversible state.

Although the emphasis are now placed especially on increasing the degree of pollution removal from wastewater from larger urban areas and cities, the development of technologies and concepts for treatment of wastewater from smaller agglomerations has its importance.

Especially in villages to 2000 population equivalents, there are still missing modern sewage systems and central facilities for wastewater treatment. Due to high costs, the wastewater treatment is provided through decentralized small sewage treatment plants.

Wastewater treatment is currently an important component in improving the environment. Due to the nature of settlements in Slovakia, many people are not able to get connected to sewerage system. Territory, where conveying the wastewater by central sewerage system into a municipal sewage treatment plant is financially and technically very demanding, can be adequately addressed by implementing small sewage treatment plants, under the condition of their technical functionality and ensuring the required technological service.

There are several ways of wastewater disposal in small villages. Beside the traditional solution with a central water treatment plant and gravity drainage, which is very expensive, there are also some other alternatives. These include, e.g. cesspits, however there is a problem with empting the tanks. Individually, small household sewage treatment plants can be used, which provide many advantages in comparison to previous systems and especially are more environment friendly.

**Small sewage treatment plants**

Small sewage treatment plant is a sewage treatment plant to 500 of population equivalents. Plant purifies wastewater from buildings such as houses, recreational facilities, restaurants, manufacturing workshops, offices, nurseries.

Small sewage treatment plant is defined as follows:

- Small treatment plant is a sewage treatment plant to 500 of population equivalents.
- Small treatment plant or cesspit is built, where wastewater cannot be discharged into public sewer.
- Small treatment plant or cesspit must be located and designed to allow future connection to public sewer.
- Small treatment plant or cesspit shall be located in a way that its content can be collected.
- Cesspit bottom and walls must be watertight.

Design of small sewage treatment plant – under the STN 75 6402 General requirements are as follows.

- Small treatment plant can only be established where the wastewater can not be discharged into public sewer with treatment plant.
- Small sewage treatment plant can treat only sewage and water of similar nature, not storm water.
- Following initial data are important for plant design and dimensioning:

- Requirements for the purity of recipient
- Flow and water quality in the recipient
- Amount and pollution of wastewater
- Planimetric, topographic, hydrogeological, geological and climate conditions.

- The amount of waste water is calculated according to water demand. Design of individual structures will be assessed to the largest inflow of wastewater which is determined from the average hourly water demand multiplied by a coefficient of hourly unevenness.
- Treatment utility where the waste water is pumped through must be dimensioned and assessed for the performance and period of the pump.
- The quantity of wastewater pollution which is fed into the treatment plant is calculated according to the number of people connected to the plant. If the number of residents in the building is unknown, four people per each accommodation unit are considered.
- The treatment plant location design must respect sanitary protection zone around the sewage facility which is determined according to local conditions.
- Informative distances of protection zone between the sewage treatment plant and residential buildings are usually proposed:
    - Structures covered and vented above the last floor (e.g. cesspit) - not required
    - Covered structures without venting -20 m
    - Structures with free surface - 50 m.
- In case of adverse conditions (prevailing winds, etc.) protection zone should be extended.
- Non-residential buildings with equipment or material can be positioned in the protection zone and will not be at risk due to treatment plant or its products.
- Land in the protection zone can be used for agriculture.
- Safe distance shall be kept between treatment plant and well, which is according to local conditions and terrain inclination (5-10 m).
- In order to protect surrounding buildings from odours and harmful gases from sewage treatment plant following is recommended:

- Construction of sewage treatment plant in the direction of prevailing winds from the protected object
- Planting bushes and trees in the area between the sewage plant and residential buildings
- Use of barrier effect by non residential buildings (warehouses, garages, outbuildings)
- Technical use of biogas.

- When designing a small sewage plant, it is important to utilize maximum advantage of local conditions enabling simple design of the plant, restrict the use of machinery as much as possible, to use technology and structures that do not require permanent attendance.

- Recovery and removal of intercepted substances must be addressed at all water treatment facilities. It is necessary to ensure that operating staff would get in contact with these substances as little as possible.
- When removing collected materials, surrounding environment should not be polluted by dripping sludge etc.
- Closable bypasses shall be designed for individual structures, allowing their withdrawal from service for maintenance and repairs.
- Possibility to measure basic values, necessary for managing the operation and to determine the performance of treatment plant, should be available in each sewage treatment plant. There should be at least the possibility to measure the amount of run-off from the plant and wastewater sampling.

**Basic characteristics and division of small sewage treatment plants**

Small sewage treatment plants treat the waste water by microorganisms, attached firmly to the base in the form of various systems of biofilters and biodisks drenched by sewage and also by activation systems with sludge in the fluid, in which there are flakes of sludge mixed with waste water and air. Most sewage treatment plants work on the principle of an aerobic treatment system where organic matter is decomposed by a mixture of microorganisms which need oxygen from the air to life.

Each treatment plant has usually three objects of purification:

- Primary treatment (coarse solids are separated from the waste water)
- Aerobic level (biological treatment is taking place followed by separation of sludge from treated water)
- Space for storing the products from treatment.

Basic requirements and conditions for small scale sewage treatment plant expected from the design can be summarized as follows:

- Purification efficiency of greater than 95%
- Quiet in operation
- Energy consumption less than 1 kWh/m 3 treated water
- Vapour tight excluding odour in the surrounding area
- Long-term functionality without any inflow of sewage
- Ability to handle inrush inflow
- Unattended operation and minimal maintenance costs
- Little or no demand for professional service
- Use of only non-corrosive materials
- Storage of treatment products for at least 3 months of operation.

The degree of biological pollution of wastewater is most commonly expressed by the value of BOD5 (biological oxygen demand). In common sewage it ranges from 200 to 400 mg/l. Discharge from well-functioning sewage treatment plant has values 15 to 30 mg/l. For discharge into water body are for the household wastewater treatment plant required values below 50 mg/l and for infiltration into the ground it is usually below 8 mg/l.

**Household sewage treatment plants**

From environmental and economical view point are the most suitable mechanical-biological treatment plants. Biological treatment of sewage water is technically the simplest and the least cost-intensive way of disposing of sewage water. It is similar to self-cleaning process of natural waters, but it is controlled and intensified. At an average production of 138 litres of wastewater per person per day a family house with five people produces about 251 m³ of wastewater per year. Sewage treatment plant recycles this amount of wastewater to 249 m³ of clean water and only 2 m³ hygienically harmless sludge. Household sewage treatment plants are designed to size of around 5 to 50 population equivalents. This implies that it is more economically efficient when more households join together for implementation of sewage treatment plant.

Technology of household sewage treatment plant is placed into tanks, which may be plastic, stainless steel or composite steel-concrete. Products are mostly manufactured from high quality plastic materials, certified and usable in all industrial areas [6]. Household sewage treatment plants are designed to treat waste water from houses, guest houses, lodges and other establishments for 2 to 50 people. Household treatment plant consists of a tank in which there is a non-aerated zone and a separation. Tremendous advantage is that the cleaning operation is stable and the need for service and maintenance is minimal.

Household sewage treatment plants occupy a minimum area. Thanks to its small size, odourless and noiseless operation it can be installed close to home. The most commonly are plants placed under the ground, but they can be placed also in home basements. A pit of required size is excavated for placement of plastic and steel tanks. Some types of tanks can be placed on to a sand bed. However, usually, a blind concrete is placed at the bottom of the pit. The thickness of the concrete slab shall conform to the soil bearing capacity at the footing bottom, approximately 10 cm. In case of high groundwater level, the tanks must be concrete encased against its buoyancy. Once installed properly, the tank is connected to inflow and outflow pipes, to power source and the blower is connected to air distribution. Backfilling and packing of sewage treatment plant shall be made on the circumference of the tank to a thickness of 30 cm by sand, for the rest of the backfilling the original soil is used and compacted.

It is advisable to invest in sewage treatment plant which already meets the criteria for sewage treatment plants in European Union countries. The assortment of treatment plants varies by technical parameters, design, efficiency and price.

**Example Application**

For further description of advantages of using Own sewage treatment systems, we selected an example of its use in a hotel with 50 beds in the Capital city of Kabul, Afghanistan. City of Kabul so far has not built a integrated system of centralized urban sewage treatment plants. Hotel accommodations are therefore forced to send waste water into their own sump. Often removal of effluent by fecal cars represent a considerable financial burden on these establishments and not least also have damaging effects on the environment around the city.

With an average production of 112 liters of wastewater per day the hotel facilities with 50 beds will produce approximately 2044 m³ of effluent per year.

[Chart 1] Price for one wastewater removal of fecal vehicle with a capacity of 24 m³ costing :
6000 AFG = 133 USD During the year, it is necessary to carry out about 85 such removals, with a total cost : 11305 USD.

[Chart 2] Own sewage treatment systems can produced during the year adjusted to approximately 2003 m³ of clean water and only 41 m³ hygienically harmless sludge destined for removal. On the basis of this procedure we can collect 2003 m³of clean water, which can be used for watering lawns and green hotel. For comparison, the cost reduction now represents 98% = 11039 USD in this hotel.

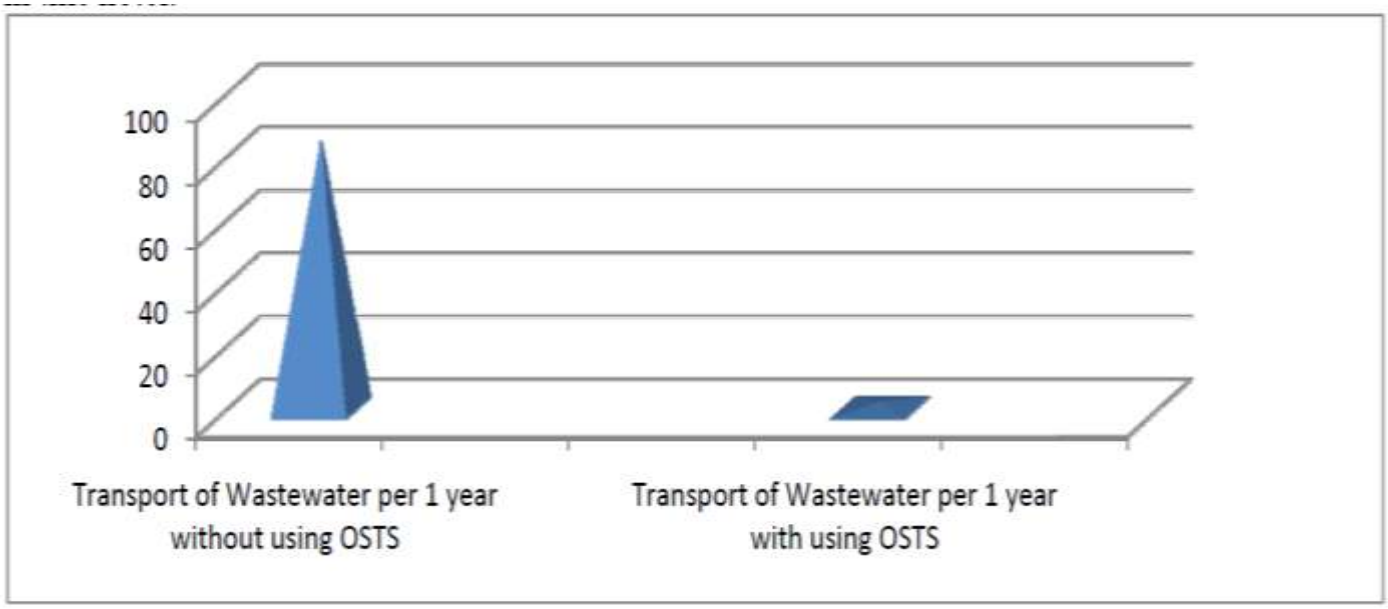



**Chart 1**. Graphics of the removal of wastewater without the use of Own sewage treatment systems and with using in the hotel service with 50 beds.

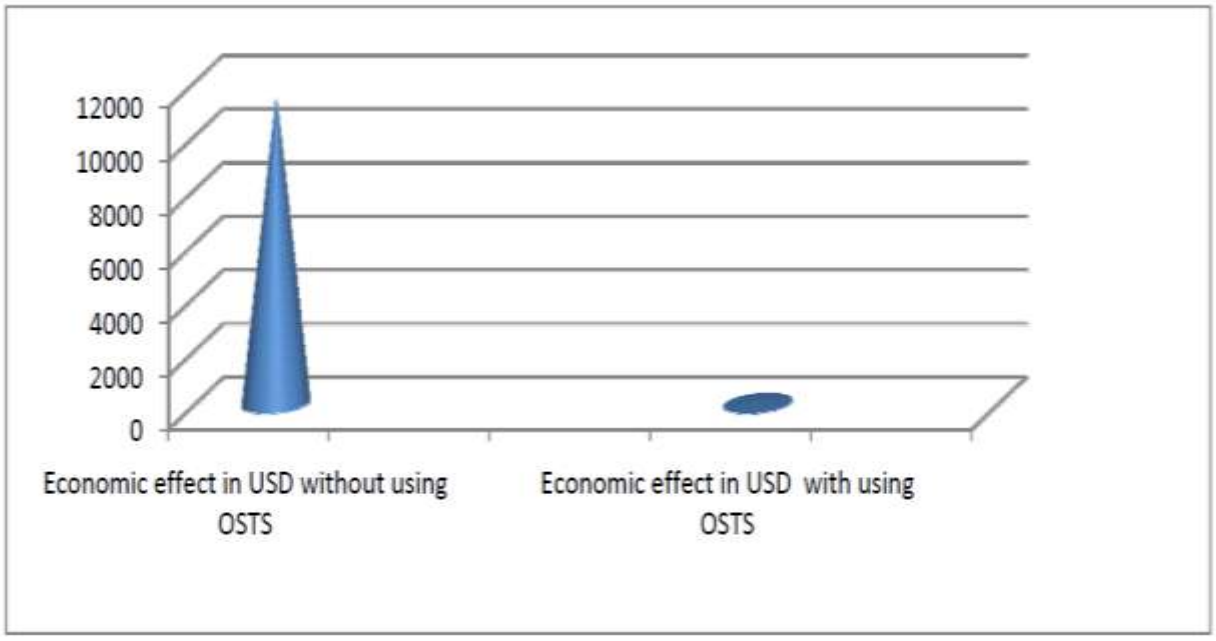



**Chart 2**. Graphics of the economic effect without the use of Own sewage treatment systems and with using in the hotel service with 50 beds.

The using of Own sewage treatment systems in the underdeveloped system of central wastewater treatment plants have huge advantage for the economy, environmental protection, and not least the health of residents. Environmental advantage of reducing the number of removing waste water in the city of Kabul and near the unprotected landfill can limit adverse health effects on groundwater and inhabitants.

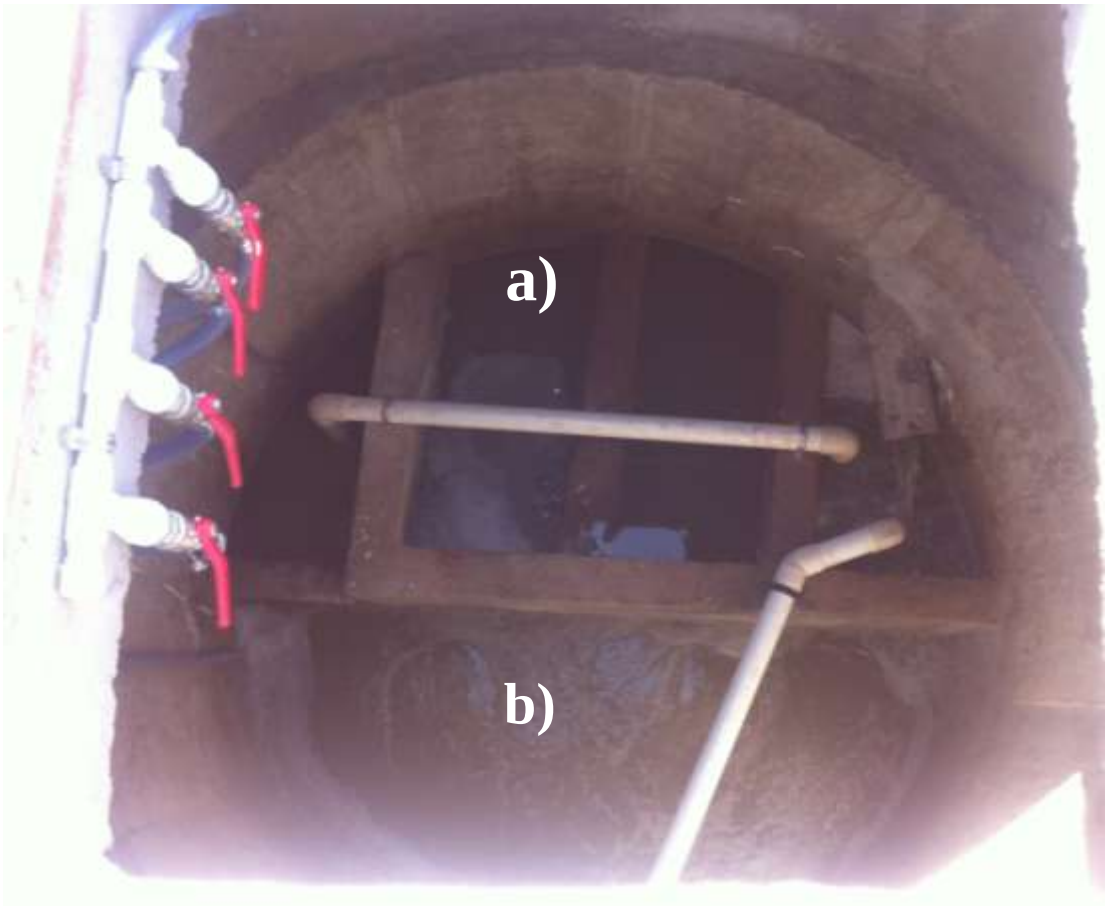
**Conclusion**

Sewerage and sewage treatment toggether form an important part of enviromental protection. One of the firs indicators of quality of human life is drinking water and its resources and related protection of water resources. The quality of drinking water is significantly affected by wastewater produced by human activity that is discharged into the recipient, and not always properly conveyed from urbanized area and then properly treated in sewage treatment plant. Disposal of waste water, and thus prevention of unpleasant impacts caused by wastewaters in natural waters and natural environment, is based on collection and treatment of waste water to the extent which ensures sustained good quality of surface waters.


**Picture 1**, Biological waste water treatment system components

**Picture 2**, Small Biological sewage treatment plants consists of three well

**Picture 3**, First well, the Aerob part of system, where is installed the air element




**Picture 4**, a) The mechanical filtration and purification of system, b) The biological filtration and purification of system


**Picture 5**, Second well a) The biological filtration and purification of system, b) The water after filtration and purification

**Picture 6**, Third well, The using of overtopping water for grass

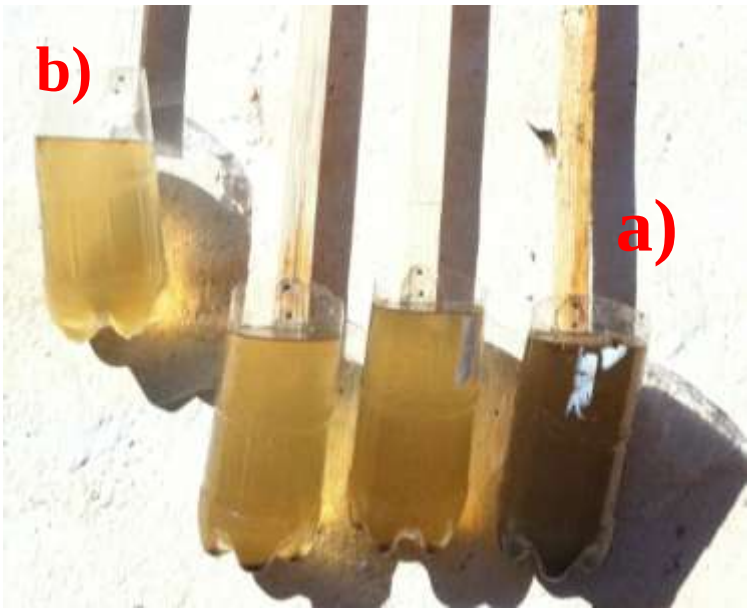
**Picture 7**, The Biological sewage treatment plants, (Herat, Family center, for 100 -120 people)

**Picture 8**, The using of overtopping water for grass ( Herat, Family center)

**Picture 9**, The irrigation of Trees with water from deep well (Herat, Family center)

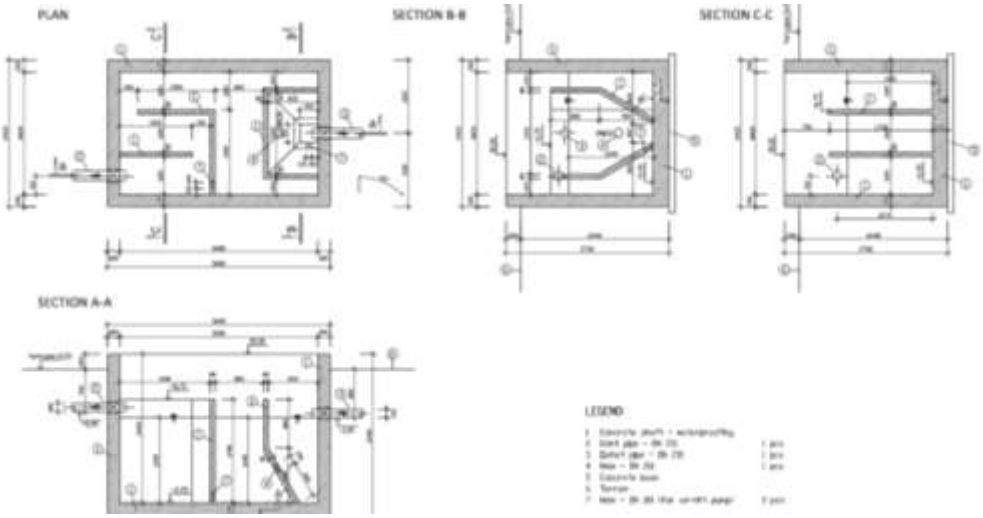
**Picture 10**, The irrigation of Trees with water from Biological sewage treatment plants (Herat, Family center)

***Note: they trees have planted in the same time***

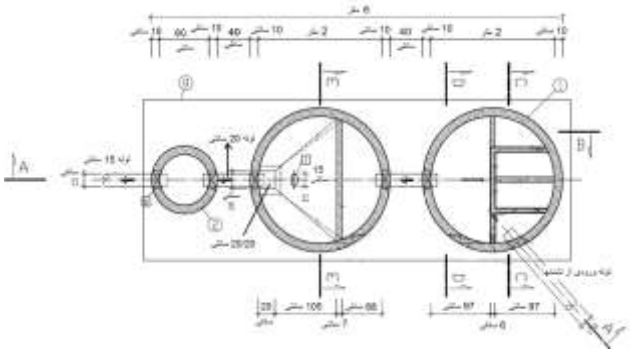



**Picture 11**, Samples of taken water from different stages of filtration and purification, a) The input sewage, b) water after purification and filtration

**Picture 12**, The Sewage water and fat water treatment system in Shikiban vilage of Zindagan district of Herat province (for 100 to 120 people) - The using of water after purification and filtration for agriculture




**Picture 13**, The Biological sewage treatment system
(Herat, Family House, for 20 -25 people)

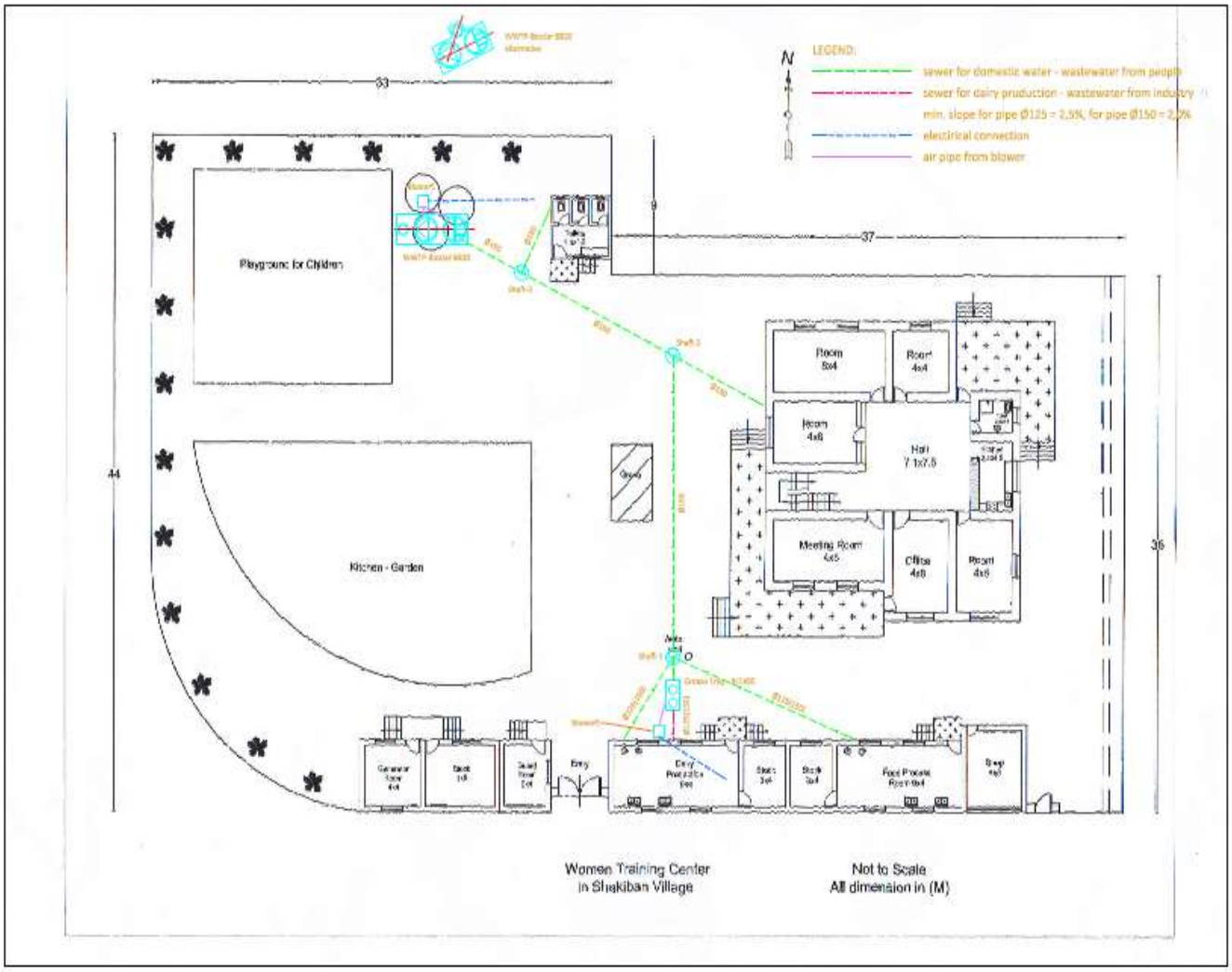


**Picture 14**, Two separate similar sewage teatment system in Gwahar Khaton school in Mazare Sharif (for 500 -800 students)

**Picture 15**, The Biological sewage treatment system
(Training center of help office in Herat, for 20 -25 people)


**Picture 16**, The Biological sewage treatment system in the are of Kabul Municipality headquarters (for 20 -25 people), Samples of taken water from different stages of filtration and purification, a) The input sewage, b) water after purification and filtration

## Technical drawings




# Please protect our land!

**"We have not inherited the land from our fathers, but have borrowed it from our children"**